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Basic concepts in computer analysis of forestry investments

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Part I: Basic Concepts in Computer Analysis of Forestry Investments

By Steven H. Bullard and Thomas J. Straka

INTRODUCTION

In the last 20 years alone, computer hardware and software developments have dramatically increased our ability to calculate financial criteria quickly and accurately. While these advances have dramatically increased our ability to *calculate,* they have not replaced the need to *understand* what is being calculated, or how the results should be interpreted and applied. Our objective in the present article is to provide background information for understanding the "what" and "how" of computer applications for forestry investment analysis. We briefly discuss the most important financial criteria that are calculated by investment analysis computer programs; we also describe their recommended uses and briefly review important guidelines for forestry financial analysis in general.

In the following discussion, note that phrases like "present value" and "future value" indicate that specific compound interest formulas are used to compound or discount the dollar values involved in an analysis – the formulas simply account for the time value of the money involved. The compound interest formulas used in computer programs for analyzing forestry investments are not reviewed here, but are described in detail in basic references on the subject. An example is Basic Concepts in Forest Valuation and Investment Analysis (Bullard and Straka, 1993); much of the

"Computers ... have not replaced the need to understand what is being calculated, or how the results should be interpreted."

following discussion is from sections 3 and 4 of this reference.

FINANCIAL CRITERIA

Computer programs for forestry investment analysis often calculate and present several formal criteria. They are "formal" in the sense that they are calculated in a specific way. The criteria presented here are *Present Net Worth, Equivalent Annual Income, Benefit/Cost Ratio, Rate of Return,* and *Land Expectation Value.* The "realizable" or "composite" rate of return is also introduced.

Present Net Worth

Present Net Worth (PNW) is very commonly used to evaluate potential capital investments. PNW is the present value of all revenues *minus* the present value of all costs (Figure 1). PNW is thus *present* because all revenues and costs are discounted to the present with compound interest, and the criterion is *net* because the costs are subtracted from the revenues. Other names for PNW are *Net Present Worth, Present Net Value,* and *Net Present Value.*

As stated in Figure 1, a project is acceptable if its PNW is greater than or equal to zero. Other things equal, of course, a large PNW is "better" than a PNW relatively close to zero. The criterion does not, however, indicate the relative *scale* of a project. For a specific project, for example, if a result of PNW = $150 is obtained, the

Figure 1. Present Net Worth.

PNW is present because all costs and revenues are discounted to the present with compound interest formulas.

PNW is net because the present value of costs is subtracted from the present value of revenues.

Decision Rule: *The project is acceptable if PNW $\geq$ 0.*
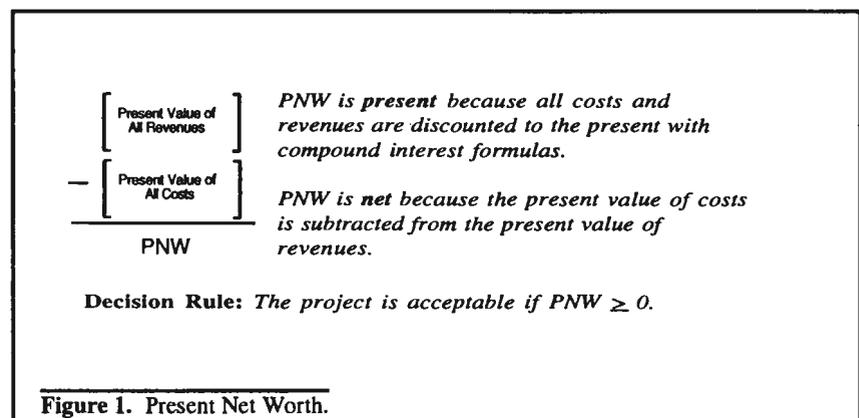
The Authors: Steven H. Bullard, Department of Forestry, Mississsippi State University, Box 9681, Mississippi State, MS, 39762-9681, and; Thomas J. Straka, Department of Forest Resources, Clemson University, 216 Lehotsky Hall, Clemson, SC, 29634-1003.

result does not indicate whether the project involves a few hundred dollars or several million dollars. It merely indicates that the project is expected to yield a rate of return greater than the interest rate used in the present value calculation.

