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A Guide to Forestry Investment Analysis

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It is often necessary to choose between several forestry projects. This paper provides the background needed to evaluate projects from a financial perspective. The basic steps for preparing a project analysis, suggestions for dealing with uncertainty, and techniques for monitoring a project are presented.

KEY WORDS: Economic analysis, project analysis, risk, sensitivity analysis.

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A GUIDE TO FORESTRY INVESTMENT ANALYSIS[1]

Dietmar W. Rose, Charles R. Blinn, *and* **Gary J. Brand**

INTRODUCTION AND OVERVIEW

Forest managers are frequently responsible for managing several timber stands. Different management treatments may be prescribed for the various stands because of differences in species composition, site productivity and suitability, stand age, etc. Because financial resources are limited, forest management decision makers need to identify and evaluate the various available management alternatives to determine how funds should best be allocated to meet the landowner's or land manager's objectives.

This guide was developed to introduce the basic principles, relations, and techniques necessary to analyze and evaluate alternative forestry projects. The focus and emphasis of this paper is to provide resource managers with:

1. an understanding of project analysis and economic evaluation techniques including procedures to deal with uncertainty and project monitoring;
2. an appreciation of economic and social factors decision makers must consider when employing project analysis and other evaluation techniques; and
3. an opportunity to obtain further knowledge of economic tools used in decision making.

A "project analysis" is a systematic and organized approach to the economic or financial evaluation of a particular proposal. A project may be defined to be any scheme for investing resources that can be evaluated as an independent unit (Grundy 1985). In many cases, foresters lack an adequate understanding of project analysis. Those who are familiar with this type of analysis, need to be provided with information on new techniques, to have various existing techniques clarified, and to gain additional insight into the many political and broad financial factors that may affect such an analysis and the resulting decisions.

Although similar to other business projects, forestry projects have some peculiarities that affect investors. They include:

1. extremely long planning horizons,
2. the "factory" (the tree) is also the marketable product, and
3. some outputs are nonmarketable (e.g., air, water, recreation).

Project analysis includes the following three steps:

1. gather information,
2. define framework for the analysis, and
3. perform an analysis.

Completing these steps will not make the decision for us. Only the decision maker can do that based on all of the information produced. Investment decisions are seldom based on just one factor and often depend on various elements that are not quantitative or even purely economic. Some of these other elements might include personal experience or the experience of others, personal objectives and values, and projections or intuitive feelings about the future.

Project analysis, nevertheless, provides a framework within which all aspects of the proposed project can be evaluated in a coordinated, systematic way. Done carefully, such an analysis identifies unrealistic or questionable assumptions and methods so a project can be modified to make it more attractive. Analysis of the sensitivity of decision criteria

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[1]*Some materials were adapted from class notes prepared by Dr. Hans Gregersen, College of Forestry, University of Minnesota, St. Paul, MN.*

to changes in project inputs and outputs often points to the need to collect more information, especially for factors identified as critical. Project analysis, thus, becomes a dynamic process of evaluation and reevaluation.

USE OF ECONOMICS IN DESIGNING AND APPRAISING PROJECTS

Economics can be applied to major programs and policies to interpret various broad implications in terms of costs and benefits derived. The following discussions concentrate on specific "projects". Broadly defined, a *project consists of inputs, outputs, and the transformation or process function that converts inputs into outputs*. An example of a project is the liquidation of a forest stand through a timber harvest.

INPUTS --->	TRANSFORMATION-> FUNCTION	OUTPUTS
Standing trees, labor, machines, and materials	Harvest and related activities	Harvested logs

Identifying and enumerating project analysis inputs and the required transformation function generally do not result in conceptual problems. *Outputs*, however, *need to be specifically defined in terms of goods and/or services that have some human use and value*.

As an example of how to properly define project economic outputs, consider the following two potential outputs for an erosion control project:

1. prevent tons of soil loss, and
2. avoid dredging cost or increase cropland productivity.

The first possible output from this project, tons of soil loss prevented, is an inadequate measure for economic analysis because it is not associated with any particular measurable human value. In contrast, dredging cost avoided or increased cropland productivity both have human use and value and, therefore, are possible measurable outputs that may be incorporated into the analysis.

If people do not want or need the output of a project, the value of the output is zero in economic terms. Regardless of how efficiently this output may be produced in technical terms, it is an inefficient use of resources in economic terms if the output has no human use or value.

Economics can be used in both *designing alternative projects* and in *appraising or evaluating a project design*. In the former case, the concern is with the appropriate *technology, size, timing, and/or location* for a project. In the latter case, the concern is with the *measures of worth* for a project design.

The difference between designing alternative projects and evaluating projects can be shown through a plantation project. In terms of designing alternative projects, we can ask: "What are the best species and rotation length and what is the best management intensity level for a given site?" When evaluating or appraising the project design, we can ask: "Given the best design for the site, how do total benefits and costs involved compare with each other? Do benefits exceed costs and if so, by how much?"

Obviously, the two types of analyses are related to each other. In many cases, the appraisal question is answered in the process of analyzing the best alternative. "Best" here is defined strictly in economic terms, i.e., the alternative with the greatest difference between benefits and costs. Many other criteria can be used to select and define "best", e.g., political, social, environmental criteria. For example, the erosion control project may be implemented strictly because of environmental benefits. The results of a project analysis provide only one input into the total decision making process.

Basic Economic Efficiency Conditions

Economic efficiency analysis can be defined as a comparison of the values of resource inputs (costs) required for a possible course of action or management alternative with the values of resource outputs (benefits) resulting from such action. In this type of analysis, *incremental* (i.e., additional) market and nonmarket benefits are compared with incremental investment and physical resource inputs.

In terms of economic analysis, it is essential to break down costs and benefits into components (analytical units) and consider them separately in the analysis. An example of how analytical units should be separated is shown in the following plantation fertilization project:

Benefits	$1,200
Costs	$1,100
Net benefits	$ 100

Benefits exceed costs so at first glance this project appears to be an acceptable use of resources. However, fertilization is a separable unit, i.e., we could analyze the plantation with or without fertilization. Breaking out the fertilization, we have the following:

Fertilization component:

Costs of fertilization	$300
Benefits due to fertilization	$200
Net cost of fertilization	$100

This indicates that the fertilization component is not an efficient use of resources. If we invest in the plantation without fertilization, we would have:

Plantation without fertilization:

Benefits	$1,000
Costs	$ 800
Net benefits	$ 200

By eliminating the fertilization component, we increase our net benefits to $200. Clearly, separable units should be isolated and analyzed individually.

To carry the above plantation fertilization example further, suppose that by changing technology (e.g., by using containerized seedlings rather than bare root planting stock) we could reduce the planting cost by $100. Now our net benefits would be $300 rather than $200. We have further increased the overall economic efficiency of the operation.

The previous examples illustrate the three basic conditions that must be met in order for a project to represent an economically efficient use of resources.

1. total benefits must exceed total costs for the project when all cash flows have been appropriately adjusted to take their timing into account,
2. each separable component of the project must have benefits at least equal to costs when all cash flows have been appropriately adjusted to take their timing into account, and
3. no lower cost means of achieving the same project benefits must be known.

Financial Versus Social Economic Analysis

The above discussions used the term "economic" analysis in a generic rather than a specific sense. In fact, we can distinguish between two major types of economic analyses. One type of analysis is the *financial analysis*, the other is the social *economic efficiency analysis*.

The term "financial analysis" is used to describe the type of analysis that develops an estimate of commercial profitability for a project. A financial analysis is carried out from the point of view of specific entities (decision makers such as corporations or individuals) involved in a project. It considers the monetary returns expected by such entities when investing their funds (resources) in a project. A financial analysis also provides information on when funds will be required (outflows or inputs) and when receipts (inflows or outputs) can be expected. Because all of this information is essential for budget planning, financial analyses are also relevant for public projects.

In a sense, an "economic efficiency analysis" is merely an extension of the financial analysis. This type of analysis is carried out from the point of view of society as an undifferentiated whole rather than from the point of view of a specific entity (or entities) within the society. The economic efficiency analysis is also concerned with "profitability", but in this case it is the profitability from society's point of view. This is called "economic profitability" to distinguish it from the "commercial profitability" evaluated in a financial analysis.

Just as the concept of economic profitability parallels the concept of commercial profitability, so the economic efficiency analysis parallels the financial analysis in terms of procedure. However, what is included as costs and benefits and how costs and benefits are identified and valued differ between the two types of analyses.

In a financial analysis, benefits are defined in terms of actual monetary returns to a specific entity (i.e., a specific company or landowner). These returns result from the sale or rental of goods and services in a market; thus, returns are measured in terms of market prices. Financial analysis costs are represented by outflows of money from the entity for goods and services that can be purchased in the market.

In an economic efficiency analysis, the concern is with what society gives up and gains from a project. Thus, costs are defined in terms of the value of opportunities foregone by society because resources are used in the specified project rather than in their best alternative use (alternative project). Costs in an economic efficiency analysis are referred to as "opportunity costs". Project benefits are defined in terms of the increased amounts of goods and services available to society due to the project.

