A GUIDE TO FORESTRY PROJECT ANALYSIS

by

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INTRODUCTION AND OVERVIEW

This guide was developed to be used in conjunction with a workshop on project analysis. The objective of this workshop is to introduce the basic principles, relationships and techniques necessary to effectively analyze and evaluate alternative forestry projects which compete for limited resources. The focus and emphasis of this workshop will be to provide public and private foresters with:

a) An understanding of project analysis and economic evaluation techniques including procedures to deal with uncertainty and project monitoring;
b) An appreciation of economic and social factors which decision makers must consider when employing project analysis and other evaluation techniques;
c) An opportunity to obtain further knowledge of economic tools used in decision making.

Foresters frequently have several timber stands to manage within a given area. Different management treatments may be prescribed for the various stands because of differences in species composition, disease infestation, age, etc. Because financial resources are limited, foresters need to be able to identify and evaluate the various available projects to determine how these funds should best be allocated.

A "project analysis" approach uses a systematic and organized approach in an economic or financial evaluation of a particular proposal. In many cases, foresters lack an adequate understanding of project analysis. For those who are familiar with this type of analysis, there is a need to provide information on new techniques, to clarify various existing techniques and to gain additional insight into the many political and broad financial factors which may affect such an analysis and the resulting decisions.

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

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1) Extremely long planning horizons
2) Identification of the "factory" (the tree) as also being the marketable product
3) Very high ratio between marketable inventory and product being harvested.

Project analysis should begin by recognizing the following three steps that must be performed before a final decision can be made:

1) The gathering of information
2) Making some assumptions
3) Performing an analysis.

Completing these steps will not make the decision for us. Only the investor 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 analysis identifies unrealistic or questionable assumptions and methods by which a project can be modified to make it more attractive.

USE OF ECONOMICS IN DESIGN AND APPRAISAL OF PROJECTS

Economics can be applied to major programs and policies to interpret various broad implications in terms of costs and benefits derived. In the following discussion, we will concentrate on specific "projects". Broadly defined, a project consists of inputs, outputs, and the transformation function which converts inputs into outputs (Example: a timber harvest).

INPUTS---------->TRANSFORMATION---------->OUTPUTS

FUNCTION

Standing trees, Harvest and related Harvested logs
labor, machines, activities
and materials

The concept of inputs provides no conceptual problems. Outputs, however, need to be defined rather specifically in an economic analysis in terms of goods and/or services which have some human use and value.
Example: Erosion control project

Possible outputs:
1. Tons of soil loss prevented is an inadequate measure for economic analysis since it has no particular human value associated with it.
2. Dredging cost avoided or increased cropland productivity have both human value and use.

Economics can be used in the design of alternative projects and in the appraisal or evaluation of 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 project evaluation can be shown through a plantation project. In terms of designing alternative projects, we can ask: "What are the best species and rotation and what is the best level of intensity of management 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? 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. There are many other criteria for selection and for defining "best", e.g., political, social, environmental criteria. Economics provides only one input into the total decision making process.

Basic Economic Efficiency Conditions

Economic efficiency analysis

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 non-market benefits are compared with incremental investment and physical resource inputs.

We need to understand and have a clear idea of how the term "possible course of action" should be interpreted. In terms of economic analysis, it is essential that separable analytical units or project components be considered 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 and 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 and without the fertilization. Breaking out the fertilization, we have the following:

Fertilization component:
Benefits due to fertilization $200
Costs of fertilization $300
Net costs 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 have increased our net benefits to $200. Clearly we should analyze logically separable units separately.

Project interrelationships

Project interrelationships also need to be identified and dealt with appropriately. The types of interrelationships that can exist include:

(1) Horizontal interrelationships, i.e., interrelationships between components at the same level in the production process (e.g., increases in site preparation costs might reduce planting costs).

(2) Vertical interrelationships, i.e., interrelationships between project components at different levels in the production process, where the output from one level is an input into the next level (e.g., an increase in fertilizer input would not only increase fertilizer costs but would probably also increase timber yields and also harvest costs).

(3) Interrelationships 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., productivity improvement of a piece of land through drainage could provide benefits past the life of a project being evaluated).
(4) Interrelationships between a given project and other activities which should be considered within the project scope if a meaningful 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 interrelationships 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 are dependent.

Another type of dependency exists when two or more alternatives are considered for the same resources, as when a given acre can be planted to either red pine or white spruce, or where the choice is to remove cull trees or not to remove these trees. Here, choosing one alternative may preclude choosing the other. Investment alternatives may be independent, where the choosing of one does not foreclose the option of choosing the other (except perhaps for lack of funds). One may choose to build roads in tract A rather than tract B this year without losing the chance to build roads in tract B in the future. Therefore, it is imperative to be aware of interrelationships that may exist among alternative projects. It is especially important to be aware of and to spell out future investment commitments that may be implied by accepting a given project now.

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 effective 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 which 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.

(2) Each separable component of the project must have benefits at least equal to costs.

(3) There must not be any known lower cost means of achieving the same project benefits.
The definition of economic efficiency analysis includes the term "incremental" benefits and costs. This relates to a very 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. Assume a piece of land is eroding at a rapid and constant rate, thereby reducing crop production. A forestry conservation project has been proposed to stop the erosion and restore the land to a higher level of fertility. The situation is shown below:

![Diagram of economic efficiency analysis]

If we did not apply the with and without principle, we might define the benefits of the project as the area ACDE. In fact, without the project erosion and soil depletion would continue along the line AB. Applying the with and without principle, we see that the actual benefits due to the project include area ACD.

This example emphasizes the point that both supply and demand conditions determine values associated with any given project or activity. If people do not want or need the output of a project, then 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. Analysis of price (both for inputs and outputs) is an extremely important part of the economist's work in a project analysis.

The with and without principle also applies to questions of separable project components, as we saw earlier with the plantation project, which should be analyzed both with and without the fertilization component.
Financial versus Social Economic Analysis

So far, we have been using the term "economic" analysis in a generic rather than a specific sense. In fact, we can distinguish between two major types of "efficiency" or "profitability" analyses. One 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 from investment of 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. Since this is information that is essential for budget planning, financial analyses are also relevant for public projects.

An "economic efficiency" analysis is in a sense merely an extension of the financial analysis concept. In this type of analysis, the entity from whose point of view the analysis is carried out now becomes society as an undifferentiated whole rather than a specific entity (or entities) within the society. As such, the economic efficiency analysis is also concerned with "profitability", but in this case it is the profitability from society's point of view, which is related to the return to society as a whole which can be obtained with a given use of its limited resources. This is called "economic profitability" to distinguish it from "commercial profitability."

