Financial Analysis for Forest Resource Managers

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Financial Analysis for Forest Resource Managers
Foresters’ Forum, Coeur d’Alene, Idaho, February 8, 2012
(4 Pro-Logger / 3.5 CFE credits available)

Basic tools for financial analysis: Compound Interest, Discounted Cash Flow, Net Present Value (NPV), Land Expectation Value (LEV), and Internal Rate of Return (IRR). Bring a laptop to practice on examples. Speaker: Jay O’Laughlin, University of Idaho, Professor of Forestry & Policy Sciences.

* [http://www.consulting-foresters.com/foresterforum/?id=presentations](http://www.consulting-foresters.com/foresterforum/?id=presentations)
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OUTLINE

Introduction
Who’s here & what do participants want to know?
Difference between financial analysis and economic analysis
Financial analysis process steps

Returns to a forest management investment (see REFERENCE [1] p. 32-38)
Review EXAMPLE PROBLEMS (see below)

Compound interest formula: \( V_n = V_0 \left(1 + \frac{i}{n}\right)^n \) (see REF [1] p. 44, [2] p. 3-4)

Problem 1: Computing compound growth with a spreadsheet (Sheet 1)

Problem 2: Optimal harvest age — tree growth & guiding interest rate (Sheets 2-6)

Discounted cash flow method and forest management decision criteria

Problem 3: Optimal management alternative — comparison of NPV & LEV (Sheets 7-10)

Problem 4: Computing forest management investment IRR on a spreadsheet (Sheet 10)

Questions and discussion: What was not covered that you want to know about?

EXAMPLE PROBLEMS (revised)

1. An 80-year-old northern Idaho naturally regenerated timber stand is fully stocked with 19,069 board feet acre (bfa) of Douglass-fir and grand fir, site index 70. At age 80, the stand table shows 24,513 bfa (Sheet 2; REF [3] Table 1). What is the average annual growth rate from age 80 to 90? (Use the compound interest formula calculator on Sheet 1.) When you are confident of your answer then, fill in the black cells in Sheet 2 by copying the formulae in cells C10.E10 into cells C11.E23. Using increment of timber volume (Sheet 2 column D), what is the optimal cut age? At that age, what is the growth rate the owner would be willing to accept?

2. The landowner has an objective to maximize long-term financial returns from sustainable timber management. She has heard that Douglass-fir plantations management may be a good choice. After calculating the tree growth rates for the four management alternatives (Sheets 3-6) and assuming a final harvest in year 80, which alternative may be best? Sheet ______

3. Using a growth rate of return of 5% (see REF [1] p. 18-22, 90), determine the NPV and LEV for the four plantation management alternatives (Sheets 3-6) (see REF [1] p. 16-18; [2] p. 5-6) and then determine which alternative is preferred from the financial point of view.

Note: The guiding rate or return is also called the alternative rate of return, hurdle rate, or discount rate. LEV is closely related to NPV. It is a perpetual periodic series of NPVs from the same timber management regime repeated again and again (see REF [1] p. 16-18, 50-52; [2] p. 7).

EXAMPLE PROBLEMS (cont.)

3. (cont.)

Proceed by copying the standing volume at ages 60, 70, etc., in column B one-by-one into the appropriate cell in columns O through S. Then enter unit values for $/mbf (use $175), $ green ton (use $1), interest rate (use .05), planting costs in year 0 (use $175) and pre-commercial thinning costs in year 20 (use $150). The costs should be entered as a negative value.

A. Determine the optimal harvest age for the no-thin alternative (Sheet 7 ______), the pre-commercial thin only alternative (Sheet 8 ______), the thin-from-below alternative (Sheet 9 ______) and the thin-from-above alternative (Sheet 10 ______). Which is better financially?

B. Determine the NPV and LEV for the four alternatives at the optimal rotation age @ 5%

NPV @ 5% Sheet 7 Sheet 8 Sheet 9 Sheet 10
LEV @ 5% Sheet 7 Sheet 8 Sheet 9 Sheet 10

C. Rede the NPVs and LEVs at an interest rate of 3%

NPV @ 3% Sheet 7 Sheet 8 Sheet 9 Sheet 10
LEV @ 3% Sheet 7 Sheet 8 Sheet 9 Sheet 10

Which alternative is best from a business point-of-view?