Although the same basic *principles* apply to both financial analyses and social economic efficiency analyses, the two types of analyses have some important distinctions that are beyond the scope of this report. This report will emphasize major aspects of financial analyses only. For further information on social economic efficiency analysis see Gregersen and Contreras (1979).

FINANCIAL ANALYSIS OF PROJECTS

General

Several points should be reiterated before getting into the mechanics of a financial analysis:

1. A financial analysis is carried out from a particular point of view, namely that of the entity that will be carrying out and/or financing the project. Outlays of money by *that* entity are "costs" and receipts of money by *that* entity are "returns". The entity can be public or private.
2. The basic objective of a financial analysis is to compare the relation between expected costs and returns for the project being analyzed.
3. A project can be considered a financially efficient use of funds if the following three conditions are met:

   a. Total returns exceed the total costs when both are appropriately adjusted to take their timing into account. The question of timing will be addressed below.
   b. Each separable component of a project has returns at least equal to costs when both are adjusted to take timing into account.
   c. No lower cost way is known for achieving the same project objective.
4. When a project represents a financially efficient use of resources, it does *not* always mean that the project will be undertaken. The decision will depend on the analyses performed for alternative projects being considered and a host of nonfinancial considerations (environmental impacts, social objectives, national economic objectives, tax considerations, etc.).

Basic Steps in Project Analysis

Every project involves a schedule of events or activities. Some activities incur costs while others result in revenues received by the investor. Financial analysis requires these four steps (Davis and Johnson 1987):

1. decide on the length of time the project activities will be evaluated,
2. identify the schedule of activities associated with the project,
3. convert the activities to their equivalent schedule of dollar-measured costs and revenues, and
4. adjust the costs and revenues using appropriate interest rate formulas.

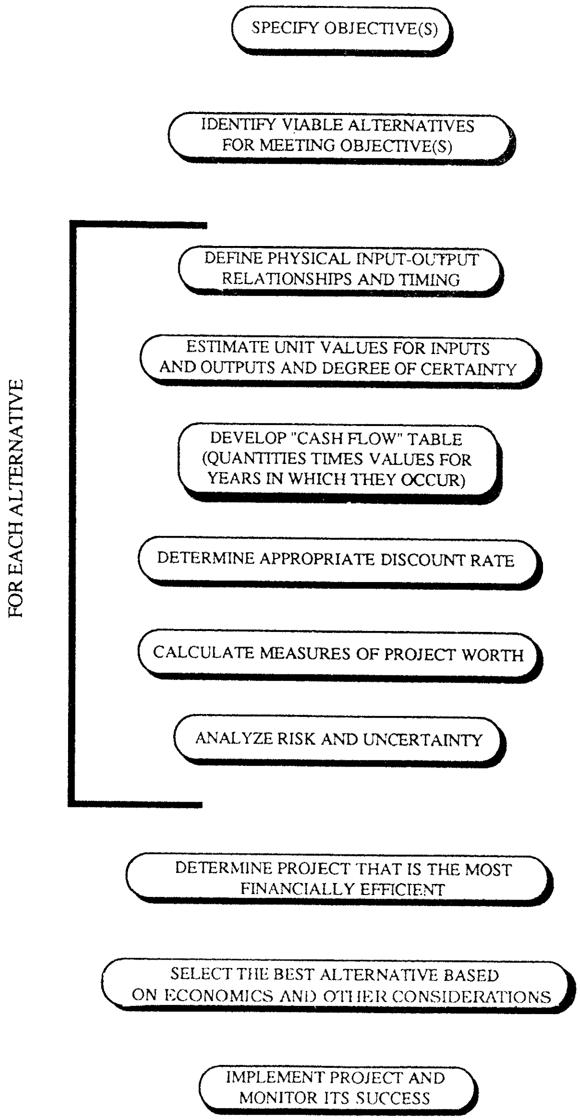

Figure 1.—*Flow diagram for the general approach to evaluate an investment opportunity.*

Several steps should be conducted sequentially when evaluating any type of investment project (fig. 1). These various steps are further discussed below.

Specify Objectives

It is fruitless to define management alternatives or alternative projects without specifying management objectives. Objectives are as numerous as decision makers. One potential objective might be to maximize returns from planting, thinning, and clearcutting a stand within an 85-year rotation. A different objective might be to maximize financial returns within a rotation that is no longer than 12 years. In any application, however, the objectives should be made explicit in order to clearly establish the link between objectives and alternatives that could meet these objectives.

Identify Alternative Projects

One of the most important activities involved in project analysis is the act of conceiving, creating, discovering, and developing all of the possible courses of action that the situation demands. Many alternative methods could be followed to accomplish any objective. A good example is evaluating how a potential plantation should be established, thinned, and harvested. Even with a restricted number of choices, billions of possible alternative courses of action could be used. Because it is impractical to evaluate such large numbers of projects individually, it is important to narrow down the list of alternatives to a manageable few. However, no simple rules can be used to accomplish this task.

One factor to consider when narrowing down the list of potential alternatives is the status of the current situation. For example, when evaluating the management options for a 400-acre tract of sedge-peat bog, there would be no reason to consider establishing a red pine plantation. The problem that is usually faced is to identify the viable alternatives available, given the current circumstances. Some of the aspects that must be considered for each alternative include:

Technical—	equipment, species, etc.
Economic—	relation between benefits and costs for alternatives; social point of view
Commercial—	procurement of inputs; product marketing
Financial—	working capital; financial obligations involved
Managerial—	staffing arrangements
Organizational—	administrative structure (e.g., level of autonomy, flexibility)
Legal/ethical—	consistent with accepted standards and expectations.

All aspects involve considerations of risk and uncertainty, contingencies, timing, constraints, etc. A good imagination, based on knowledge of the current situation, and a willingness to explore a wide range of alternatives is essential to identify and define management opportunities. However, often times little data are available to predict outcomes for alternative treatments. Many potential opportunities may be discarded even if they look promising because little or no information can be found regarding treatment response (i.e., outputs).

Define Physical Inputs and Outputs

Projects require the use and consumption of physical inputs such as plants, fertilizer, labor, machines, etc., and produce physical outputs such as wood, fodder, etc. The classical output functions are models describing the relation between inputs and outputs of scarce resources. Determining these production functions is one of the most important activities of economists. Production functions describe the efficiency with which a specific output can be produced as well as the impact of project size on productivity.

Economies of scale are important in evaluating projects. The scale of the project may influence its overall potential for success. For example, what is the impact on future markets of establishing 100 acres of intensively cultured, genetically improved aspen for harvesting as silage with special harvesting equipment? If only 100 acres are established, the entire project is likely to fail because it will not generate a supply of raw material large enough to support the special logging systems needed to harvest it. However, if 100,000 acres are established, the results could be different.

Costs of harvesting, planting, and other activities are often strongly affected by the scale of operation. Generally, larger operations realize economies of scale, up to a point. The principle of economies of scale refers to the decreases in long-run average costs that occur as the size (scale) of the project increases (Spencer 1974). Factors that give rise to economies of scale include: (1) greater specialization of resources, (2) more efficient utilization of equipment, and (3) reduced unit costs of inputs. Economies of scale must be considered in any project analysis because of its potential effect on incomes and costs.

Estimate Values for Inputs and Outputs

The private firm has market prices for its inputs and outputs. These prices might represent historical records or current prices. The main point is that goods and services can be bought in these markets at specified rates and that money (cash) flows are associated with project inputs and outputs.

The public firm may have a product (or a resource) for which no market price is available (e.g., recreation opportunities). One approach to this problem is to estimate the prices that people might be willing to pay for publicly provided products. This may result in various prices actually being used for the same kind of product. In some instances, the product could be marketed, but the market is not used for some reason. In this case, the decision maker estimates what the market price would be if a market existed. An example is recreational use of a public reservoir. Although fees could be charged and prices ascertained, this is not done. Instead, the decision maker estimates the market price with methods that involve deductions from other related market behavior.

Closely related to the question of pricing is the question of who pays for the product or resource produced by the public firm. A private firm may have a negative output such as polluted water, but it may ignore this output in the financial analysis if it does not have to pay to clean up the pollution.

At the same time that inputs and outputs are quantified, their timing needs to be determined as necessary input into a cash flow table. At this step, thought also needs to be given to quantifying the variability in each input or output estimate to facilitate later sensitivity analyses.