Equivalent Annual Income

Projects of unequal duration can be compared by converting each project's PNW to an Equivalent Annual Income (EAI). To calculate EAI for a specific project, first calculate the project's PNW, then multiply the PNW by the "installment payment factor" – a specific compound interest formula (Figure 2). Other names for EAI are *Annual Equivalent* and *Equal Annual Equivalent.*

Calculating an EAI is analogous to responding to the question: *"If an amount equal to PNW is borrowed, what annual amount would be necessary to repay the loan?"* EAI is thus the *annual* amount that (if received) would be *equivalent* to a project's PNW.

Since PNW is expressed as an annual equivalent, EAI allows competing projects of different lives to be compared. In many cases, EAI is provided as information in addition to PNW; the concept of an annual income is perhaps more readily understood than the more abstract concept of present net worth. EAI is especially useful when comparing forestry activities with farming or other land uses with annual income.

Benefit/Cost Ratio

Benefit/Cost (B/C) ratios are obtained by *dividing* the total present value of revenues by the total present value of costs (Figure 3). The present value computations for B/C ratios are therefore exactly the same as for the PNW criterion; with the B/C ratio, however, a *ratio* is calculated rather than a present value *difference.* The B/C ratio may be interpreted as the present

value of dollars earned per dollar invested.

As shown in Figure 3, for a project to be acceptable, the B/C ratio should be greater than or equal to one. This simply means that the present value of revenues is greater than the present value of costs (the same decision rule as indicated for PNW and EAI).

B/C ratios are often used by government agencies, but the criterion is not as commonly used as PNW and rate of return in evaluating capital investment projects in the private sector.

Rate of Return

The rate of return (ROR) of a project is the rate of compound interest that is "earned" by the capital invested; it is the average rate of capital appreciation during the life of the project. ROR is calculated by finding the compound interest rate that equates the total present value of costs with the total present value of revenues (Figure 4). Other names for ROR are *Internal*

Rate of Return and *Return on Investment.*

The ROR criterion is very often used in project analysis. In fact, surveys of U.S. corporations over the last 20 years have consistently shown that ROR is the preferred choice of corporate managers for accept/reject investment decisions. In calculating and using ROR, however, caution is necessary in some cases.

While considering the rate of return or "internal" rate of return as an investment analysis criterion, it's necessary to introduce the "composite" or "realizable" rate of return criterion. Indeed, many of the computer programs used to evaluate forestry investments present this criterion as part of their standard output. This measure of investment performance is a good example of the need for analysts to understand what is calculated and presented by computer programs. As shown in the sidebar on the following page, forest economists have not universally accepted the com-

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(1) Calculate the project's PNW (as shown in Figure 1),

(2) Multiply the PNW by the term in brackets below:

$$EAI = PNW \left[\frac{i\ (1+i)^n}{(1+i)^n - 1} \right]$$

Where
"n" is the number of periods involved, and
"i" is the interest rate.

Decision Rule: *The project is acceptable if EAI $\geq$ 0.*

Figure 2. Equivalent Annual Income.

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(1) Discount all of the project's ▶ revenues to the present. $B = \left[\begin{array}{c} \text{Present Value of} \\ \text{All Revenues} \end{array} \right]$

(2) Discount all of the project's ▶ costs to the present. $C = \left[\begin{array}{c} \text{Present Value of} \\ \text{All Costs} \end{array} \right]$

(3) Divide the total present ▶   **B/C Ratio = B ÷ C**
value of revenues by the
total present value of costs.

Decision Rule: *The project is acceptable if B/C $\geq$ 1.*

Figure 3. Benefit/Cost Ratio.

To Calculate the Rate of Return of a Project:
(1) Assume an initial interest rate and calculate the total present value of revenues **[R]** and the total present value of costs **[C]**.

(2) Compare **[R]** and **[C]**. Through the iterative process illustrated at right, identify the ROR – the interest rate where **[R]** equals **[C]**.