C. Are the NPV and LEV replies to the question consistent?

("Unusual project lives" problem; see REF [2] p. 10-11)

4. Calculate the IRR for the optimal harvest age determined above for all four alternatives.

Note: IRR is the interest rate at which NPV = 0 (REF [1] p. 17)

Sheet 7 ______ Sheet 8 ______ Sheet 9 ______ Sheet 10 ______

WORKSHEETS (in file: worksheets_financial_analysis_shortcourse_jayOLaughlin_2-8-2012)

Sheet 1. CALCULATOR — COMPOUND INTEREST Formula: \( PV = FV \times \frac{(1 + i)^n - 1}{i} \)

Sheet 2. GROWTH RATE CALCULATOR — naturally regenerated grand fir / cedar-hardwood stands.

Sheet 3. GROWTH RATE CALCULATOR — Douglas-fir plantations, 500 trees / ac @ 5 yrs., no thinning.

Sheet 4. GROWTH RATE CALCULATOR — Douglas-fir plantations, pre-commercial thinning @ 20 yrs.

Sheet 5. GROWTH RATE CALCULATOR — Douglas-fir plantations, pre-commercial thinning @ 20 yrs., thinnings to 100 trees / ac @ 5 yrs.

Sheet 6. GROWTH RATE CALCULATOR — Douglas-fir plantations, pre-commercial thinning @ 20 yrs., thinning to above to 100 trees / ac @ 5 yrs.

Sheet 7. FINANCIAL ANALYSIS — Douglas-fir plantations, 500 trees / ac @ 5 yrs., no thinning, optimal final harvest is maximum LEV.

Sheet 8. FINANCIAL ANALYSIS — Douglas-fir plantations, pre-commercial thinning @ 20 yrs., optimal final harvest in maximum LEV.

Sheet 9. FINANCIAL ANALYSIS — Douglas-fir plantations, pre-commercial thinning @ 20 yrs., thinnings below to 100 trees / ac @ 50 yrs., optimal final harvest in maximum LEV.

Sheet 10. FINANCIAL ANALYSIS — Douglas-fir plantations, pre-commercial thinning @ 20 yrs., thinnings from above to 100 trees / ac @ 50 yrs., optimal final harvest in maximum LEV.
Selected Yield Tables for Plantations and Natural Stands in Inland Northwest Forests
Albert R. Sipe
David L. Remerr
Roger C. Chapman

Endowment Fund Reform and Idaho’s State Lands: Evaluating Financial Performance of Forest and Rangeland Assets
by Jay O’Laughlin and Philip S. Cook

Economically Sustainable Working Forests: Financial Analysis Principles and Applications
October 24, 2005

Kevin W. Zobrist
Real Estate Institute
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The "maximum long term financial return" goal of the Idaho Constitution could be attained more effectively if managers viewed land as a fiscal, not physical, asset.

The "maximum long term financial return" goal of the Idaho Constitution could be attained more effectively if managers viewed land as a fiscal, not physical, asset.
**Handouts – Process Diagram & Formula**

### Financial Analysis Process

1. **Specify Objective(s)**
2. **Identify Alternatives for Meeting Objective(s)**
3. **For Each Alternative:**
   - **Define Physical Relationships of Inputs–Outputs & Timing**
4. **Estimate Unit Values of Physical Inputs & Outputs**
5. **Develop Cash Flow Table**
6. **Compute Decision Criteria (NPV, IRR, etc.)**
7. **Analyze Uncertainty (Sensitivity Analysis)**

### Cheat Sheet

**Compound Interest and Discounted Cash Flow Decision Criteria Formulae**

**Variables**
- $r$ = annual rate
- $T$ = time
- $F$ = future value
- $P$ = present value
- $I$ = interest
- $r$ = effective rate
- $n$ = number of periods

**Formulas**
- **Future Value (FV)**: $FV = PV(1+i)^T$
- **Present Value (PV)**: $PV = FV/(1+i)^T$
- **Net Present Value (NPV)**: $NPV = \sum_{t=0}^{n} \frac{R_t}{(1+i)^T}$
- **Internal Rate of Return (IRR)**: $IRR = \sum_{t=0}^{n} \frac{R_t}{(1+i)^T}$
- **Benefit/Cost Ratio**: $B/C = \sum_{t=0}^{n} \frac{B_t}{C_t}$

**Land Expectation Value (LEV)**: $LEV = NPV \times 1/(1+i)^T$

**Equal Annual Equivalent (EAE)**: $EAE = NPV \times 1/(1+i)^T$

**Composite Rate of Return**: $CRR = \sum_{t=0}^{n} \frac{R_t}{(1+i)^T}$

**Benefit/Cost Ratio**: $B/C = \sum_{t=0}^{n} \frac{B_t}{C_t}$
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Introduction
- Who’s here & what do participants want to know?
- Difference between financial analysis and economic analysis
- Financial analysis process steps
- Returns to a forest management investment (see REFERENCE [1] p. 32-38)
- Review EXAMPLE PROBLEMS (see below)