Project interrelations need to be identified and dealt with appropriately. Each analysis requires that appropriate costs and revenues be incorporated. The types of interrelations that can exist include:

1. horizontal interrelations, i.e., interrelations between components at the same level in the production process (e.g., increases in site preparation costs might reduce planting costs),
2. vertical interrelations, i.e., interrelations between project components at different levels in the production process—the output from one level is an input into the next level (e.g., an increase in fertilizer input might increase fertilizer costs, timber yields, and harvest costs),
3. interrelations through time, i.e., the problem of identifying costs and benefits in a "time-slice" project, or a project that only involves one time segment of an on-going activity or program (e.g., draining a piece of land to improve its productivity could provide benefits past the life of a project being evaluated), and
4. interrelations between a given project and other activities that should be considered within the project scope if an economic analysis is to be carried out—this relates to the problems associated with identifying and valuing indirect effects (e.g., downstream pollution of a new paper plant).

When analyzing alternative investment projects, it is also important to be aware of interrelations *among* alternatives or with nonproject activities. A planting decision may also assume some series of future actions—a program of release, pruning, and thinning practices, for example, which in turn may be considered as individual investment alternatives. But an evaluation of release options, such as method and timing of release, in turn must assume certain planting and timber harvesting decisions. These alternatives are interrelated and dependent.

The definition of economic efficiency analysis includes the term "incremental" benefits and costs. This relates to a basic concept used in economics. It is called the "with and without" principle and can be explained briefly as follows: When analyzing any project, the analyst should be careful to identify the costs and benefits that will result with and without the project (i.e., what are the additional costs and/or benefits that will be derived through the project).

The following soil protection project provides an example of the with and without concept. A piece of land is currently eroding at a rapid rate, thereby reducing crop production. A soil conservation project has been proposed to stop the erosion and restore the land to a higher level of fertility (line AD in fig. 2).

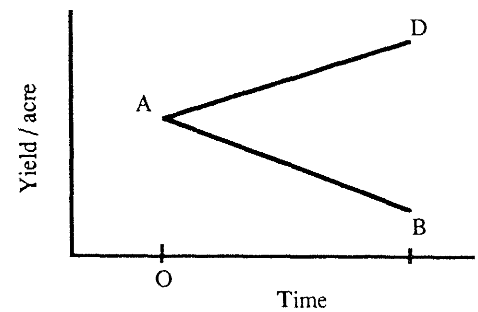

Figure 2.—*Benefits derived from implementing a soil conservation project. A is the current productivity, B is the decreased productivity due to soil erosion, and D is the productivity expected after implementing a conservation project.*

Without the project, soil fertility is declining along the line AB, i.e., the benefits or returns of this project are described by the area of the triangle AOB. The additional benefits of the erosion control project would be the area ABD (the polygon AOBD minus the triangle AOB).

The with and without principle also applies to questions of separable project components. An earlier example was the plantation project that was analyzed both with and without the fertilization component to determine the profitability of this amelioration.

Develop a Cash Flow Table

When establishing the project cash flows, the analyst must clearly state when the project activities will occur (i.e., whether activities are carried out at the beginning or end of the specified years (periods)). All cash flows are then discounted back to the point of the first period in the analysis. In all cases, cash flows should be expressed in base year monetary units.

The first (initial) investment period for an alternative where all activities occur at the *end* of the period is "0" to indicate that this activity will not be discounted. The end of period 0 is also the point to which all costs and revenues are then discounted under this convention. For those analyses where all activities occur at the *beginning* of the specified periods, the initial investment period is designated as "1," and all cash flows are then discounted back to this point. The difference in cash flow timing between these two conventions is shown in figure 3.

Convention	Appropriate Period Indicator	Activity takes place at
1	0 1 2 3 4 5 6 ...n-1	end of period
2	1 2 3 4 5 6 7 ...n	at beginning of period

Figure 3.—*Comparison of conventions for indicating occurrence of cash flow activities.*

To describe an activity that takes place at the end of year 15 in convention 1, "15" would be used to indicate the year of occurrence. Under convention 2, "16" would be used (i.e., the beginning of year 16 which naturally is the same as the end of year 15) to indicate the year of occurrence. For discounting purposes, in both cases one would discount back 15 discount periods. When applied consistently throughout a specific project evaluation, both conventions will lead to identical analytical results. The analyst should clearly state when activities will occur within a specified year. For all examples in this paper we use convention 2, activities occur at the beginning of each period.

When evaluating alternatives, frequently it is easier to begin with a list of activities and a picture of what is actually happening. Suppose that we own 25 acres of forest land and are contemplating the 60-year hypothetical project (Alternative 1) outlined in table 1.

Cash flow tables may be used to graphically illustrate the timing of the cash flows (table 2).

One of the questions that frequently arises when analyzing forestry projects is how to treat initial cash flows generated from harvesting an existing stand where a plantation project is to be considered. Should the positive cash flow generated from the harvesting done to clear a site before establishing a Christmas tree plantation be added to the plantation project or should that cash flow be ignored? Obviously, including an early positive cash flow will make the plantation project more attractive financially, and might lead to the conclusion that the plantation project should be undertaken. What if the plantation project without the initial harvest of old-growth appears financially unattractive (i.e., the with and without principle)? To resolve these two conflicting recommendations, we need to explore what causes these apparently different conclusions concerning the desirability of the investment.

The answer to this dilemma can be found in the discussion on separable components. The initial harvest has nothing to do with the plantation investment and can be separated from it. Therefore, it is not appropriate to include the initial harvest cash

Table 1.--Cost and revenue activities for a hypothetical investment example (Alternative 1)

Activity	Year[1]	Cash flow[2] ($/acre)
Site preparation	1	-50
Planting	1	-100
Weed control	1-2	-15
Precommercial thinning	16	-50
Administration[3]	1-60	-5
Thin	41	500
Thin	51	1,500
Clearcut	61	2,500

[1] All activities occur at the beginning of the indicated year.

[2] Cash flow in Year 1 dollars. All costs are indicated with a minus (-) sign.

[3] Any administrative cash flow in year 61 is included in the next rotation.

Table 2.--Cash flow table for the hypothetical investment example[1]

Activity[2]	Year 1	2	3	4	5	16	41	51	60	61
	($/acre)									
Administration[3]	-5	-5	-5	-5	. . .	. . .	. . .	. . .	-5	
Site preparation	-50									
Planting	-100									
Weed control	-15	-15								
Precommercial thinning						-50				
Thin at age 40							500			
Thin at age 50								1,500		
Clearcut at rotation age 60										2,500

[1] All costs are indicated with a minus (-) sign.
[2] All activities occur at the beginning of the indicated year.
[3] Any administrative cash flow in year 61 is included in the next rotation.

flow prior to establishing a new stand to analyze a plantation alternative for that stand.

Assess degree of confidence in input and output estimates.—As was noted earlier, the degree of certainty or uncertainty associated with each cash flow should be stated before performing the analysis (fig. 1). This step is important for the portion of the analysis called sensitivity analysis. Table 3 illustrates how the information might look for our hypothetical example.

The ranges indicate that revenues from a clearcut, for example, might be 25 percent lower or 25 percent higher than our current best estimate. As a matter of fact, all values between −25 and +25 percent will be equally likely (uniform distribution). Other ways to state the degree of confidence or uncertainty of a cash flow activity is to describe the distributional characteristics of the estimate or state the parameters of the distribution. An example of this latter procedure would be to assume a normal distribution around the stated mean (best estimate) with an assumed variance. The expected range could also be expressed in absolute terms.

Time value of money.—Financial evaluations can use either of two approaches—those that recognize the time value of money and those that do not. The "time value of money" reflects the notion that a dollar today is worth more than the same dollar 10 years from now. When we receive a dollar today, we can use it immediately. When we get a promise instead

Table 3.--Degree of uncertainty of costs and revenues for a hypothetical investment example

Activity	Best estimate ($/acre)	Expected range (percent) (Below	Above)	Degree of uncertainty
Site preparation	-50	- 5	+ 5	low
Planting	-100	- 5	+ 5	low
Weed control	-15	- 5	+ 5	low
Precommercial thinning	-50	-10	+25	high
Administration	-5	- 5	+15	medium
Thin at age 40	500	-10	+20	medium
Thin at age 50	1,500	-20	+10	medium
Clearcut	2,500	-25	+25	high

of the money, we must wait. What happens if the loaner changes his/her mind, dies, or inflation continues at the current rate?

Obviously, due to the uncertainty involved, the dollar received is worth more than the promised dollar. Evaluation methods that do not recognize money's time value assume that future dollars are equally as valuable as current dollars. The timing of a project's monetary transactions is not important in analyses that do not incorporate the time value of money.

To explain the rate of interest or time value of money concepts, we need to go to the *theory of capital*. This theory has the purchase and use of durable plants, equipment, and other related inputs as its subject. Commodity prices are not simply explained by the amount of physical labor needed to produce them, e.g., two items with the same input of labor may not cost the same.

Measuring capital involves two variables, quantity and time. The cost of keeping money immobilized in a project is indicated by the interest or discount rate. Generally, a project that needs a large quantity of immobilized capital to be implemented will require a higher rate. Time is a crucial requisite of production. Time can also be considered an input like labor and materials. Time costs money just like other inputs, and the price of time is usually measured by the interest rate. Generally, projects with a longer life or immobilization period require higher discount rates.