If [R] > [C], the interest rate you used is less than ROR. *Increase the interest rate, recalculate [R] and [C], and compare again.*

If [R] = [C]. STOP. *The interest rate you used is the ROR.*

If [C] > [R], the interest rate you used is greater than ROR. *Decrease the interest rate, recalculate [R] and [C], and compare again.*
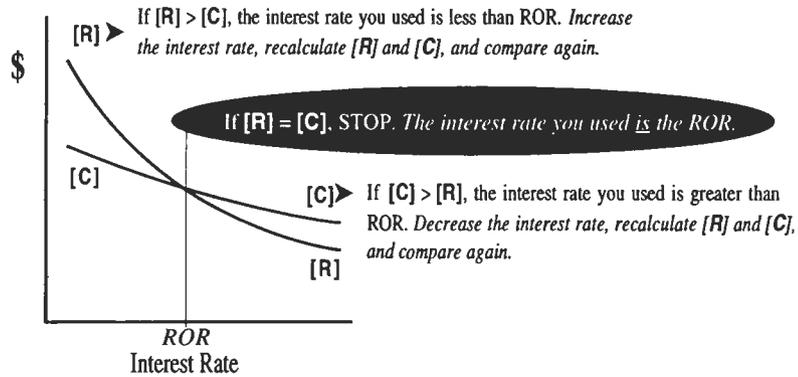
Decision Rule: *The project is acceptable if ROR ≥ the guiding rate of interest.*

Figure 4. Rate of Return.

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posite rate of return as appropriate. Before using the criterion, we recommend that analysts consult as many of these articles as needed to fully understand the criterion's development, potential problems, and potential uses as an aid to decision making.

Some cautions in using ROR:
- For the criterion to be meaningful, there must be an initial cost, or the costs toward the beginning of the investment must be substantial enough that an average rate of capital appreciation is meaningful.
- If an analysis has revenues but costs are excluded entirely, the average rate of capital appreciation is infinite; also, if costs are understated or very insignificant, the ROR will be extremely high.
- ROR does not indicate the scale of an investment.
- In some cases there may be multiple ROR's – more than one interest rate at which the present value of revenues and the present value of costs are equal.

Land Expectation Value
Land Expectation Value (LEV) is an estimate of the value of a tract of land for growing timber. It is the present net value of *all* revenues and costs

Composite Rate of Return

The "composite" or "realizable" rate of return has been proposed as an improvement over the "internal" rate of return described above. The composite rate is calculated by: (1) compounding all intermediate cash flows to the end of the investment period (using an interest rate that reflects the actual or "realizable" potential for reinvestment), and then (2) determining the interest rate that will equate the initial costs with the compounded value of the project's cash flows. The criterion is not presented here in detail because it's not universally accepted as a useful and valid criterion for investment analysis. It is, however, presented with other output by several forestry investment analysis computer programs.

Articles describing the criterion and its advantages and disadvantages include:
Foster, B.B. 1982. Economic nonsense. (Letter to the editor on the composite rate of return). J. For. 80(9):566.

Foster, B.B. and G.N. Brooks. 1983. Rates of return: Internal or composite? (see Harpole, 1984) J. For. 81(10):669—670.

Foster, B.B. 1984. A service forester's guide to investment terminologies — which ones are most easily understood by landowners? South. J. Appl. For. 8(3):115—119.

Harpole, G.B. 1984. "Rates of return: Internal or composite?" — A response. (see Foster and Brooks, 1983) J. For. 82(9):558—559.

Klemperer, W.D. 1981a. Interpreting the realizable rate of return. (see Schallau and Wirth, 1981, and Klemperer, 1981b) J. For. 79(9):616—617.

Klemperer, W.D. 1981b. Interpreting the realizable rate of return: A rejoinder (see Schallau and Wirth, 1981, and Klemperer, 1981a) J. For. 79(10):673.

Marty, R.J. 1969. The composite internal rate of return. For. Sci. 16:276—279.

Schallau, C.H. and M.E. Wirth. 1980. Reinvestment rate and the analysis of forestry enterprises. J. For. 78(12):740—742.

Schallau, C.H. and M.E. Wirth. 1981. "Interpreting the realizable rate of return": A reply. (see Klemperer, 1981a and 1981b) J. For. 79(9):618.

spond to this question is a very important part of effectively using computer programs for evaluating forestry investments. Most programs allow you to select the criterion to calculate, or they present you with calculated values for several of the investment criteria discussed above. Does it matter which criterion you use, and if it does matter, which one is best for your analysis situation?