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. They differ, however, in terms of what is included as costs and benefits and how costs and benefits are valued.

In the 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, and thus returns are measured in terms of market prices. Costs in the financial analysis are represented by outflows of money from the entity that are mainly paid out for goods and services that can be purchased in the market. In the economic analysis, on the other hand, the concern is with what society gives up and what it gains from a project. Costs are thus defined in terms of value of opportunities forgone by society because resources are planned to be used in the specified project rather than in their best alternative use (alternative project). Thus, costs in an economic analysis are referred to as "opportunity costs." Project benefits are defined in terms of the increased amounts of goods and services available to society as a whole due to the project. These two different concepts of costs and benefits give rise to some specific differences in the ways in
which costs and benefits are identified and valued in the two types of analyses.

While the same basic principles of analysis apply to both financial and economic considerations, there are some important distinctions which are beyond the scope of this paper. This paper will emphasize major aspects of financial analyses only.

FINANCIAL ANALYSIS OF PROJECTS

Project Preparation

In this section we will describe how to analyze a specific project. At a later stage we will discuss how a number of independent projects can be compared and ranked for making decisions concerning allocation of a limited budget. Several points that should be reiterated before getting into the mechanics of a financial analysis include:

1. A financial analysis is carried out from a particular point of view, namely that of the entity which 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 relationship between expected costs and returns for the project being analyzed.

3. A project can be considered a financially efficient use of funds if each of the three conditions already described above are met:
   a) The returns exceed the costs, when both are appropriately adjusted to take their timing into account.
   b) Each separable component of a project has returns at least equal to costs, when both are adjusted to take timing into account.
   c) There is no lower cost way of achieving the same project objective.

4. Just because a project represents a financially efficient use of resources, this does not always mean that the project will be undertaken. The decision will depend on the values associated with other projects being considered and a host of non-financial considerations (environmental impacts, social objectives, national economic objectives, financial losses for tax shelter etc.).
Basic steps in a project analysis

Figure 1 lays out the overall approach which can be used in evaluating any type of investment project.

Objective(s) Specified

Alternatives for meeting objective(s) are identified

For each alternative

- define physical input-output relationships and timing as well as degree of certainty or uncertainty
- estimate unit values for inputs and outputs
- develop "cash flow" table (quantities times values for years in which they occur)
- calculate measures of project worth
- analyze uncertainty associated with alternative being analyzed

Determine which project represents the financially most efficient use of resources

- implement project and monitor its success

Figure 1. General Project Analysis Approach

Defining alternative projects

One of the most important activities involved in project analysis is the act of conceiving, creating, discovering, and developing all possible courses of action that the situation demands. Usually there are many alternative methods to accomplishing any particular job. A good example is the simple problem of evaluating a potential plantation establishment, thinning, and harvesting opportunity. Even with a restricted number of choices, the possible alternative courses of action could number in the billions. Since 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, there are no simple rules for accomplishing this task.

One major constraint on what can be done is what we have to work with. There is little reason to consider establishing a red pine plantation if we are evaluating management options for a 400-acre tract of sedge-peat bog. The problem that is usually faced is to identify the viable alternatives that are available, given the current circumstances. Some of the aspects that should be considered include:

- **Technical**: right 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**: adequacy of staffing arrangements
- **Organizational**: administrative structure (e.g., level of autonomy, flexibility).

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 identifying and defining management opportunities. However, there is frequently a lack of data to predict outcomes for alternative treatments. Thus, many potential opportunities may have to be discarded, even if they look promising, because there is little or no information regarding treatment response (i.e., outputs).

**Scale of project operation**

It is important to recognize that 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 were established, the results could be entirely 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. This aspect must be considered in any project analysis because of its potential affect on incomes and costs.

**Estimating values for inputs and outputs**

The private firm has market prices for its inputs and outputs. As already noted, 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. In some cases, the product could be marketed, but the market is not used for some reason, e.g., a public recreation project could charge fees and thus establish a price through the demand-supply interaction. Closely related to the question of pricing is the question of who pays for the product or resource. A private investment may have a negative output such as polluted water, but ignores this output in the analysis if it does not have to cover the cost of this pollution.

Methods for Evaluation of Alternatives

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 ten years from now. This is well accepted because when a dollar is received today, it can be used immediately. When we get a promise instead of the money, we must wait. What happens if the loaner changes his mind, dies, or if inflation continues at the current rate?

Obviously, due to the uncertainty involved, the dollar in hand will be 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. These methods are not concerned with the timing of project monetary transactions.

Everyone knows that money can generally be made by lending money. Individuals, governments and businesses are willing to pay for the use of money. An initial investment usually returns the principal 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% for 5 years yields $127.63 at the end of the investment period. This may be determined by first multiplying $100 by 1.05 in year one (Table 1).

Table 1. Example of compounding $100 at 5 percent for 5 years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount at start of year</th>
<th>Interest rate</th>
<th>Interest earned</th>
<th>Amount at end of year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$100.00</td>
<td>5%</td>
<td>$5.00</td>
<td>$105.00</td>
</tr>
<tr>
<td>2</td>
<td>105.00</td>
<td>5%</td>
<td>5.25</td>
<td>110.25</td>
</tr>
<tr>
<td>3</td>
<td>110.25</td>
<td>5%</td>
<td>5.51</td>
<td>115.76</td>
</tr>
<tr>
<td>4</td>
<td>115.76</td>
<td>5%</td>
<td>5.79</td>
<td>121.55</td>
</tr>
<tr>
<td>5</td>
<td>121.55</td>
<td>5%</td>
<td>6.08</td>
<td>127.63</td>
</tr>
</tbody>
</table>

In year two, we have done it twice, on up to five times in year five. This tedious task of making these repeated multiplications can be simplified by using the general formula:
\[ V_n = V_0 (1+i)^n \]  
(1)

where:  
\( V_0 \) = Value in year (period) 0 (i.e., the beginning of the investment)  
\( i \) = Interest rate  
\( n \) = Number of years (periods)  
\( V_n \) = Value at end of the investment period

This formula could have been applied to the above example as:

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

Various tables have also been developed to provide these multipliers for specified interest rates (Lundgren 1971, US Forest Service 1966). Although costs and revenues may occur throughout the year, it is frequently assumed that these transactions occur at the end or the beginning of the year to simplify calculations. Care must be taken to properly count the number of discounting periods.