Because financial analyses in forestry often evaluate alternatives that span several years, time and interest can have a large impact. The effects are particularly important when major differences exist in cash flow timing between competing investments [i.e., forestry (periodic revenues) vs. agriculture (annual revenues)]. Although more accurate, the tools that account for money's time value are more difficult to use because they require:

1. cash flow projections, and
2. a knowledge of the mechanics for adjusting the value of money (i.e., the mathematics of finance).

Most investors know that money generally can be made by lending money. Individuals, governments, and businesses are willing to pay for the use of money. Loan agreements usually call for the return of the principal (initial investment) plus some interest, depending on how long the principal is used. The process of an investment growing at a specified interest rate is called *compounding*. One hundred dollars invested at 5 percent for 5 years yields $127.63 at the end of the investment period when interest is compounded annually. This may be determined by first multiplying $100 by 1.05 in year one (see table 4).

At the end of year two, the initial investment has been compounded twice and so on up to five compounding periods in year five. The tedious task of making these repeated multiplications can be simplified by using the formula:

$$V_n = V_o\,(1+i)^n \qquad (1)$$

where: V_n = value at the end of the investment period,
V_o = value in period 0 (i.e., the beginning of the investment),
i = interest rate per period, and
n = number of periods.

This formula as applied to the above example would be:

$$V_5 = \$100(1.00 + 0.05)^5 = \$100(1.05)^5 = \$127.63$$

Note that the analysis in this example was conducted for a 1-year evaluation period (table 5). Analyses can also be conducted biannually, quarterly, monthly, etc., by adjusting the interest rate for the

Table 4.--Example of compounding $100 at 5 percent at the end of each year for 5 years

Year	Amount at beginning of year (Dollars)		Interest rate (Percent)		Interest earned		Amount at beginning of year		Amount at end of year
					- - - - - - - -		- (Dollars) -		- - - - - - - -
1	$100.00	x	5	=	$5.00	+	$100.00	=	$105.00
2	105.00	x	5	=	5.25	+	105.00	=	110.25
3	110.25	x	5	=	5.51	+	110.25	=	115.76
4	115.76	x	5	=	5.79	+	115.76	=	121.55
5	121.55	x	5	=	6.08	+	121.55	=	127.63

Table 5.--Net present value for the hypothetical investment example (Alternative 1) assuming a 5 percent discount rate[1]

Activity	Discounting formula	Present value ($/acre)
Site preparation	-\$50	-50.00
Planting	-\$100	-100.00
Weed control	-\$15 + (- \$15/1.05)	-29.29
Precommercial thinning	$-\$50 \frac{1}{(1.05)^{15}}$ (see Eq. 2)	-24.05
Administration	$\$5 \frac{(1.05)^{59} - 1}{0.05(1.05)^{59}} + \$5$ (see Eq. 5)	-99.38
Total present value of costs		-302.72
Thin at age 40	$\$500 \frac{1}{(1.05)^{40}}$ (see Eq. 2)	71.02
Thin at age 50	$\$1,500 \frac{1}{(1.05)^{50}}$ (see Eq. 2)	130.81
Clearcut	$\$2,500 \frac{1}{(1.05)^{60}}$ (see Eq. 2)	133.84
Total present value of revenues		355.67
Net present value		+ 32.95

[1] All cash flows occur at the beginning of the year.

appropriate period. As an example, if the 5 percent annual rate were compounded quarterly, the appropriate compound rate per period would be determined by dividing the annual rate (5 percent) by the number of compounding periods per year (4) to yield 1.25 percent per quarter (compounding period). This quarterly compounding would lead to an *effective annual rate* of 5.1 percent (1.0125^4). The original 5 percent rate in this case is called the *nominal annual rate*. Various tables have been developed to provide multipliers for specified interest rates (Lundgren 1971, USDA Forest Service 1966).

Another basic financial operation, discounting, is the reverse of compounding. Remember that compounding began with a present amount and grew it into a future amount. Discounting does the opposite. It begins with a future amount and finds its worth today. The basic formula for discounting is:

$$V_o = V_n/(1+i)^n \quad (2)$$

In the above example, today's value of a payment of \$127.63 received in year five with a discount rate of 5 percent would be:

$$V_O = \$127.63/(1.05)^5 = \$100$$

Although costs and revenues may occur throughout the year, frequently it is assumed that these transactions occur at either the beginning or the end of the year to simplify calculations. Formulas 1-4 assume that the cash flow transactions occur at the end of the period. Care must be taken to properly count the number of discounting periods.

An infinite series of periodic payments in the amount a has a present value of:

$$V_0 = a/i \quad (3)$$

where: a = a periodically recurring cost or revenue incurred at the *end* of each period.

A uniform series of costs or revenues that begins in the first period can be discounted to the present using the formula:

$$V_O = a \frac{(1+i)^n - 1}{i(1+i)^n} \quad (4)$$

where: a = a periodically recurring cost or revenue incurred at the *end* of each period.

If the uniform series of payments occurs at the *beginning* of each year (period), with the first occurrence in period 1, equation 3 needs to be modified to:

$$V_O = a \frac{(1+i)^{n-1} - 1}{i(1+i)^{n-1}} + a \quad (5)$$

For example, a rent of $5/acre paid at the end of every year for 10 years would be worth $38.61 in today's dollars if the discount rate were 5 percent or:

$$V_O = \$5 \frac{(1.05)^{10} - 1}{0.05(1.05)^{10}} = \$38.61.$$

The same payments for 10 years paid at the beginning of each year would be:

$$V_O = \$5 \frac{(1.05)^{9} - 1}{0.05(1.05)^{9}} + \$5 = \$40.54.$$

Discounting $40.54 by 5 percent, yielding $38.61, is the same as delaying the annual payments by 1 year.

Selecting the appropriate discount rate.—The discount or compounding rate used in formulas (1) to (5) is the *alternative rate of return* (ARR) or *minimum acceptable rate of return* (MARR) established by the decision maker. MARR is a device designed to make the best possible use of a limited resource, money. Generally, the lower bound for MARR should be the cost of capital, which is derived from the capital available to the decision maker.

The MARR is peculiar to each firm and differs from case to case and from time to time. In setting the MARR, allowances should be made for any differences in risk and other influences such as time, scale, and income taxes. The actual rate of return expected from an investment is normally greater than the cost of capital. How much greater depends on the amount of risk involved. Riskier projects are subject to higher discount rates to compensate for the chance that they will not meet net return expectations.

Because interest represents the cost for the use of capital, this cost could be represented as: (a) the *borrowing rate*, or (b) the *opportunity cost* or opportunity forgone when capital is put into its next best alternative. The rate of time preference or rate at which individuals subjectively discount future versus current consumption is greatly influenced by income levels.

You may be wondering why we used a 5 percent discount rate in our example (table 4) when it may be possible to receive 6 percent or a higher rate of return by investing available capital in a bank or other financial institution. The reason brings us to an important difference. The 6 percent and higher rates are called *market* or *nominal rates* because they reflect both a real rate plus inflation. The 5 percent rate does not include inflation and is called a *real rate*. Use of nominal rates requires that both costs and returns reflect inflation.

A nominal discount rate is calculated by incorporating both a real rate and a general inflation rate using the following formula:

$$NR = [(1 + RR)*(1 + GI)] - 1. \quad (6)$$

where: NR = nominal rate per period,
RR = real rate per period, and
GI = general inflation rate per period.

This formula can also be manipulated to calculate a real rate when both nominal and general inflation rates are known:

$$RR = [(1 + NR)/(1 + GI)] - 1. \quad (7)$$

When calculating a nominal rate, given a 5 percent real rate and a 2 percent general inflation rate, Equation 6 becomes:

$$NR = [(1 + 0.05)*(1 + 0.02)] - 1 = 0.071 \text{ or } 7.1 \text{ percent.}$$

Economists generally use real discount rates when evaluating alternatives because analyses whose results are based on nominal rates reflect both real project return plus return due to inflation. Sorting out the two types of returns when interpreting the results can be tricky. Because good financial analysis is hard enough without trying to project future inflation rates for the economy, the real analysis gives a clearer picture of the project's true status. Decision makers should compare analyses based on several appropriate real discount rates.

Calculate Measures of Project Worth

We already are aware of the concept of time value of money. This financial principle may be used to generate one profitability criterion, the *Net Present*

Value (NPV). Another name for NPV is Present Net Worth (PNW). NPV recognizes money's time value by using the MARR to discount all costs and returns back to project initiation (period 0 or period 1, depending upon the convention assumed for cash flow timing) and then subtracting the discounted cost from the discounted income. That is:

$$NPV = V_1 \text{ (revenues} - V_1 \text{ (costs)}. \quad (8)$$

NPV = Present worth (revenues) − Present worth (costs).