FURTHER GUIDELINES for FORESTRY FINANCIAL ANALYSIS

Computer programs for analyzing forestry investments differ in their specific purposes and they vary a great deal in their level of sophistication (see the article in this issue comparing four programs, for example). No matter how sophisticated the program, however, the *analyst* must ensure that the numbers used are consistent in terms of taxes and inflation, for example, and that they are as accurate as possible; the analyst must also ensure that the overall analysis procedure is appropriate.

For general guidance, in this section we've summarized some of the most important issues for the analyst to address.
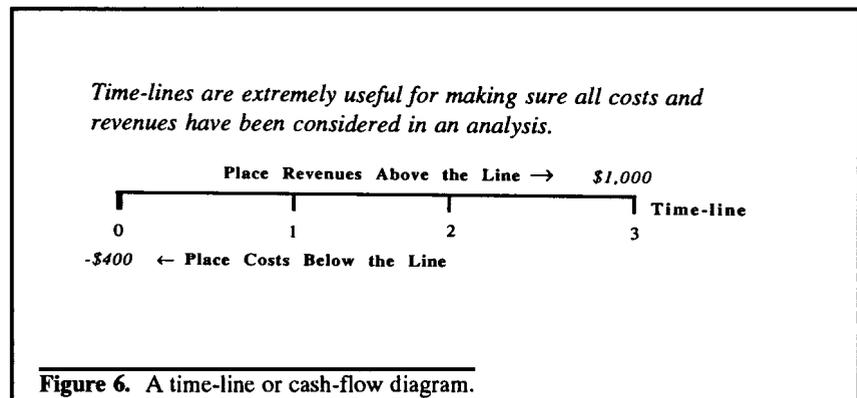
Begin with a "Time-Line"
Once the costs and returns for a specific project are known or projected, a very useful device is to place the numbers on a "time-line" or "cash-flow" diagram (Figure 6). The diagram is simply a line representing the time period involved in the investment, with all of the costs and revenues placed on the line at the appropriate points (times). If the analysis involves both costs and revenues, costs are typically placed below the line and revenues above the line. By drawing a simple time-line, the analyst can make sure that all of the relevant costs and revenues will be entered into the computer program.

Ignore "Sunk" Costs
Project analysis is often called "marginal analysis" since only the *added* costs and *added* benefits of a potential investment are considered. Costs that have *already* been incurred, meanwhile, are "sunk" in the sense that they have already been made and cannot be changed. "Sunk" costs are outside the realm of current decisions, and therefore should *not* be included in calculating PNW, ROR, or other financial criteria for a specific project. If you own a certain property or production facility, for example, the *past costs of the asset are irrelevant to decisions about future uses of the property.* The current value of the property, equipment, or other asset may be relevant, but the price paid for the asset in the past is irrelevant (other than in a historical rate of return context).

Include "Opportunity" Costs.
When a resource is put to a particular use, opportunities for using the resource in other ways are affected – some alternative uses, or opportunities, for the resource may no longer be possible. These opportunities are foregone, and foregone opportunities often include foregone revenues or other benefits. Alternative uses therefore often involve *"opportunity costs"* – revenues foregone by using a resource such as land or capital for a specific purpose. By using a positive interest rate to account for the time value of money in an investment analysis, we're recognizing the fact that the funds have alternative uses; by investing funds in a specific forestry project, we're foregoing the income that would be earned on the funds if they were invested in other forestry or non-forestry activities.

Time-lines are extremely useful for making sure all costs and revenues have been considered in an analysis.

Place Revenues Above the Line → $1,000

| | | | |

0   1   2   3

-$400 ← Place Costs Below the Line

Figure 6. A time-line or cash-flow diagram.

An Example of Sunk Costs

Last year you spent $80 per acre for site preparation and planting. You're now considering the need for a herbicide application that will increase seedling survival...

* The $80 per acre you've already spent cannot be changed and is therefore *not* relevant to your herbicide decision. It should not be placed on the project's time-line or entered into a computer program to evaluate the herbicide treatment.