Another basic operation, discounting, is the exact reverse of compounding. Remember that compounding started with a present amount and grew it into a future amount. Discounting does just the opposite, starting with a future amount and finding its worth today, its present value equivalent. The basic formula for discounting is:

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

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

\[ V_0 = 127.63 / (1.05)^5 = 100 \]

A uniform series of costs or revenues can be discounted to the present using the formula:

\[ V_0 = a \frac{(1+i)^n - 1}{i(1+i)^n} \]  
(3)

where \( a \) = an annually (periodically) recurring cost or revenue incurred at the end of the year (period).

If payments occur at the beginning of each year (period), equation 3 needs to be modified:

\[ V_0 = a \frac{(1+i)^{n-1} - 1}{i(1+i)^{n-1}} + a \]  
(4)

For example, a rent of $5/acre paid at the end of every year for 10 years in today's dollars would be worth $38.60 if the discount rate were 5 percent or:
\[ (1.05)^{10} - 1 \]
\[ V_0 = \frac{5}{0.05(1.05)^{10}} = 38.60 \]

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

\[ (1.05)^9 - 1 \]
\[ V_0 = \frac{5}{0.05(1.05)^9} + 5 = 43.60 \]

Selecting the appropriate discount rate

The discount or compounding rate used in these formulas is the alternative rate of return (ARR) or minimum acceptable rate of return (MARR) established by the decision maker. MARR is a devise designed to make best possible use of a limited resource, money. It is generally accepted that the lower bound for MARR should be the cost of capital which is derived from the composition of the capital available to the decision maker. If the decision maker were to borrow $100 at 10 percent and another $100 at 12 percent from two different financial institutions, the MARR for him would be 11 percent.

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

Measurement of capital involves two variables, quantity and time. The derivation of interest rates or the alternative rate of return (ARR) is the hardest part to determine when working with interest rates. There is a need for an external and objective basis for rate setting, e.g., if the long-run benefits of a public project are to be evaluated.

The cost of keeping money immobilized in a project is indicated by the rate of interest. 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 ARR.

Since interest is the cost for the use of capital, cost could be:

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.

The ARR is peculiar to each firm, varies from case to case and varies from time to time. In setting the ARR based on the alternative with the highest rate of return (best opportunity), allowances should be made for any differences in risk and other influences such as time, space and income.
taxes. The actual rate of return expected from new investments 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.

Adjusting the discount rate for risk

The rate of return must be adjusted for risk whenever alternatives are compared (Guttenberg 1950). Risk are noninsurable losses that may occur, e.g., physical damage, increases in costs, or decreases in product prices.

The Pure Rate is defined as the average yield of invested capital without inclusion of risk. The Effective Rate incorporates risk as follows:

\[
\text{Effective Rate} = \frac{\text{Pure Rate} + \text{Risk Rate}}{100 - \text{Risk Rate}} * 100
\]

Example: An investor can invest $80,000 for a 4 percent return with no risk (Treasury Bond) or he can invest into an alternative with a chance of 1 in 30 or 3.3 percent of losing both capital and interest. What minimum rate should the investor require to keep his capital intact and yield an average rate of return of 4 percent?

\[
\frac{4.0 + 3.3}{100 - 3.3} * 100 = 7.55 \text{ percent}
\]

(This rate should not be confused with the Effective Annual Rate).

This calculation is not necessarily the most accurate way to estimate risk (actuarial way). Risk does not necessarily occur uniformly or cumulatively as is assumed when it is regarded as part of the interest rate. Often it is better to work with a safe rate of return and then estimate risk separately.

Examples of adjustments for risk

Risk is generally perceived as either an annual phenomenon that occurs during all or part of an investment's duration, or as an accumulated lump of risk that accrues at maturity.

As an example of accumulated lumps of risk, suppose one faces an investment that is judged to have a 50-50 chance of losing everything, including the original capital, by the maturity date (i.e., the accumulated probability of success is 0.5). Suppose also that a stand-by riskless alternative guarantees to pay 4 percent compounded annually. What rate of compound growth should be required of the risky investment to make its expected value equivalent to the riskless investment?
The more acceptable way of adjusting for risk in an investment is to determine the expected or estimated final value and then discount with the riskless rate. This approach is acceptable where the discount rate is to be used as the adjusting tool.

The appropriate adjusted discount rate for the above example depends on the investment duration as well as the accumulated probability of success. Once the duration is specified, the approach to determining the required rate is to:

1. Calculate the per-dollar value of the riskless alternative at maturity;
2. Adjust this value to account for risk;
3. Calculate backwards to determine the required rate for the risky investment.

**Case A:** Duration one year
1. $(1.00+0.04) = $1.04
2. $(1.04/0.5) = $2.08 with 0.5 chance
3. Target rate of 108 percent ($2.08-$1.00) required

**Case B:** Duration 10 years
1. $(1.04)^{10} = $1.48
2. $(1.48/0.5) = $2.96
3. $(1+1)^{10} = 2.96 or \((1+1) = (2.96)^{1/10} = 1.1146 or 11.46 percent.

As an accumulated risk is spread over longer and longer project durations, the average annual risk declines. That is, the investment becomes less risky, and therefore the premium in the discount rate should and does also decline.

It is common in forestry to require a premium when risk is constant and continuous year after year. Determining the premium is simple and straightforward, almost an intuitive process. This is known as Constant Annual Risk.

Suppose that each year the probability of wildfire totally destroying a new plantation is 1 in 500 or 0.2 percent. What risk premium should be used to carry the plantation through the first 20 years until it reaches salvable size, thus offering the owner a chance to recoup some of the loss if it does burn? The assumed riskless rate is 4 percent in this situation, the annual risk probability, 0.2 percent, should simply be added to the riskless rate of 4 percent to yield a risk premium of 4.2 percent. This can be proven by using the accumulated approach. Because the probability of surviving a wildfire each year is 0.998 (1.0-0.002), the probability of surviving 20 years is $(0.998)^{20}$, or 0.96.

1. $(1.04)^{20} = $2.19
2. $2.19/0.96 = $2.28
3. $(2.28)^{1/20} = 1.0421 or risk premium of 0.21 percent.

The slight difference between the accumulated approach and the "intuitive" premium is due to the standard practice of compounding on a once-a-year basis instead of continuous compounding. As with accumulated risk, the
premium when the annual probability of risk is known is, for all practical purposes, independent of the riskless rate or duration length.

In the above examples of discounting for risk the assumption is made that the investor is risk-neutral, i.e., his utility curve for additional income levels is a straight line (Figure 2). A risk-averting person would have a concave utility curve, a risk-seeking person a convex utility curve for money as shown in the same figure. This can be easily demonstrated using a simple example:

Assume a riskless investment A of $100 for one year growing at 4 percent. That investment will grow to $104 by the end of the year. For an investment B with a 50-50 chance of failing, one must obtain $208 at the end of the year in order to average $104 (0.5*208 + 0.5*0). Consider a third alternative C which has the same expected return of $104 because it offers a 50 percent chance of making $158 after one year and a 50 percent chance of making $50. While all three investments offer the same expected return, are they really equally attractive? The answer to this depends on whether a person is risk-averting, risk-seeking, or risk-neutral. A risk-averting person would prefer alternative A to C and C to B. A risk-seeking person would prefer B to C and C to A. Only a risk-neutral person will regard A, B, and C as equal (Figures 2, 3, and 4).