The hypothetical cash flow (table 1) shows that several costs must be discounted back to period 1 (e.g., administrative costs (each for the proper number of years) and precommercial thinning costs for 15 years). Similarly, thinning incomes must be discounted for 40 and 50 years and the final harvest for 60 years. All cash flows are discounted at the decision maker's minimum acceptable rate of return, 5 percent. NPV's are calculated by first discounting all costs and returns back to the initial investment period at the decision maker's MARR and then subtracting discounted costs from discounted returns. Doing this for our sample project yields an NPV of $32.95/acre (table 5)—the minimum acceptable rate of return (5 percent) plus a present value sum of $32.95 per acre.

To tell exactly how much more (or less) than the discount rate our project is earning, we must calculate its expected rate of return. Then the rate of return can be compared with the project's discount rate (i.e., the MARR). The *Internal Rate of Return* (IRR), another technique that accounts for money's time value, shows the investment's actual rate of return. The IRR is the discount rate when the present value (PV) of discounted costs equals the PV of revenues or when NPV equals zero. That is, IRR finds the discount rate where: PV (revenues) = PV (costs) or NPV = 0. IRR generally is calculated using an iterative process to solve for the appropriate discount rate.

One advantage of IRR is that it can be calculated without the investor having to specify an appropriate discount rate, but one disadvantage is that multiple interest rate solutions are possible, all of which will equate the present value of costs and revenues. The number of IRRs for any one investment is a function of the number of times the periodic cumulative net cash flow (the algebraic sum of costs and revenues within one period) changes sign from negative to positive (or vice versa) (Riggs and West 1986). That is, the number of feasible IRRs is equal to the number of cumulative cash flow sign switches. If multiple internal rates of return are calculated, it is not easy to select the correct one to represent the project. When multiple IRRs are calculated, it is sometimes useful to calculate a table of NPVs at various discount rates to help determine the most appropriate rate. Most forestry projects have only one sign change (costs early and revenues later) so the multiple interest rate solution normally is not a problem.

As an example of an investment that has multiple rates of return, consider the following (Gansner and Larsen 1969).

Year	Cash flow	Cumulative cash flow
	------ $ ------	
1990	− 25.00	− 25.00
2000	112.25	87.50
2010	−165.96	−78.71
2020	80.78	2.07

Because this investment has three sign switches for cumulative cash flow, calculating internal rate of return yields multiple values. In fact, present value is zero at discounting rates of approximately 2, 4, and 6 percent.

The NPV for the cash flow example in table 5 would result in −$79.84 for a 6 percent discount rate. Therefore, the IRR must lie between 5 percent (NPV = $32.95) and 6 percent (NPV = −$79.84). By iterating between these two values, the IRR is calculated to be 5.23 percent (i.e., all costs and benefits, discounted by this percentage, would make NPV equal to zero).

A project with the IRR smaller than the MARR is less profitable than we are willing to accept and the profit from a project with the IRR greater than the MARR would exceed our minimum requirements. Obviously, we will prefer projects whose IRRs exceed the MARR. For this example, the IRR of 5.23 percent exceeds the MARR of 5 percent so the investment appears to be attractive. This conclusion, as we will see later, might not be justified in view of the amount of uncertainty associated with the project's cash flows.

The NPV and IRR are the two most widely used and accepted decision criteria. A major advantage of the IRR is that the answer provided is an interest rate. Many investors, particularly nonindustrial private landowners, are most comfortable with rate of return (IRR) information (Bullard *et al.* 1986).

Other measures of project performance include:

1. *Equivalent annual income (EAI) or equal annual equivalent.* This is the net present value converted to an annual value paid at the *end of each year (period)* for the life of the investment with interest

calculated at the appropriate discount rate. EAI is calculated using the formula:

$$EAI = NPV \frac{i(1+i)^n}{(1+i)^n - 1} \qquad (9)$$

This is the inverse of the formula for discounting annually recurring costs or revenues (Eq. 3) (i.e., EAI takes the place of "a" and NPV takes the place of V_0). In our example it would be:

$$EAI = \$32.95 \frac{0.05(1.05)^{60}}{(1.05)^{60} - 1} = \$1.74$$

This indicates that the hypothetical project would return 5 percent plus an additional $1.74 per acre at the end of each year throughout the life of the investment (60 years).

2. *Soil expectation value (SEV).* This is the value of bare forest land, and is equivalent to the capitalized value of an infinitely long series of cash flows resulting from timber management. SEV represents the maximum amount that could be paid for a tract of land and still earn the required interest rate. It is useful for estimating the bid price of bare land for growing successive crops of even-aged timber. Because SEV is defined to be the value of bare forest land, forest management alternatives must incorporate all cash flows that occur during a complete forest management rotation beginning with initial site treatments. Land purchase costs and land sale returns must be removed from a cash flow stream before SEV is computed. SEV is equivalent to the net present value for an infinite time horizon.

SEV assumptions are (Bullard *et al.* 1986; Davis and Johnson 1987):

1. All tree growing costs within one rotation (such as management fees, administrative costs, and taxes) are included in the analysis.
2. The discount rate correctly reflects the context and outlook of the landowner.
3. The land will be forested in perpetuity. The prescription for future management of the land has been decided and the same prescription will be used for each future timber production cycle.
4. The land requires regeneration costs at the beginning of the rotation.

SEV is calculated using the formula:

$$SEV = \frac{R}{(1+i)^r - 1} \qquad (10)$$

where: R = net income from one rotation (r) in year r,
i = discount rate per period, and
r = rotation age.

Note that this formula differs from the general discounting formula (Eq. 2) only by the presence of the "−1" in the denominator. For our case, we calculate R by compounding NPV to age 60 (the rotation age), i.e.,

$$R = \$32.95(1.05)^{60} = \$615.48 \text{ and}$$
$$SEV = \$615.48/[(1.05)^{60} - 1] = \$34.82.$$

The first rotation contributes $32.95 to the soil expectation value and all future rotations contribute only $1.87 ($34.82 − $32.95). This is caused by the exponential increase of the expression $(1+i)^r$ with increasing values for r.

3. *Benefit/cost (B/C) ratio.* This is the present value of discounted revenues divided by the present value of discounted costs. Benefit/cost ratios are frequently used to evaluate public sector projects. Benefit/cost is calculated using the formula:

$$B/C = \frac{\text{Present value of revenues}}{\text{Present value of costs}} \qquad (11)$$

A calculated B/C value greater than 1.0 indicates that discounted benefits exceed costs. For our hypothetical example (table 1), we can calculate the B/C as 1.11 based on data from table 5:

$335.67/$302.72 = 1.11.

4. *Payback period.* This is the length of time needed to recover the investment's initial cost where a project's cumulative annual cash flow exceeds the initial investment. In its simplest form, this recovery period is based upon dollar flows that are not discounted. Cash flows are discounted in more sophisticated applications.

   By not discounting cash flows, the payback period may show a preference for an alternative that is inferior by a discounted cash flow comparison. In our case, using not-discounted costs and revenues, it could be shown that the cumulative net cash flow becomes positive in year 41 (after 40 discount periods). Investments with short payback periods are sometimes considered to have a lower risk because less uncertainty is involved with shorter investment periods.

A summary of the various project performance measures for the sample cash flow (table 1) is shown in table 6.

Table 6.--Financial summary for the hypothetical investment example (Alternative 1) assuming no inflation and a 5 percent discount rate

Net present value ($/acre)	$32.95
Equivalent annual income ($/acre)	$ 1.74
Soil expectation value ($/acre)	$34.82
Benefit/cost ratio	1.11
Time to payback (years)	60 years
Internal rate of return (percent)	5.23

Interpret the results of a cash flow analysis

After completing the mathematical computations, it is important that the calculated results be interpreted correctly. Discounting costs and revenues by 5 percent is the same as assuming that we are earning that rate in some other investment project (MARR). In this example, the project meets the MARR of 5 percent. In fact, NPV indicates that the project will yield a 5 percent return on investment plus $32.95/acre.

Other calculations indicate that the project would return the required 5 percent plus an additional $1.74 per acre at the *end* of each year throughout the 60-year rotation. The landowner could afford to pay $34.82 per acre for the tract to earn a 5 percent return on investment, assuming the land is used to grow timber according to the management schedule outlined. Discounted benefits exceed discounted costs by a ratio of 1.11 to 1.00. Cumulative net discounted cash flows will recover the initial project investment after 60 periods. A payback that occurs near the end of the project is typical for many forestry investments because that is when many of the returns are realized. Finally, a positive net present value will be calculated for all discount rates less than 5.23 percent. At a discount rate of 5.23 percent, discounted costs equal discounted revenues.

NPV serves as a guide for accepting or rejecting the project by representing earnings above and beyond the MARR. Positive NPVs reflect opportunities that return more than the MARR, while negative NPVs indicate projects that will return less than this rate. Depending on the size of the NPV, investments with a positive NPV are usually accepted and those with a negative NPV are usually rejected. The other measures of project performance that are directly related to NPV, such as SEV and EAI, would be interpreted similarly.