Compound interest formula: \( V_n = V_0 (1 + i)^n \) (see REF [1] p. 44; [2] p. 3-4)
- Problem 1. Computing formula variables with a spreadsheet (Sheet 1)
- Problem 2. Optimal harvest age—tree growth & guiding interest rate (Sheets 2-6)

Discounted cash flow method and forest management decision criteria
- Problem 3. Optimal management alternative—computation of NPV & LEV (Sheets 7-10)
- Problem 4. Computing forest management investment IRR on a spreadsheet (Sheet 10)

Questions and discussion: What was not covered that you want to know about?
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Questions and discussion: What was not covered that you want to know about?
Financial analysis step-by-step

1. Specify Objective(s)
2. Identify Alternatives for Meeting Objective(s)
   - For Each Alternative:
3. Define Physical Relationships of Inputs—Outputs & Timing
4. Estimate Unit Values of Physical Inputs & Outputs
5. Develop Cash Flow Table
6. Compute Decision Criteria (NPV, IRR, etc.)
7. Analyze Uncertainty (Sensitivity Analysis)

- Most Difficult
- More Difficult
- Easier
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Questions and discussion: What was not covered that you want to know about?
Forestry investment return components

- Timber growth
Forestry investment return components

- **Timber growth**
- **Stumpage price increase**

**Graph:**
- **Y-axis:** $/mbf
- **X-axis:** Years from 1970 to 2004
- **Legend:**
  - [Graph Data]

**Notes:**

Zobrist (2005, p. 9)
Forestry investment return components

- **Timber growth**
- **Stumpage price increase**
- **Land value increase**

Land value for growing timber may be calculated using a compound interest formula. Increasing that value for future land use change is highly speculative and problematic.

The Land Expectation Value (LEV) represents the maximum additional outlay that could be made at the beginning of the rotation for the actual purchase of the land while still earning the target rate of return on the total investment. Thus LEV is also considered the maximum willingness to pay for land for forestry use given management expectations (Zobrist 2005, p.7).
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Questions and discussion: What was not covered that you want to know about?
Formulae

[FV] Future Value … \( V_n = V_0 (1 + i)^n \)

[PV] Present Value … \( V_0 = \frac{V_n}{(1 + i)^n} \)

\[ n \] number of years … \( n = \frac{\ln \left( \frac{V_n}{V_0} \right)}{\ln (1 + i)} \)

\[ i \] interest rate … \( i = \left( \frac{V_n}{V_0} \right)^{\frac{1}{n}} - 1 \)

Leak Avoidance Value … \( LEV = \frac{NPV (1 + i)^n}{(1 + i)^n - 1} = \frac{NPV}{((1 + i)^n - 1)} \)

Equal Annual Equivalent … \( EAE = \frac{NPV * i}{((1 + i)^n - 1)} \)

Internal Rate of Return … \( 0 = \sum_{t=0}^{n} \frac{R_t - C_t}{(1 + IRR)^t} \) \text{ or } \( 0 = \sum_{t=0}^{n} \frac{R_t (1 + IRR)}{(1 + IRR)^t} - \sum_{t=0}^{n} C_t (1 + IRR)^t \)

Composite Rate of Return … \( 0 = \sum_{t=0}^{n} \frac{R_t (1 + k)^n}{(1 + CRR)^t} - \sum_{t=0}^{n} C_t (1 + CRR)^t \)

Benefit-to-Cost ratio … \( B/C = \frac{\sum_{t=0}^{n} R_t (1 + i)^{n-t}}{\sum_{t=0}^{n} C_t (1 + i)^{n-t}} \)
Financial calculator . . .

Formulae

[FV] Future
[PV] Present
[n] number of
[i] interest rate

CHEAT SHEET

Compound Interest and Discounted Cash Flow Decision Criteria Formulae

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F = exponential function</td>
<td></td>
</tr>
<tr>
<td>0 = year zero, or present time</td>
<td></td>
</tr>
<tr>
<td>a = amount of payment (R - C) produced annually or periodically (i.e., every p years)</td>
<td></td>
</tr>
<tr>
<td>B = Benefit (in discounted cash flow analysis, Revenue or cash receipt)</td>
<td></td>
</tr>
<tr>
<td>C = Cost (in discounted cash flow analysis, Cost or cash expenditure)</td>
<td></td>
</tr>
<tr>
<td>D / C = Discounted Cost ratio</td>
<td></td>
</tr>
<tr>
<td>CRR = Composite Rate of Return (decimalized)</td>
<td></td>
</tr>
<tr>
<td>Interest rate 5% then decimalized interest</td>
<td></td>
</tr>
</tbody>
</table>