![Utility Curve for Risk Neutral Person](Figure 2)

utility curve for money.
Developing a cash flow

Since financial analysis often evaluates projects that span several years, the impact of time and interest can be considerable upon the final analysis. The affects are particularly important given major differences in cash flow timing between competing investments [i.e., forestry (periodic) vs. agriculture (annual)]. Although more accurate, the tools which account for money's time value are more difficult to use because:

1) They require cash flow projections over time.
2) They require a knowledge of the mechanics for making adjustment in the value of money (i.e., the mathematics of finance).

When evaluating alternatives, it frequently is easier to start 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 project outlined in Table 2.

Table 2. Cost and revenue activities for a hypothetical investment example.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>($/Acre)</td>
</tr>
<tr>
<td>Site preparation</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Planting</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Weed control</td>
<td>1-2</td>
<td>15</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinning</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>Administration</td>
<td>1-61</td>
<td>5</td>
</tr>
<tr>
<td>Thin²</td>
<td>41</td>
<td>500</td>
</tr>
<tr>
<td>Thin³</td>
<td>51</td>
<td>1,500</td>
</tr>
<tr>
<td>Clearcut⁴</td>
<td>61</td>
<td>2,500</td>
</tr>
</tbody>
</table>

¹All activities are assumed to occur at beginning of indicated year
²Cash flow in Year 0 dollars. All costs are indicated with a minus (-) sign
³Assumed stumpage return to the landowner is $50/MBF with 10 MBF cut/acre.
⁴Assumed stumpage return to the landowner is $100/MBF with 15 MBF cut/acre
⁵Assumed stumpage return to the landowner is $125/MBF with 20 MBF cut/acre

When establishing the cash flow, the analyst should make explicit the assumption underlying the time of occurrence of any specified activity, i.e., whether the activity is carried out at the beginning or end of the specified period. Under different conventions, the year (period) in which an activity takes place could have two different meanings. In Table 2, activities are assumed to occur at the beginning of the indicated year. Site preparation and planting, therefore, are taking place at the very beginning of the investment. Clearcutting takes place at the beginning of year 61 or after 60 investment periods. When the convention is used that the year (period) in which an activity occurs indicates that the activity takes place at the end of the year, an activity that is to begin at the beginning of the investment is associated with a year (period) of "0". Figure 5 illustrates the difference between the two conventions.

<table>
<thead>
<tr>
<th>Convention</th>
<th>Appropriate Period Indicator</th>
<th>Activity takes place</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 5. Conventions for Indicating Occurrence of Cash Flow Activity
To describe an activity that takes place at the end of year 15, in convention 1, one would use "15" to indicate the year of occurrence, in convention 2 one would use "16" 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 cash flow, both conventions will lead to identical analytical results. The analyst should clearly spell out the assumption underlying the occurrence of activities within a specified year.

Cash flow tables graphically illustrate the overall situation to help us make the transition from pictures to numbers (Table 3).

Table 3. Cash flow table for hypothetical investment example

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cash flow ($/Acre/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration</td>
<td>-5</td>
</tr>
<tr>
<td>Site prep.</td>
<td>-5</td>
</tr>
<tr>
<td>Planting</td>
<td>-100</td>
</tr>
<tr>
<td>Weed control</td>
<td>-15</td>
</tr>
<tr>
<td>Pre-comm. thinning</td>
<td>-50</td>
</tr>
<tr>
<td>Thin at age 40</td>
<td>500</td>
</tr>
<tr>
<td>Thin at age 50</td>
<td>1500</td>
</tr>
<tr>
<td>Clearcut at rotation age 60</td>
<td>2500</td>
</tr>
</tbody>
</table>

*All costs are indicated with a minus (-) sign. All activities are assumed to take place at the beginning of the indicated year.*

Treatment of uncertainty

Several ways to account for risk are being used:

1. **Finite Horizon Method**: any forecast for a period longer than x years is not considered. The shortcoming of this method is that our prediction even for the immediate future is uncertain, so why not predict for longer period.

2. **Discounting for Risk**: add an appropriate percentage to the discount rate as an insurance premium. This is accomplished 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. A caution is to be aware of the exponential increase of \((1+i)^n\).

3. **Probability Theory Approach**: use expected values in the analysis, e.g., $100 with \(P=0.4\), $200 with \(P=0.5\) or $300 with \(P=0.1\) yields an expected return of $170 ($100*0.4 + 200*0.5 + 300*0.1$).
4. Sensitivity Analysis: test sensitivity of investment performance measures to changes in input values (cost 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 most closely monitored and possibly better information needs to be collected before making the final investment decision.

In figure 1, outlining the general steps for a project analysis, it was stated that the degree of certainty or uncertainty associated with each input and output into the cash flow should be stated. This step is of importance for the portion of the analysis called sensitivity analysis. Table 4 illustrates how the information might look for our hypothetical example.

Table 4. Degree of uncertainty of costs and revenues for a hypothetical investment example.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Best Estimate</th>
<th>Expected Range</th>
<th>Degree of Certainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>-- $/Acre --</td>
<td>below above</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Site preparation</td>
<td>50</td>
<td>- 5, + 5</td>
<td>high</td>
</tr>
<tr>
<td>Planting</td>
<td>100</td>
<td>- 5, + 5</td>
<td>high</td>
</tr>
<tr>
<td>Weed control</td>
<td>15</td>
<td>- 5, + 5</td>
<td>high</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinning</td>
<td>50</td>
<td>-10, +25</td>
<td>low</td>
</tr>
<tr>
<td>Administration</td>
<td>5</td>
<td>- 5, +15</td>
<td>medium</td>
</tr>
<tr>
<td>Thin</td>
<td>500</td>
<td>-10, +20</td>
<td>medium</td>
</tr>
<tr>
<td>Thin</td>
<td>1,500</td>
<td>-20, +10</td>
<td>medium</td>
</tr>
<tr>
<td>Clearcut</td>
<td>2,500</td>
<td>-25, +25</td>
<td>low</td>
</tr>
</tbody>
</table>

The ranges would indicate that, for example, revenues from clearcutting might turn out to be 25 percent lower or 25 percent higher than our current best estimate. As a matter of fact, without further information provided, it must be assumed that all values between -25 and +25 percent will be equally likely (uniform distribution). Other ways to state the degree of confidence or uncertainty one has with respect to a cash flow activity is to describe the distributional characteristics of the estimate or state the parameters of the distribution. An example would be to assume a normal distribution around the stated mean (best estimate) with an assumed variance. We will return to this table later on.