A natural symmetry exists between NPV, IRR, and B/C as shown below (i is the discount rate):

NPV		**IRR**		**B/C**
if > 0	then	$> i$	and	> 1
if < 0	then	$< i$	and	< 1
if $= 0$	then	$= i$	and	$= 1$.

Despite this symmetry, problems arise when comparing alternative projects. Different rankings or evaluations of our sample project can result depending on whether NPV, IRR, or B/C is used to make the selection. This brings up the important question on which criteria to use when assessing alternative projects.

Rank Alternative Projects

Feasible projects may be grouped into two classes: mutually exclusive projects and independent projects (Davis and Johnson 1987). In mutually exclusive projects only one of the feasible projects can be chosen. As an example, the regeneration and culture for a given stand can be handled in many ways but only one method can be implemented. The problem is to find the best one. Independent projects, by contrast, can be implemented simultaneously and two or more projects can be chosen out of a group. Building a forest road, buying a planting machine, and constructing a storage shed for fire control tools are examples of independent projects.

Relationship between NPV, IRR, and B/C.—In most cases, several alternatives can be specified and evaluated before any project is implemented. After analyzing the project according to the steps outlined in figure 1, the individual alternatives must be ranked and the most attractive one(s) selected and implemented. Investment criteria yield the same answer when used to answer the question, "Is this investment profitable?". However, project rankings with NPV and IRR do not always agree. Gittinger (1982) presents a good discussion of this topic.

IRR and B/C provide no measure of the magnitude of a project's net benefits. Therefore, it is possible that several projects selected by these criteria provide lower total net benefits (NPV) than another project ranked lower on the basis of IRR or B/C. For this reason NPV should always be a part of a ranking scheme for alternative projects.

A decision criterion can be selected only after the projects have been classified into one of several classes. When alternatives are mutually exclusive (i.e., implementing one alternative excludes the implementation of the other alternatives), differences between criteria can be significant, with different projects being favored when different ranking criteria are used. Gansner and Larsen (1969) used a simple example to illustrate the pitfalls of using the IRR to rank mutually exclusive investments. Assume that we have three investments with the following cash flows, each cash flow is known with certainty, and the investor's MARR is 4 percent:

	Year			
Investment	**1985**	**1995**	**2005**	**2015**
	$			
A	−25	29	58	88
B	−25	0	0	250
C	−25	42	42	42

All three of these investments would be worth undertaking because the NPVs would be approximately $48, $52, and $35, respectively, for investments A, B, and C. However, selecting the best investment depends on whether the NPV or IRR is used as the selection criterion.

The IRR's for investments A, B, and C are approximately 10, 8, and 10 percent, respectively. Therefore, the investor would be indifferent between alternatives A or C but prefer either one to alternative B. The best financial alternative, however, is clearly B because it yields the greatest NPV at the investors cost of capital. The problem of using the IRR for ranking in this case is that in deciding between mutually exclusive alternatives, the choice of the one with the highest IRR is not generally correct and the IRR will not rank investments consistently with their NPV's. B/C can have the same problem as IRR and should not be used for ranking mutually exclusive projects. For mutually exclusive alternatives, investments should be ranked by the NPV criterion (Copeland and Weston 1983). In fact, a decision between the alternatives cannot be made without knowing the appropriate discount rate.

For the unrealistic subcase of independent projects with no constraints on costs, each of the three measures, NPV, IRR, or B/C, can be used for selection because each measure distinguishes between efficient and inefficient use of resources. For the normal case of independent projects with constraints on costs, i.e., not all economically justifiable projects can be selected, only the B/C measure can give correct rankings for project selection. NPV does not work in this case because it does not indicate anything about returns per unit of the scarce factor. A correct selection implies that the projects selected will yield the largest total net present worth when the limiting factor—budget, land, etc.—is used up.

Capital and land are frequently limiting factors in timber management. Therefore, IRR alone is not an acceptable ranking criterion for either mutually exclusive or independent projects.

Compare projects with different time horizons.—To compare and choose among alternative projects, the discussion above about mutually exclusive or independent alternatives is important for selecting the proper ranking criterion. An additional complication arises when the alternatives do not cover the same investment period. *Neither NPV nor EAI can be used to directly compare projects with different investment periods.* The two basic philosophies for comparing NPV's from projects with different economic lives are:

1. disregard the future events and their consequences beyond some specified period, and
2. predict the future events (i.e., future rotation activities and cash flows) in order to predict equal lives or rotation lengths for both alternatives.

The first method is not recommended for analyzing forestry projects because revenues from forestry projects generally do not occur until the latter portion of the rotation. Projects with shorter natural rotation lengths generally will look more favorable if future events are disregarded.

The second method is known as the "least common-multiple method" because alternatives are compared by selecting an analysis period that spans a common multiple of the lives of the projects involved. For instance, if projects had lives of 2, 3, 4, and 6 years, the least common multiple would be 12 years. In this case, then, the 2-year project would be repeated 6 times during the analysis period, and the projects with 3-, 4-, and 6-year lives would be repeated 4, 3, and 2 times, respectively. The legitimate use of this method depends on the validity of the assumption that projects will be repeated with identical input and output characteristics. This assumption may not be valid where technological developments are expected to occur, markets vary, cash flows change between rotations, etc.

A special case of the common multiple method is the use of infinity as the "common multiple" as assumed when calculating soil expectation value (SEV). SEV is widely used and accepted as a criterion that allows an automatic comparison of forestry projects of any length where every alternative begins with bare land and includes all timber management cash flows that occur within one entire rotation. Land purchase costs and land sale returns must be removed from a cash flow stream before computing SEV. Fortunately, the increasing uncertainty is made less important because early cost and revenues contribute most to SEV, and the impact of events in the distant future become less and less important. Use of higher discount rates (MARR) also lessens the impact of future uncertainty. In that sense, disregarding events beyond some specified period (method 1) can provide similar answers if the cutoff point for the analyses are far enough into the future (i.e., more than 10 years) and all projects have cash flows similarly distributed throughout their rotation lengths. However, a 10-year cutoff period might not be appropriate for comparing a Christmas tree planting that has a 10-year rotation with an alternative that has a 60-year rotation.

As an example of comparing projects, assume that an alternative project (Alternative 2) to the one described in table 2 was to grow a genetically improved tree variety that would permit a rotation of 40 years to harvest the desired sawtimber. It would cost more to plant this improved stock due to higher plant material prices. However, weed control would be needed only during the first year, the first precommercial thinning would be in year 13, and the only commercial thinning would take place in year 31. The sequence of cash flows and management activities for this project alternative are shown in table 7.

The two investments are mutually exclusive. Therefore, NPV is an appropriate ranking criterion. On the basis of NPV, Alternative 2 looks a little more attractive (table 8). Alternative 2 has a shorter investment period than Alternative 1 however, so they can not be directly compared using NPV. They can be compared using the SEV criterion, though, because both alternatives began with bare land and all timber management cash flows that are to occur within one rotation are included in each analysis. Comparisons on the basis of SEV show that Alternative 2 is preferable. This conclusion is also supported by the shorter payback period for Alternative 2.

Table 7.--Cost and revenue activities for Alternative 2[2]

Activity	Year[1]	Cash flow[2] ($/acre)
Site preparation	1	-50
Planting	1	-125
Weed control	1	-15
Precommercial thinning	13	-50
Administration[3]	1-40	-5
Thin at age 30	31	525
Clearcut	41	1,550

[1] All activities occur at the beginning of the indicated year.

[2] Cash flow in year 1 dollars. All costs are indicated with a minus (-) sign.

[3] Any administrative cash flow in year 41 is included in the next rotation.

Table 8.--Financial summary for Alternatives 1 and 2, assuming no inflation and a 5 percent discount rate

	Alternative 1	Alternative 2
Net present value ($/acre)	$32.95	$33.72
Equivalent annual income ($/acre)	$ 1.78	$ 1.96
Soil expectation value ($/acre)	$34.82	$39.30
Benefit/cost ratio	1.11	1.11
Time to payback at discount (years)	60	40
Internal rate of return (percent)	5.23	5.34

Impact of Discount Rate on Investment

The discount rate used in the evaluation exerts a tremendous effect on the final analysis results. When our hypothetical analysis is reevaluated using various real rates, the results are different (table 9). The project's profitability can clearly change with the discount rate used.

Effect of Inflation on Evaluation of Forestry Projects

Forestry investments often have been sold short because of a failure to distinguish between real and current prices or a failure to uniformly take inflation into account (Gregersen 1975). "Real" means removing inflation from future costs and returns. Real prices are often discussed as "relative" prices, meaning relative to some price index (i.e., the rate of inflation in the economy). "Current prices" (or nominal) refer to the year in which the costs and returns occur and include inflation.

Nominal rates can certainly be used for an analysis. However, when these rates are used, all costs and returns must include inflation. It would be incorrect to increase project costs with inflation and not do the same with project revenues.