* *What is relevant?* The physical characteristics of the site and the current biological opportunities for release are quite relevant to your analysis and decision — you now have an asset that has attributes related to the site prep and planting. The actual expenses you incurred to achieve the attributes of your stand, however, cannot be changed and are *not* relevant to future decisions.

associated with growing timber on the land (not just those associated with one rotation or other time period). As shown in Figure 5, LEV is a special case of PNW – it is PNW where revenues and costs from *all* future rotations are considered. LEV can be interpreted as the maximum price you can pay for a tract of land for growing timber – if you expect to earn a rate of return greater than or equal to the discount rate used to calculate LEV.

If you estimate the present net *value* of all cash flows *expected* from growing timber on a specific tract of *land*, the expected value of the land has been estimated (hence the name "Land Expectation Value"). The LEV criterion is also called "soil expectation value" and "bare land value" since many applications assume the cash flow stream begins with bare land. Also, LEV is sometimes called the "Faustmann formula." The technique was first published in 1849 by Martin Faustmann, a German forester who developed the formula to place values on bare forest land for tax purposes.

LEV is the theoretically correct criterion for determining the optimal management regime and rotation age for a given species on a specific site. The optimal management strategy and age for final harvest is the combination that yields the highest value for LEV.

Two cautions should be noted regarding the calculation of LEV. First, do not include a land purchase price in the cash flow stream. This is not an expense that will be repeated in future rotations, and besides, land value *is* the value of the LEV calculation. Second, do not start the calculations in mid-rotation. Compute the LEV of subsequent full rotations, then add the PNW of the current rotation.

RECOMMENDED USES for SPECIFIC FINANCIAL CRITERIA

Which criterion is most appropriate for your analysis? Being able to re-

1. Determine all of the costs and revenues associated with the *first* rotation. These values should include initial costs of planting, site preparation, etc., as well as *all* subsequent costs and revenues.

2. Place the costs and revenues on a timeline and compound all of them to the end of the rotation. Subtract the costs from the revenues

$$LEV = \frac{\text{Compounded Revenues} - \text{Compounded Costs (compounded to the end of the 1st rotation)}}{(1+i)^n - 1}$$

3. Use the present value of a perpetual periodic series formula to calculate the present value of an infinite series of identical rotations. (Divide by $(1+i)^n - 1$ where n is the rotation length.)

Decision Rule: *There is no specific decision "rule" for using LEV, but the criterion can be interpreted as an estimate of the dollar value of bare land for growing timber, given the assumptions used in deriving timber yields, prices, etc. It thus represents the amount of money that the investment is expected to yield over and above the interest rate that was used.*

Figure 5. Land Expectation Value.

A specific investment analysis is normally intended to address one of the two questions below:

Is this particular investment profitable?	How do I choose between two (or more) profitable investments?
PNW, B/C, EAI, and ROR will result in the same answer to this question. That is, if PNW ≥ 0, then EAI ≥ 0, B/C ≥ 1, and ROR is greater than the guiding rate of return. This means, of course, that preference may play a role in selecting which criterion is best to address the above question. 　ROR is often preferred, perhaps because of its intuitive appeal. Surveys have shown ROR to be the criterion most often used in forest industry. ROR is also popular with nonindustrial private landowners considering forestry investments versus alternative rates of return. 　B/C ratios are most often used by U.S. government agencies.	PNW is the criterion most often recommended for comparing profitable, mutually exclusive investment alternatives. EAI is an extension of PNW, and may be preferred if the choices compared are alternative land uses such as annual rent from crop or pasture land. EAI is also used to compare investments of unequal duration. Note that LEV is also an extension or a special case of PNW. LEV is the most appropriate criterion for selecting the optimal rotation age and management regime for timber on a particular tract of land. LEV is most appropriate because it considers all of the present and expected future income and costs on a property. This is also the criterion to use when determining the maximum price that can be paid for bare land if the land is to be used to grow timber.

Table 1. Summary of recommended uses for the financial criteria discussed in this article.