Common project evaluation criteria

A yardstick or profitability criterion is needed to evaluate the investment after the relevant cash flows have been identified. This is obtained by reducing the cash flow to a single number which describes the relationship between costs and incomes. That seems simple enough; why not just subtract costs from income? While a good idea, that is not how the financial world works. 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). NPV recognizes money's time value by discounting (using the MARR) all costs and returns back to project initiation (time 0) and then subtracting the cost from the income. That is:

\[
\text{NPV} = V_o (\text{revenues}) - V_o (\text{costs})
\]

\[
\text{NPV} = \text{Present worth (revenues)} - \text{Present worth (costs)}
\]

The hypothetical cash flow (Table 2) shows that several costs must be discounted back to time 0, e.g., administration 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. Calculations indicate that the project yields an NPV of $32.85/acre (Table 5). All NPV's are found in the same way, by discounting all costs and returns back to time 0 and then subtracting costs from returns.

Table 5. Net present value for hypothetical investment example assuming a 5 percent discount rate.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Net Present Value $/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site preparation</td>
<td>-50</td>
</tr>
<tr>
<td>Planting</td>
<td>-100</td>
</tr>
<tr>
<td>Weed control</td>
<td>-29.28</td>
</tr>
<tr>
<td>Pre-comm. thinning</td>
<td>-24.05</td>
</tr>
<tr>
<td>Administration annual cost paid at beginning of year</td>
<td>-99.37</td>
</tr>
<tr>
<td></td>
<td>0.05(1.05)^{59} - 1</td>
</tr>
<tr>
<td>Thin at age 40</td>
<td>71.00</td>
</tr>
<tr>
<td>Thin at age 50</td>
<td>130.80</td>
</tr>
<tr>
<td>Clearcut</td>
<td>133.75</td>
</tr>
<tr>
<td>Total present value of costs</td>
<td>-302.70</td>
</tr>
<tr>
<td>Total present value of revenues</td>
<td>335.55</td>
</tr>
<tr>
<td>Net present value</td>
<td>+32.85</td>
</tr>
</tbody>
</table>
In order to tell exactly how much more (or less) than the discount rate our project is earning, we must calculate its expected rate of return. This can then be compared with the project's discount rate (i.e., the MARR). This is accomplished by calculating the Internal Rate of Return (IRR), another technique which accounts for money's time value, to show the investment's actual rate of return. The IRR is the discount rate which equates discounted costs and revenues or where NPV is equal to zero. That is, IRR finds the discount rate where: NPV (revenues) = NPV (costs) or NPV=0. IRR is generally calculated using an iterative process to solve for the appropriate discount rate. The NPV for the cash flow example in Table 2 would result in -$79.99 for a 6 percent discount rate. The IRR must, therefore, lie between the ARR or 5 percent which yielded an NPV of $32.85 and 6 percent. By iterating between these two values, the IRR can be determined as 5.29 percent, i.e., all costs and benefits, discounted by this percentage, would make NPV equal to zero.

IRR's smaller than the discount rate used to construct the analysis indicate that the project's rate of return is less than the MARR (the project would also yield a negative NPV). IRR's exceeding the discount rate (MARR) reflect a project whose rate of return will also exceed this alternative rate. Obviously, we will prefer projects whose IRR's exceed the MARR. For this example, the IRR of 5.29 percent exceeds the ARR, making the investment appear to be attractive. This conclusion, as we will see later, might not be justified in view of the uncertainties associated with our data.

Other measures of project performance include:

1) Benefit/cost (B/C) ratio - The present value of discounted revenues divided by the present value of discounted costs. A value greater than 1.0 indicates that discounted benefits exceed costs. For our sample cash flow (Table 2), we can calculate the B/C as 1.11 from:

\[ \frac{335.55}{302.70} = 1.11 \]

2) Soil expectation value (SEV) - Net present value for an infinite time horizon. SEV is calculated using the formula:

\[ SEV = \frac{R}{(1+i)^r - 1} \]

where:  
\( R \) = Net income from one rotation \((r)\) in year \((r)\) terms  
\( i \) = Discount rate  
\( r \) = Rotation age

Note that this formula differs from the general discounting formula (Equation 2) only by the presence of the "1" in the denominator. For our case, we can calculate first \( R \) by compounding NPV to year 60 (the rotation age), i.e.,
\[ R = 32.85(1.05)^{60} = 613.61 \text{ and} \]
\[ SEV = \frac{613.61}{[(1.05)^{60} - 1]} = 34.71 \]

It should be noted that the first rotation contributes $32.85 to value and that all future rotations past the first contribute only $1.86 ($34.71-$32.85). This is caused by the exponential increase of the expression \((1+i)^n\) with increasing \(r\).

3) Equivalent annual income (EAI) - Net present value converted to an annual value paid at the end of each year (period) over the investment period with interest calculated at the appropriate discount rate. EAI is calculated using the formula:

\[
EAI = \frac{i(1+i)^n}{(1+i)^n - 1} \tag{5}
\]

You will note that this formula is the inverse of the formula for discounting annually recurring costs or revenues (Equation 3), i.e., EAI takes the place of "\(a\)" and NPV takes the place of \(V_0\). In this case, it would result in:

\[
0.05(1.05)^{60} \]
\[
EAI = \frac{32.85}{(1.05)^{60} - 1} = 1.73
\]

4) Payback period - The length of time needed to recover the investment's initial cost. 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, this method may show a preference for an alternative that is inferior by a discounted cash flow comparison. In our case, using discounted costs and revenues, it could be shown that in year 61 the cumulative net cash flow become positive.

A summary of the various project performance measures discussed so far for the sample cash flow in Table 2 is shown in Table 6.

<table>
<thead>
<tr>
<th>Table 6. Financial summary for the hypothetical investment example assuming no inflation and a 5 percent discount rate.¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net present value</strong></td>
</tr>
<tr>
<td><strong>Equivalent annual income</strong></td>
</tr>
<tr>
<td><strong>Soil expectation value</strong></td>
</tr>
<tr>
<td><strong>Benefits over costs</strong></td>
</tr>
<tr>
<td><strong>Years to payback at discount</strong></td>
</tr>
<tr>
<td><strong>Internal rate of return</strong></td>
</tr>
</tbody>
</table>

¹ All monetary values are in dollars per acre.
Interpreting 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, the project will yield a 5 percent return on investment plus a present sum of $32.85/acre. NPV serves as a guide to accepting or rejecting the project by representing earnings above and beyond the MARR. Positive NPV's reflect opportunities that return more than the MARR while negative NPV's indicate opportunities that return less than this rate. Depending on the size of the NPV, investments with a positive NPV are usually accepted while those with a negative NPV are usually rejected.