Table 9.--Net present value per acre for our hypothetical example using discount rates of 2, 4, 5, 6, and 8 percent

Discount rate (Percent)	Net present value ($/acre)
2	+$1,151.56
4	+ 228.04
5	+ 32.95
6	- 79.84
8	- 181.80

Long-term records show that stumpage prices have been increasing about 2 percent per year above and beyond the inflationary rise of other product prices. This means that whatever the average rise in product prices, stumpage increases have averaged an additional 2 percent. Building a 2 percent annual stumpage price increase into the hypothetical example at each of the two commercial thinnings and the final clearcut (table 1) yields a NPV of $645.31/acre (compared to $32.95/acre (table 5) without the 2 percent increase). The new IRR would be 7.65 percent. The effect of real price increases on the evaluation of the project is apparent. Historical records for real price increases for activities, therefore, may be used in the analysis where appropriate.

A conservative but realistic approach for making comparisons with other analyses using different assumptions would be to allow a 2 percent annual stumpage price increase in conjunction with a 5 percent inflation-free real discount rate and no inflationary cost increases. Both the 2 percent and the 5 percent figures have historical validity. Essentially, this amounts to ignoring inflation and increasing stumpage prices at the historical rate (2 percent above inflation). Disregarding inflation initially and including it later will change the results calculated for the project evaluation criteria. Applying inflation equally to costs and returns, however, would not change the final decision. Because even the best returns can be eaten up by unrealistic combinations of inflation, price increases, and interest rates, it is important that all assumptions be as realistic as possible.

An estimated real rate of return from an investment can not be compared with an alternative rate of return based on cash flows that incorporate inflation. Therefore, an analysis using real terms should not be compared with rates for passbook savings, money markets, certificates of deposit, etc., that include inflation.

Evaluate Risk and Uncertainty

The amount of risk or uncertainty associated with each project must be analyzed before comparing alternatives. The term "risk" is used when the probability of an events occurrence can be estimated. Uncertainty, on the other hand, is used when the probability of an events occurrence cannot be quantified. Risks and uncertainties are noninsurable losses such as physical damage, cost increases, or product price decreases that may occur.

Several general methods may be used to account for the risk or uncertainty associated with future project cash flows. Among these methods are:

1. *Finite Horizon Method*: any forecast for a period longer than n years is not considered. The shortcoming of this method is that our prediction, even for the immediate future, is uncertain. Therefore, why not predict for longer periods of time? This method tends to make forestry investments appear very unprofitable when project revenues are expected to occur in the future.
2. *Discounting for Risk*: add an appropriate percentage to the discount rate as an insurance premium (Guttenberg 1950). This is automatically done in the discounting process as more distant returns are multiplied by higher powers of the discount factor, thereby assigning a higher weight to the risk in the more future periods. Be aware of the exponential increase of $(1+i)^n$
3. *Probability Theory Approach*: use expected values in the analysis. For example, if the probability of a $100 return is 40 percent, a $200 return is 50 percent, and $300 return is 10 percent, the expected return is $170 ($100*0.4 + $200*0.5 +$300*0.1).
4. *Sensitivity Analysis*: test sensitivity of investment performance measures to changes in input values (costs and receipts). The inputs, which are the most uncertain and to which the investment performance measures show a high degree of sensitivity, need to be closely monitored and better information may need to be collected before making the final investment decision. This is usually the most appropriate procedure to use when analyzing the effect of uncertainty in project cash flows on investment performance.
5. *Monte Carlo Simulation*: estimates the probability of achieving a specific project result, e.g., NPV, given that all or some model inputs and outputs have probability distributions associated with them (Lothner *et al.* 1986). To generate the probability of achieving a specific result, it is necessary to recalculate the cash flow after drawing random observations from all distributions. Repeating this process several hundred or thousand times allows development of an empirical probability distribution for the desired project result. This procedure requires a computer program (Lothner *et al.* 1986).

Analyze Sensitivity

Sensitivity analysis is the most common approach to dealing with risk and uncertainty of project cash flow estimates. Sensitivity is analyzed to furnish information concerning the effect of a specified change in the amount (price) of each project activity on measures of project performance (i.e., NPV, EAI, and SEV). Activities that show the highest sensitivity should be further assessed to determine the accuracy with which they have been estimated. Another way to analyze risk and uncertainty is to show the amount and percent of change necessary for each cost and revenue variable to force NPV to $0.00, thereby just returning the MARR.

As stated above, the degree of confidence for every cash flow estimate in the analysis should be established before performing the analysis so the investment decision is not biased. Activities that the analyst considers to be risky or uncertain, either due to wide ranges or variability in amount, and those activities identified by the sensitivity analysis to be critical factors deserve further special attention.

As calculated above, Alternative 1 will return a present net worth of $32.95/acre (table 5). In addition, it yields favorable values for EAI, SEV, and benefit/cost ratio; it meets the payback criterion; and it will yield a positive present net value for all discount rates less than 5.23 percent. Despite the fact that the project appears favorable, it needs to be further assessed for its sensitivity to changes in cash flow estimates.

Would it be wise to hurriedly make such an investment and then to expect these returns? Probably not. In today's financial world, one month is a long time—let alone 60 years. Prices, costs, and interest rates fluctuate continually, which creates a great deal of uncertainty. Examining several different scenarios for these three factors reduces uncertainty by providing a more complete picture of what we might realistically expect. The decision maker's problem, then, is to identify the most realistic scenario.

The sensitivity analyses shown in tables 10 and 11 indicate how variances in project cash flows would influence the various project performance measures for the hypothetical project (Alternative 1) described in table 1. Table 10 details the sensitivity of NPV, EAI, and SEV to a 10-percent change in input value for each cash flow activity. Activities with the highest

Table 10.--Sensitivity analysis to a 10-percent change in cash flow for each activity in the hypothetical investment example (Alternative 1) assuming no inflation and a 5 percent discount rate

Activity changed	NPV change	EAI change	SEV change
	- - - - - - - - -	($/acre)	- - - - - - - - -
Site preparation	$ 5.00	$ 0.26	$ 5.28
Planting	10.00	.53	10.57
Weed control	2.93	.15	3.09
Precommercial thin	2.41	.13	2.54
Administration	9.94	.53	10.50
Thin at age 40	7.10	.38	7.50
Thin at age 50	13.08	.69	13.82
Clearcut	13.38	.71	14.14

calculated values will have the greatest impact on changing one of the investment criteria if errors are made in estimating cash flow. SEV sensitivity analysis data should not be used or interpreted for a project that does not begin with bare forest land and that does not include all cash flows for a complete management rotation. Table 11 shows the amount (percent) of change necessary to force NPV to $0.00. The calculations that need to be carried out for these sensitivity tables will not be detailed here because they are best left to an automated procedure. The reader should be comfortable with the understanding, however, that the numbers in tables 10 and 11 could be derived by repeating the above analyses after making the appropriate changes in the cost and revenue cash flow values.

The decision maker needs to attach the proper sign to the values in tables 10 and 11 to use the information for sensitivity analysis. Obviously, increases in costs and decreases in revenues would decrease NPV, EAI, and SEV and vice versa.

Sensitivity and risk analyses indicate that clearcutting revenue at age 60 is the most sensitive project activity (tables 10 and 11). If the projected revenue for this activity decreased by 10 percent to $2,250/acre (table 10), NPV would decrease by $13.38/acre, EAI by $0.71/acre, and SEV by $14.14/acre. If revenue for the clearcutting activity decreased by 24.62 percent (table 11) to $1,884.50/acre, NPV would equal exactly $0.00. Given this new clearcutting revenue and a NPV of $0.00, the project would yield a 5 percent

Table 11.--Risk analysis indicating the amount of change necessary for each activity to force NPV to $0.00 for the hypothetical investment example (Alternative 1) assuming no inflation and a 5 percent discount rate [1]

Activity changed	Percent change	Value change
	(Percent)	($/acre)
Site preparatrion	65.91	-$32.95
Planting	32.95	- 32.95
Weed control	100.00	- 29.29
Precommercial thin	100.00	- 24.05
Administration	33.16	- 32.95
Thin at age 40	-46.40	- 32.95
Thin at age 50	-25.19	- 32.95
Clearcut	-24.62	- 32.95

[1] When percent change equals 100 and dollar change is smaller than $32.95, the input variable will not alter the overall project selection, given the NPV decision criteria.

rate of return. It can also be seen that only the estimate for clearcutting revenue includes an expected range (25 percent) that would directly reduce NPV to zero (table 4). Combinations of changes in other individual factors, however, could easily produce a negative NPV. Sensitivity analysis information should be carefully interpreted before implementing any project.