There are many examples of opportunity costs in forestry investment analysis. A very important example is the opportunity cost of *forest land.* As shown in the example below, the fact that we are using a specific tract of land for a forestry investment means that the dollar value of the land is "tied up" during the period of the investment. In the example, we've got $150 per acre "tied up" in the land for the entire period of the investment (27 years); unless we add this value to our time-line and thus to the numbers we enter into an investment analysis computer program, the PNW, ROR or other criteria that are calculated will be overstated. They simply will not reflect all of the costs that are relevant to our investment.

Should You Account for Taxes?
American writer H.L. Mencken has been quoted as saying "*To all complex questions there are simple answers – and they're all wrong.*" Whether or not you should incorporate taxes in a specific forestry investment analysis is one of those questions without a simple answer. We can, however, generalize in at least one way – if you *do* account for taxes, your analysis results will more accurately reflect the true profitability of a specific investment.

The tax aspects of forestry investments can be significant, and taxes can therefore affect the overall profitability of an individual project, or they may affect the order of ranking of profitable investments. To incorporate taxes, however, one must have knowledge of specific tax laws for forestry costs and revenues, or the analyst must rely on computer programs that calculate PNWs or other criteria on an after-tax basis "automatically," i.e., with minimal input from the user.

Should You Account for Inflation?
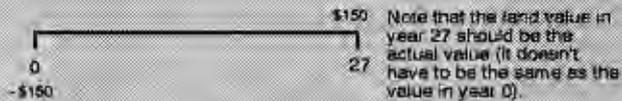Inflation must be considered in any analysis involving revenues and/or costs that occur in the future. You must account for inflation by making sure that the discount rate and all values on the investment time-line are in inflated terms, or that they are all in uninflated terms. If you're *consistent,* whether you use inflated or uninflated terms won't impact the outcome of your analysis in many cases. If the investment doesn't involve costs that are "capitalized" for tax purposes, you may choose to state the discount rate and all costs and revenues in "nominal" or inflated terms, or you may state them in "real" or uninflated terms – the PNW, B/C or other results of the analysis will be exactly the same in either case. If inflation is treated consistently throughout the analysis, the inflation cancels out of the compound interest formulas (Gregersen 1975, Klemperer 1979). If capitalized costs *are* involved in a forestry analysis, inflation should be included in the discount rate and in all costs and revenues. In such cases, excluding inflation will result in overstated PNWs, etc., because the erosion in present value of capitalized cost deductions will reflected.

Accounting for Uncertainty
Rarely are all of the physical and financial values of a project known with certainty. Cost savings, future yields

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An Example of Opportunity Costs

$150   Note that the land value in year 27 should be the actual value (it doesn't have to be the same as the value in year 0).

The investment time-line above has a land "cost" of $150/acre entered at year 0, and a "revenue" of $150/acre at the end of the rotation. Although the land may not actually be bought or sold, if we include the values on our time-line, PNWs or other criteria that we calculate will reflect the fact that we've had this much money effectively "tied up" –not available for use elsewhere – during the 27-year period. Our results will therefore reflect the opportunity cost of the land. Note that land opportunity costs are not included in LEV calculations (since the LEV we calculate is the land value).

Consistency in Accounting for Taxes

In an after-tax analysis, it is extremely important to be consistent. *All* of the numbers involved — the costs, the revenues, *and* the discount rate — should be expressed on an after-tax basis (Bullard and Straka 1992). If a time-line is used, all of the revenues should be placed on the diagram after taxes have been subtracted and all of the costs should also be placed on an after-tax basis. If the costs are deductible, for example, the tax savings from the deduction(s) must be accounted for. The discount rate used to calculate PNW, B/C or other criteria must also be an after-tax discount rate, and it should be a nominal rate if capitalized costs are involved. For more information on after-tax analysis in general, see Bullard and Straka (1993). An excellent source for more information on tax law specifics is Hoover et al. (1989).

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and revenues, sales and profit increases, etc., are typically estimated based on the best information available at the time a potential forestry project is evaluated.