Impact of discount rate on investment

The discount rate used in the evaluation exerts a tremendous affect on the final analysis results. You may be wondering why we used a 5 percent discount rate when banks are paying between 6 percent and 8 percent. The reason brings us to a very important difference. The 6 percent - 8 percent bank rates are called market or nominal rates because they reflect inflation. The 5 percent rate does not include inflation and is called a real rate. Remember that use of nominal rates requires that both costs and returns reflect inflation.

Economists generally use real rates because analyses whose results are based on nominal rates reflect both real project return plus return due to inflation. Sorting the two out can be tricky. Since good financial analysis is hard enough without trying to project future inflation rates, it is felt that the real analysis gives a clearer picture of the project's true status. Decision makers should compare analyses based on several realistic discount rates. Table 7 shows quite different results when our analysis is redone using various alternative real rates. The project's profitability can clearly change with the discount rate used in the analysis.

Table 7. Net present value per acre for hypothetical example under discount rates of 2, 5, and 8 percent.

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>Net present value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>+1,150.04</td>
</tr>
<tr>
<td>4%</td>
<td>+ 227.56</td>
</tr>
<tr>
<td>5%</td>
<td>+ 32.85</td>
</tr>
<tr>
<td>6%</td>
<td>- 79.99</td>
</tr>
<tr>
<td>8%</td>
<td>- 181.85</td>
</tr>
</tbody>
</table>
There is absolutely nothing wrong with using nominal rates 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. Some examples will show why.

As an example, if the general price index for goods rises from 100 to 103 from one year to the next and the price index for stumpage rises from 100 to 107, stumpage has increased by 4 percent approximately in real terms. Another way of presenting the same example is if $100 is invested in a bank for one year and pays $107 at the end of the year, and if the general rate of inflation was 3 percent that year, the real value of the account would be $107/1.03=$103.88. That is, the real rate of interest or return on investment is 3.88 percent.

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 interest 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). Initially disregarding inflation, and including it later, obviously changes the results. 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.

Effect of inflation on evaluation of forestry projects

Forestry investments have often 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" terms mean applying a deflation factor to 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.

Long-term records show that stumpage prices have been increasing about 2 percent annually above and beyond the inflationary rise of other product prices. This means that whatever the general national rise in product prices, stumpage increases have averaged an additional 2 percent. Building a 2 percent annual stumpage price increase at each of the two commercial thinnings and the final clearcut into the hypothetical example (Table 2) yields a NPV of $645.04/acre compared to $32.85/acre (Table 6) without the 2 percent increase. The new IRR would be 7.65 percent. The effect of inflation on the evaluation is apparent.
Sensitivity analysis methods

Sensitivity analysis is the most common approach to dealing with uncertainty. Sensitivity analysis is conducted to furnish information concerning the affect of a specified change in the amount 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. Similarly, risk analysis shows the amount and percent of change (up to a maximum of 100 percent) necessary for each cost and revenue variable to force NPV to $0.00. The degree of confidence for every activity estimate in the cash flow should be established before performing the economic analysis to avoid biasing one's investment decision. Activities which the analyst considers to be uncertain, either due to wide ranges or variability in amount, and those activities that are identified as being critical factors by the sensitivity analysis deserve further special attention.

As calculated above, the project will return a present net worth of $32.85/acre (Table 6). Although the project yields favorable values for EAI, SEV, benefit/cost ratio, and does meet the payback criterion, it needs to be further analyzed. The project will yield a positive present net value for all discount rates less than 5.29 percent (Table 6). Despite the apparent positive investment, we should remain skeptical. 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 are fluctuating greatly, creating a great deal of uncertainty. Examining several different scenarios for these three factors reduces uncertainty by giving 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 8 and 9 indicate how changes in the level of project activities would influence the various project performance measures for the project described in Table 2. 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 these numbers could all be generated by repeating above analyses after making the appropriate changes in the input and output values.
Table 8. Sensitivity analysis to a 10 percent change in input value for the hypothetical investment example assuming no inflation and a 5 percent discount rate.

<table>
<thead>
<tr>
<th>Activity changed</th>
<th>NPV change</th>
<th>EAI change</th>
<th>SEV change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site preparation</td>
<td>5.00</td>
<td>0.26</td>
<td>5.02</td>
</tr>
<tr>
<td>Planting</td>
<td>10.00</td>
<td>0.53</td>
<td>10.04</td>
</tr>
<tr>
<td>Weed control</td>
<td>2.93</td>
<td>0.15</td>
<td>2.94</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td>2.41</td>
<td>0.13</td>
<td>2.41</td>
</tr>
<tr>
<td>Administration</td>
<td>9.96</td>
<td>0.53</td>
<td>10.00</td>
</tr>
<tr>
<td>Thin at age 40</td>
<td>7.10</td>
<td>0.38</td>
<td>7.13</td>
</tr>
<tr>
<td>Thin at age 50</td>
<td>13.08</td>
<td>0.69</td>
<td>13.13</td>
</tr>
<tr>
<td>Clearcut</td>
<td>13.38</td>
<td>0.71</td>
<td>13.43</td>
</tr>
</tbody>
</table>

Table 9. Risk analysis indicating the amount of change necessary for each activity to force NPV to $0.00 for the hypothetical investment example assuming no inflation.1

<table>
<thead>
<tr>
<th>Activity changed</th>
<th>Percent change</th>
<th>Value change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site preparation</td>
<td>65.37</td>
<td>-32.85</td>
</tr>
<tr>
<td>Planting</td>
<td>32.69</td>
<td>-32.85</td>
</tr>
<tr>
<td>Weed control</td>
<td>100.00</td>
<td>-29.85</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td>100.00</td>
<td>-24.05</td>
</tr>
<tr>
<td>Administration</td>
<td>32.80</td>
<td>-32.85</td>
</tr>
<tr>
<td>Thin at age 40</td>
<td>-46.02</td>
<td>-32.85</td>
</tr>
<tr>
<td>Thin at age 50</td>
<td>-24.99</td>
<td>-32.69</td>
</tr>
<tr>
<td>Clearcut</td>
<td>-24.42</td>
<td>-32.85</td>
</tr>
</tbody>
</table>

1 When percent change equals 100 percent and dollar change is smaller than $32.85, the input variable will not alter the overall project selection, given the NPV decision criterion.