The effect of a combination of changes in activity cash flows on project profitability can be determined once the impact of any change (percent or absolute) on NPV, EAI, and SEV have been calculated (an example is shown in table 4). This is possible because any change will result in a proportional impact on the project performance measures (i.e., a 5-percent change will result in exactly half the impacts shown in table 10, and a 30-percent change will have impacts three times larger than shown in table 10). Individual changes can also be summed to reflect changes in more than one cost or revenue activity (i.e., a 10-percent decrease in both planting and weed control costs would increase NPV by $15.00 ($5.00 + $10.00) =$15.00). A 15-percent increase in all costs combined with a 5-percent increase in all revenues would lead to the following change in NPV:

A 10-percent increase in all costs will decrease NPV by the sum of ($5.00 + $10.00 + $2.93 + $2.41 + $9.94) = $30.28. A 15-percent increase in all costs would decrease NPV by $45.42 (1.5*$30.28). A 5-percent increase in all revenues would increase NPV by 0.5($7.10 + $13.08 + $13.38) = $16.78. The combined impact of cost and revenue changes would be a reduction in NPV by $28.64 ($45.42 − $16.78). Therefore, the revised NPV resulting from a 15-percent increase in all costs and a 5-percent increase in revenues would be $4.31/acre ($32.95 − $28.64).

Similar calculations could be carried out to predict the impact of these and any other changes on EAI and SEV (table 11).

Analyze Breakeven and Cost-Price

Another common approach to dealing with uncertainty is to calculate the "breakeven" level or value for a given project activity. This means that for any activity we calculate the cash flow that will make the entire project yield a NPV of zero when the alternative rate of return is used to discount all cash flows. Looking at our example, we can generate this information from table 11. With a NPV of $32.95, an increase of 65.91 percent in site preparation costs would reduce NPV to zero. Therefore, the breakeven price for site preparation is $82.96 ($50.00*(1 + 0.6591), the cash flow that will cause the project to just return the alternative rate of return.

Implement and Monitor the Project

A project should be implemented only after the decision maker has identified all the alternatives, selected the important decision criteria, performed the necessary analyses, and carefully evaluated and compared the output reports generated. However, after having completed all of these steps, the decision maker must continually reassess the project to determine whether it should be continued or terminated.

As stated above, forestry projects generally are long-lived. One result of these long planning horizons is that projects often have low rates of return, compared to the levels of risk and uncertainty involved. In the future decision makers should be able to reduce this risk and uncertainty and appraise similar projects by systematically monitoring forestry projects.

The monitoring process involves collecting data and performing appropriate analyses. The project should be monitored both while it is being implemented (if necessary) and after it has been initiated because projects seldom are implemented exactly as indicated in the initial appraisal. It is very important to perform further analyses during the implementation and monitoring phases of a forestry project. Monitoring provides informtion that can be used to (Harou 1983):

1. judge whether the project should be terminated or changed,
2. improve future capital investment decisions and implementations,
3. propose and implement changes in the allocation process and timing of activities,
4. develop staff training programs aimed at reducing costs incurred in other projects while increasing benefits,
5. improve the total profitability of the project by continually adjusting and improving,
6. understand organization and managerial problems,
7. develop contingency plans, and
8. insure a smooth transition between the initial project appraisal and the implementation.

From the initial appraisal (table 2), a project's economic performance depends upon assumptions derived from past experience, information obtained from outside the firm, and forecasts that depend on the fluctuations in the economy. If vast differences from the initial appraisal are encountered either when the project is implemented or after it has begun, the project should be reassessed to reduce possible investment losses.

General principles of project monitoring can be applied to forestry projects. The project's physical inputs and outputs and their respective prices provide the information to generate the initial cash flow table (table 2). Future deviations in costs and revenues are measured against this standard. Some methods for monitoring projects are described by Harou and Massey (1982):

Recalculating NPV and IRR with adjusted cash flow estimates and including historical data and new forecasts that have become available is called a *Full Cost Analysis*. This analysis can tell the manager how near the projected NPV the project is performing. Performance of past projects provides information for appraising similar projects in the future.

In a *Marginal Cost Analysis* past costs and revenues are considered to be sunk (i.e., cash flows have already occurred but should not be incorporated into the analysis). Past costs and benefits are removed and only future cash flows are considered. For typical forestry projects, the revenues occur late in the project's life and costs occur early, thereby yielding potentially high NPV and IRR values according to this method. This revised NPV needs to be compared with other alternatives that exist now. This is done in the *Abandonment Test*, which compares the costs and benefits to be incurred in the future against today's Abandonment Value (AV) of the project. The Abandonment Value would be either the resale value of the liquidated assets or the value associated with investing these assets in another, more profitable project. If the Abandonment Value is higher than the revised NPV of the marginal cost anslysis, the project should be abandoned. The Abandonment Test considers only today's AV. Ideally, both Abandonment Values for today and for the future would be compared with the revised NPVs of future time periods.

The *Optimal Abandonment Test* (OAT) can be used to project whether abandonment in a later year may result in an even greater NPV. This OAT is similar to the Abandonment Test in that today's Abandonment Value and NPVs are calculated and compared. In addition, however, future Abandonment Values and NPVs for the length of the project are estimated and compared. The project is liquidated if the maximum NPV calculated for the length of the rotation is lower than the current Abandonment Value, AV_0. The OAT can be summarized as follows: (1) find the maximum NPV for the project today as well as for all other periods within the rotation length, (2) calculate the current Abandonment Value, and (3) liquidate if the maximum NPV for the project is lower than the current Abandonment Value.

Although the OAT is the most appropriate method to monitor a project, it requires a large amount of additional information (e.g., the abandonment and NPV values for all periods). This additional information adds substantially to the computational requirements.

The Abandonment Test is easy to perform and is a reasonable alternative to the OAT. In this test cash flow and NPV analyses are done annually throughout the life of the project using the most current information on costs, revenues, and inflation. The revised NPV is then compared with the Abandonment Value of the project (i.e., its current liquidation value). The liquidation value might consist of the sale of equipment and machinery, the harvest of all timber, etc. The project is continued only if the revised NPV is greater than the project's current Abandonment Value. We will illustrate how the Abandonment Test is performed for the initial cash flow example (table 2).

Assume that the project was implemented as described in table 2 and that we are currently at the beginning of year 41 of the project. Table 12 shows the actual and estimated cash flows at the beginning of year 41.

Note that all cost estimates except precommercial thinning turned out to be the same as originally estimated and that the return for the planned commercial thinnings (year 41 and 51) and the return for the final harvest have been revised downward. Assume that the project could be abandoned at this time by clearcutting the stand and that the revenue per acre from this operation based on current market conditions would be $950. To decide whether to continue or abandon the project, we carry out a cash flow analysis utilizing the revised cash flow values beginning in year 41 (table 12). The results of this analysis using a 5 percent real discount rate are shown in table 13.

Because the NPV is greater than the Abandonment Value of $950, we would recommend that the project not be abandoned at this time. Although the Abandonment Value is more or less certain, any future estimates and the calculated NPV have uncertainties attached. This uncertainty of NPV needs to be considered when it is compared with the AV. Although in this example NPV is greater than AV, there may be conditions such as smaller than expected harvest incomes that would make NPV smaller than AV. If lower incomes are likely, that would need to be considered in the decision to discontinue the project.

Table 12.--Original and actual or revised cost and revenue estimates for the hypothetical investment example (Alternative 1) 41 years after the project was implemented[1]

Activity	Year	Original estimate	Actual or revised estimate
		- - - - - ($/acre)	- - - - - -
Site preparation	1	-50	-50
Planting	1	-100	-100
Weed control	1-2	-15	-15
Precommercial thinning	16	-50	-60
Administration	1-60	-5	-5
Thin	41	500	400
Thin	51	1,500	1,300
Clearcut	61	2,500	2,000

[1] Note that all costs before year 41 are considered sunk for the marginal cost analysis.

Decisions based upon the Abandonment Test or any other project monitoring test must be consistent with the decision maker's current and future goals. If current goals are expected to change in the near future or if goals have changed since the project was implemented, the decision of whether or not to abandon a project must be consistent with all goals that are set.

PROJECT ANALYSIS THROUGH APPLICATION OF A MICROCOMPUTER

Evaluating all of the various potential alternatives when performing project analysis can involve many mathematical calculations. This process can become tedious and time consuming. Therefore, microcomputer investment analysis algorithms have been developed to simplify the task of enumerating the various alternatives. The user is only required to input discount rates and the timing and amount of project costs and revenues in base year dollars. Financial measures are then computed internally. However, access to these models does not diminish the decision maker's need to understand the conceptual basis of financial analysis and the importance of the data inputs required for applying these tools. Individuals interested in obtaining forestry investment analysis software may wish to contact the Forest Resources Systems Institute, 122 Helton Court, Florence, AL 35630, telephone (205) 767-0250. A fee may be required to obtain software.

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Table 13.--Project monitoring for investment Alternative 1

Net present value ($/acre)	$1,884.56
Equivalent annual income ($/acre)	$ 151.22
Soil expectation value	N.A.
Benefits/costs	29
Time to payback at discount (years)	0
Internal rate of return (percent)	> 200

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FINDING OUT AND TELLING

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it--in short, "finding out and telling." As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager to meet these challenges while protecting the environment is what research at North Central is all about.

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