Various techniques to account for uncertainty have been advanced in financial analysis and engineering economy texts and articles. The techniques include such methods as calculating "certainty equivalents" and methods to adjust the discount rate upward for riskier projects. A frequently applied means of considering the potential impacts of uncertainty is *"sensitivity analysis"* – an orderly or systematic examination of how different assumptions influence PNW, ROR, or other criteria, and therefore how they may influence the accept/reject decision for a project. You may feel there is a great deal of uncertainty in projecting timber prices at the end of a rotation that is several decades long, for example. You may also find, however, that because they are discounted for long periods, considering wide ranges of future prices in your analysis has relatively little impact on PNW or other financial criteria. [See the following article by Nodine for more information on this subject.]

Computer programs for forestry investment typically allow the user to change selected inputs, and the program then recalculates PNW and other criteria. These programs make sensitivity analysis a relatively easy way to evaluate the potential impacts of changing values for which you are highly uncertain.

Obtaining a Discount Rate
The discount rate used to evaluate a specific project should be consistent with the rest of the numbers in the analysis in terms of taxes and inflation. That is, the rate used may be real or inflated, and it may be specified as before or after taxes; how the rate is specified should be consistent with the overall analysis. In many cases, the

Common Inconsistencies in Accounting for Inflation

The most important aspect of accounting for inflation is **consistency** — either include inflation in the discount rate and in all costs and revenues, or leave it out entirely.

• *It's inconsistent to use an inflated interest rate to discount uninflated dollar values.* This error occurs, for example, when an interest rate that includes inflation is used to discount future timber sale revenues that are obtained by multiplying future timber volumes by the prices that prevail *today* (uninflated values).

• *It's inconsistent to calculate a forestry project's ROR without considering inflation, and then compare the ROR with an alternative rate of interest that does include inflation.* Comparing an uninflated ROR for a forestry investment with the interest rate earned at a bank, for example, is inappropriate since the bank rate includes inflation — you expect to receive the rate of interest they quote regardless of the rate of inflation that occurs.

actual rate of interest that's appropriate to use in forestry and natural resources analyses depends on who owns the land or other resource:

Public Agencies. Discount rates for public agencies are often specified by law. The federal government, for example, requires that agencies use a "real" rate (uninflated) of 10% unless a special rate, formula, or other guideline is set by law. The USDA Forest Service currently uses a "real" rate of 4% for long-term investments (generally more than 10 years), and 10% for other, shorter-term investments. For further information, see Row et al. (1982) and the reference to the USDA Forest Service Economic Analysis Manual (1984 draft).

Corporations. Publicly-held corporations usually define discount rates as a weighted average cost of capital (the cost of debt capital and the cost of equity capital weighted by the firm's percentage of debt and equity). Privately-held companies typically specify a discount rate by considering alternative uses for the capital (the "alternative" rate), or by the interest rate paid on borrowed capital.

Private Individuals. Individuals may specify their discount rate by considering alternative uses for their capital – alternative rates may thus be the rate they expect to earn on other investments, or they may be the rates they are paying on borrowed capital. Each landowner is different, however, and discussion may be needed to elicit an individual landowner's preferences for money today versus money in the future. While many factors may influence an individual's rate of time preference for money, perhaps the most important one is their current wealth – the amount of money and other assets they already have available for current and expected future needs.
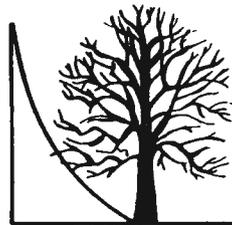
DISCUSSION

As we stated in the *Introduction,* rapid advances in computer technologies have not replaced or reduced the need to understand what software programs calculate or how their output should be interpreted and applied. Forestry investment analysis programs are no exception, of course, and analysts should fully understand the "what" and "how" of the applications software they use.

Our discussion of basic concepts in computer analysis of forestry investments is, of course, limited here by space. We've therefore summarized some of the most important aspects of understanding and using the investment software that's available to today's forest managers, but we haven't fully explored any of the concepts, methods, or uses of the criteria. Managers may need more information on key topics such as after-tax analysis or whether or not the composite rate of return should be used, for example. We therefore conclude by emphasizing the references listed on these and other important topics. As we also stated in the *Introduction*, much of the discussion here was from material included in "Basic Concepts in Forest Valuation and Investment Analysis" by Bullard and Straka (1993). This reference is described more fully in this issue in Selecting *"Forestry Finance Software"* by Stephen Nodine.

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