The decision maker needs to attach the proper sign to the values in Table 8 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 8 and 9). If the projected revenue for this activity decreased by 10 percent to $2,250/acre, NPV would decrease by $13.38/acre, EAI by $0.71/acre, and SEV by $13.43/acre. If revenue decreased by 24.42 percent (Table 9) or to $1,889/acre, NPV would equal exactly $0.00. It can also be seen that only the clearcutting revenue includes in its estimate of a lower possible range (Table 7) a value that would reduce NPV to zero. Combination of changes in individual factors, however, could easily produce such a result.

To see how this kind of information might be derived from Tables 7 and 8, it will be shown that it is possible to assess the impact of any one or more changes of any magnitude on the three performance measures NPV, EAI,
and SEV once the impact of any change (percent or absolute) on NPV, EAI, and SEV have been calculated as, for example, the impact of a 10 percent change seen in Table 8. The reason that this is possible is the fact that any other assumed 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 8, and a 30 percent change will have impacts three times larger than shown in Table 8. Furthermore, individual changes can be summed to reflect changes in more than one cost or revenue, i.e., a 10 percent decrease in both planting and weed control costs would increase NPV by $(5.00+10.00)=$15.00. A 15 percent increase in all costs combined with a 5 percent increase in all revenues would, therefore, 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+9.96)=$30.30. A 15 percent increase in all costs would decrease NPV by $45.45 (1.5*$30.30). A 5 percent increase in all revenues would, therefore, increase NPV by 0.5(7.10+13.08+13.38)=$16.78. The combined impact of cost and revenue changes would, therefore, be a reduction in NPV by $28.67 ($16.78-$45.45), leaving the new NPV at $4.18.

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

Breakeven and cost-price analysis

Another common approach to dealing with uncertainty is to calculate the "breakeven" level or value for a given project parameter. What this means is that we calculate the value of the parameter that will make the project just return the alternative rate of return or yield a NPV of zero when the alternative rate of return is used to discount costs and benefits. Looking at our example, we can generate this information from Table 8. With an NPV of $32.85, an increase of 65.4 percent in site preparation costs, for example, would reduce NPV to zero.

Ranking of Alternative Projects

Relationship between NPV and IRR

In most cases, several alternatives can be specified. After having performed project analyses according to the steps outlined in Figure 1, it is necessary to rank these individual alternatives and to select and implement the most attractive one(s).

Many different measures of project performance give similar results (i.e., favor the same project) when the decision at hand involves investment opportunities that are not mutually exclusive (i.e., implementing one alternative does not exclude the implementation of the other or others). The internal rate of return would have an advantage in this case because
this measure does not require that a discount rate be specified before performing the analysis.

When alternatives are mutually exclusive, differences between criteria can be significant, with different projects being favored when different ranking criteria are being used. Gansner and Larsen (1966) used a simple example to illustrate the pitfalls of using the IRR to rank mutually exclusive investments. Assume, we have three investments with the following cash flows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-25</td>
<td>29</td>
<td>58</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>-25</td>
<td>0</td>
<td>0</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>-25</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>

Assuming the investor can borrow money at 4 percent, and the question is: "Are the projects worth undertaking?", the answer would be that all three investments would be worth undertaking because the NPV's would be $48, $52, and $35 respectively for investments A, B, and C. However, when the question were asked: "Which of the projects is the better one?", the answer would differ depending on whether the NPV or IRR is used as a selection criterion. The IRR's for investments A, B, and C are 10, 8, and 10 percent respectively, i.e., the investor would be indifferent between A or C, but prefer either one to B. The best financial alternative, however, is clearly B which yields the greatest NPV. 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, in general, correct and the IRR will not rank investments consistently with their NPV's. For mutually exclusive alternatives, it is, therefore, recommended to rank investments by the NPV criterion.

General rules for selection of ranking criteria

Capital is frequently the primary limiting factor in timber management (i.e., a choice must be made on which project to implement). Internal rate of return is an appropriate criterion in this case because a high rate of return on a given investment is preferable to a low rate of return, all other things being equal. And other things are equal if capital is the primary limiting factor.

If land and the associated opportunities for investment in timber management are the primary limiting factors, a criterion that reflects the amount of the investment as well as the rate of return will be a better choice, i.e., NPV. The reasoning is again quite simple. A relatively low rate of return on a large investment may give a larger absolute profit than would a higher rate of return on a much smaller investment.
Project comparisons

To compare and choose among alternative projects, the discussion above about mutually exclusive or non-mutually exclusive alternatives is important for the selection of the proper ranking criterion. An additional complication arises out of the fact that alternatives might not cover the same investment period. NPV cannot be used to directly compare projects with different investment periods. The two basic philosophies for handling projects with different economic lives are:

1. Disregard the future events and their consequences beyond some specified period;

2. Predict the future events (i.e., future rotation activities and costs) in order to make a prediction over equal periods for both alternatives.

The second method is also known as the "common-multiple method" because alternatives are terminated by selecting an analysis period that spans a common multiple of the lives of the involved projects. For instance, if projects had lives of 2, 3, 4, and 6 years, the least common multiple is 12 years, which means the 2-year project would be repeated 6 times during the analysis period. 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 having identical input characteristics. A special case of this method is the use of infinity as the "common multiple" as assumed in the calculation of SEV. The latter measure is widely used and accepted in forestry analysis and, therefore, provides an automatic comparability of projects of any length. Fortunately, the increasing uncertainty over increasing time is made less important because early cost and revenues contribute most to SEV, and the impact of events in the far future become less and less important especially the higher the MARR. In that sense, method of disregarding events beyond some specified period can be considered to provide quite similar answers especially if the cutoff point for the analysis is far enough into the future.

Assume that an alternative project to the one described in Table 2 was to grow a genetically improved variety of tree that would permit a shorter rotation of only 40 years to harvest the desired sawtimber. It would cost more to plant this improved stock due to plant material prices, but weed control due to rapid plant growth would be needed only the first year, the first precommercial thinning could occur already in year 13, and the only commercial thinning could take place already in year 31. The cash flow for this project alternative is shown in Table 10.
Table 10. Cost and revenue activities for a hypothetical investment alternative

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year</th>
<th>Cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site preparation</td>
<td>1</td>
<td>-50</td>
</tr>
<tr>
<td>Planting</td>
<td>1</td>
<td>-125</td>
</tr>
<tr>
<td>Weed control</td>
<td>1</td>
<td>-15</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>thinning</td>
<td>13</td>
<td>-50</td>
</tr>
<tr>
<td>Administration</td>
<td>Annual</td>
<td>-5</td>
</tr>
<tr>
<td>Thin</td>
<td>31</td>
<td>525</td>
</tr>
<tr>
<td>Clearcut</td>
<td>41</td>
<td>1,550</td>
</tr>
</tbody>
</table>

The analysis yields the following results (Table 12):

Table 11. Financial summary for the hypothetical investment example assuming no inflation and a 5 percent discount rate.¹

<table>
<thead>
<tr>
<th>Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net present value</td>
<td>$33.01</td>
</tr>
<tr>
<td>Equivalent annual income</td>
<td>$ 1.92</td>
</tr>
<tr>
<td>Soil expectation value</td>
<td>$38.47</td>
</tr>
<tr>
<td>Benefits over costs</td>
<td>1.11</td>
</tr>
<tr>
<td>Years to payback at discount</td>
<td>40 years</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>5.38%</td>
</tr>
</tbody>
</table>

¹All monetary values are in dollars per acre.

On the basis of NPV, the two alternatives look almost equally attractive. Alternative 2, however, has a shorter investment period and is, therefore, not directly comparable with investment alternative 1. Comparison on the basis of SEV, i.e., over a common time horizon, shows that the new alternative is preferable. This conclusion is also supported by the shorter payback period for alternative 2.

Project Implementation and Monitoring

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 outputs. However, after implementation, the decision maker must continually reassess the project to determine whether it should be continued or terminated.

The monitoring process involves collecting further data and performing appropriate analyses. The importance of the implementation phase of a forestry project has not been stressed as much as the initial phase of
comparing alternatives for new capital projects. Projects are, however, seldom implemented exactly as indicated in the initial appraisal. In that phase (see Table 2), a project's NPV and IRR depend upon assumptions derived from past experience and forecasts which are dependent on the fluctuations in the economy.

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 a cash flow table. Future deviations in costs and revenues are measured against this standard. Some methods of project monitoring include (Harou and Massey 1982):

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

2. **Marginal Cost Analysis**: This analysis considers past costs and revenues as sunk. 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. When capital assets are depreciating slowly through time, or appreciating such as timber in forestry, this analysis is not appropriate in directing management actions.

3. **The Abandonment Test**: An improvement over the marginal cost analysis is a comparison of the costs and benefits to be incurred in the future against today's Abandonment Value (AV) of the project. This 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 NPV, the project is abandoned.

4. **The Optimal Abandonment Test**: The Abandonment Test considers only today's AV. The traditional abandonment decision rule asserts that the project should be abandoned the first year in which the estimated AV exceeds the NPV of the remaining expected cash flows from continued operation. This decision rule may not result in the optimal abandonment decision. Abandonment in later years may result in even greater NPV depending on the estimates of AV's in later years. The Optimal Abandonment Test can be summarized as follows: find the maximum NPV depending on a given evaluation period. If the maximum NPV is lower than the current abandonment value, AV₀, the project is liquidated.

While the Optimal Abandonment Test is the most appropriate method for project monitoring, it requires a large amount of additional information, e.g., the abandonment values for all periods, and adds substantially to the computational requirements. The Full Cost Analysis and Marginal Cost Analysis methods are not considered appropriate. The Abandonment Test, on the other hand, is quite appropriate and is relatively easy to carry out. This test involves annually performing cash flow and NPV analyses 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 in 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 for our cash flow example (Table 2), how this test is performed.

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 flow at this time.

Table 12. Actual and estimated cost and revenue activities for a hypothetical investment example (Project was implemented 30 years ago).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year</th>
<th>Original Estimate</th>
<th>Actual or Revised Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site preparation</td>
<td>1</td>
<td>-50</td>
<td>-50</td>
</tr>
<tr>
<td>Planting</td>
<td>1</td>
<td>-100</td>
<td>-100</td>
</tr>
<tr>
<td>Weed Control</td>
<td>1</td>
<td>-15</td>
<td>-15</td>
</tr>
<tr>
<td>Pre-commercial</td>
<td>16</td>
<td>-50</td>
<td>-60</td>
</tr>
<tr>
<td>Thinning</td>
<td>Annual</td>
<td>-5</td>
<td>-5</td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>Thin</td>
<td>41</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Clearcut</td>
<td>61</td>
<td>2,500</td>
<td>2,500</td>
</tr>
</tbody>
</table>

Note, that all cost estimates except precommercial thinning turned out to be the same as originally estimated and that only the expected return for the currently planned commercial thinning (year 41) and has been revised upward due to temporarily higher current prices for timber. 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 $250. To decide whether to continue the project or to abandon it, we carry out a cash flow analysis utilizing the actual or revised values of Table 12. The result of this analysis are shown in Table 13.

Table 13. Financial summary for the hypothetical investment example assuming no inflation and a 5 percent discount rate.¹

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net present value</td>
<td>$42.08</td>
</tr>
<tr>
<td>Equivalent annual income</td>
<td>$2.22</td>
</tr>
<tr>
<td>Soil expectation value</td>
<td>$44.46</td>
</tr>
<tr>
<td>Benefits over costs</td>
<td>1.14</td>
</tr>
<tr>
<td>Years to payback at discount</td>
<td>60 years</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>5.36%</td>
</tr>
</tbody>
</table>

¹ All monetary values are in dollars per acre.
To properly compare the new NPV with the abandonment value of $250, we need to bring the NPV to the same time period as the time period of the project reevaluation, i.e., year 31. This is accomplished by compounding NPV using Equation 1 by 40 years. The result is:

$$42.08(1.05)^{40} = \$296.24$$

This value is larger than the abandonment value of the project, and we, therefore, would recommend that the project be continued at this time. An additional complication, beyond the scope of this paper, is that this test needs to naturally include considerations of sensitivity analysis. Under these additional considerations, the abandonment decision might not be as clear-cut because under certain factor combinations NPV could well be smaller than the abandonment value and we would recommend to abandon the project.

**ECONOMIC EVALUATIONS THROUGH APPLICATION OF THE MICROCOMPUTER**

As seen from the above hypothetical examples, evaluating all of the various potential alternatives can involve many mathematical calculations. This process can become very 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. Interest factors 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 application of these tools.

The General Economic Evaluation Program (GEEP) is a microcomputer investment analysis program that was developed for application on an IBM PC or IBM compatible computer with a minimum of 256K RAM. It is an interactive, user-friendly program written in Microsoft Basic. This program is described in detail in a User's Manual developed by Blinn, Rose, and Belli (1985). The program follows closely the format developed for the sample case described in this paper. It also performs sensitivity analyses as described above to simplify the task of interpreting cash flow results.
LITERATURE CITED


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