Load Expectation Value

Equal Annual Equivalent

Internal Rate of Return

Composite Rate of Return

Benefit-to-Cost ratio
### Spreadsheet

#### Sheet 1. CALCULATOR — COMPOUND INTEREST

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sheet 1. CALCULATOR — COMPOUND INTEREST</td>
<td>Formula: $FV = PV \left(1 + i\right)^n$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Data Entry*</td>
<td></td>
<td>Result**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>PV</td>
<td>#VALUE!</td>
<td>PV</td>
<td>Present Value (or $V_0$, Value in time period zero)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FV</td>
<td>#VALUE!</td>
<td>FV</td>
<td>Future Value (or $V_n$, Value in time period $n$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>n</td>
<td>#VALUE!</td>
<td>n</td>
<td>number of time periods (usually years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>i</td>
<td>#VALUE!</td>
<td>i</td>
<td>interest rate (decimalized; e.g., if $i = 5%$, $i = .05$)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Enter numeric value for 3 of the 4 parameters.

Round PV and/or FV to the nearest unit (resize columns if PV or FV is > 1 billion).

Use decimalized interest rate (e.g., if $i = 5\%$, enter as .05).

Leave blank the cell for the 4th parameter (i.e., what you are calculating);
move cursor to the 4th parameter cell, computed value is in Result column.

** Result for the 4th parameter is displayed; #VALUE! notation appears because each calculation
formula computes the missing 4th parameter value from the other 3 values entered.
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Selected Yield Tables for Plantations and Natural Stands in Inland Northwest Forests

Albert R. Stage
David L. Renner
Roger C. Chapman

Figure 5—Distribution of natural regeneration site index values for Inland Northwest forests of the grand fir/cedar/hemlock ecosystem.
### Example Problems (revised)

1. An 80-year-old northern Idaho naturally regenerated timber stand is fully stocked with 19,069 board feet/acre (bf/ac) of Douglas-fir and grand fir, site index 70. At age 90, the stand table shows 24,513 bf/ac (Sheet 2: REF [3] Table 1). What is the average annual growth rate from age 80 to 90? ____ (Use the compound interest formula calculator on Sheet 1.) When you are confident of your answer then, fill in the blank cells in Sheet 2 by copying the formulae in cells C10:E10 into cells C11:E23.
Yield table: naturally generated

### EXAMPLE PROBLEMS (revised)

1. An 80-year-old northern Idaho naturally regenerated timber stand is fully stocked with 19,069 board feet/acre (bf/ac) of Douglas-fir and grand fir, site index 70. At age 90, the stand table shows 24,513 bf/ac (Sheet 2; REF [3] Table 1). What is the average annual growth rate from age 80 to 90? ____ (Use the compound interest formula calculator on Sheet 1.) When you are confident of your answer then, fill in the blank cells in Sheet 2 by copying the formulae in cells C10:E10 into cells C11:E23. Using increment of timber volume (Sheet 2 column D), what is the optimal clearcut harvest age? ____ At that age, what is the growth rate the owner would be willing to accept? ____
2. The landowner has an objective to maximize long-term financial returns from sustainable timber management. She has heard that Douglas-fir plantation management may be a good choice. After calculating the tree growth rates for the four management alternatives (Sheets 3-6) and assuming a final harvest in year 80, which alternative may be best? Sheet ____
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Questions and discussion: What was not covered that you want to know about?
Land and timber valuation

The principles of discounted cash flow analysis can be used to determine the economic value of forestland and timber (Faustmann 1849). In the case of bare land, the economic value for forestry use is the NPV of expected future revenues and costs. This value is not limited to a finite period of time, such as a single forest rotation, as the land does not end up with zero value at the end of the rotation. Rather, the land retains the same earning potential it started with, as the rotation could be repeated or the land could be sold to someone else for the same use. Because there is always that residual value at the end of a use cycle, the full economic value of land must consider its potential to provide economic benefits in perpetuity.

The economic value of bare land is called soil expectation value (SEV) or land expectation value. SEV is the NPV, given expected future cash flows, of growing timber in perpetuity starting with bare land. As such it represents the maximum additional outlay that could be made at the beginning of the rotation for the actual purchase of the land while still earning the target rate of return on the total investment. Thus SEV is also considered the maximum willingness to pay for land for forestry use given management expectations (Klemperer 1996).
Land Expectation Value (LEV = SEV)

\[ SEV = \frac{-E(1+i)^R \pm M_T(1+i)^{(R-T)} + H_R}{(1+i)^R - 1} - \frac{a}{i} \]

Where:
- SEV = Soil expectation value
- E = Establishment cost
- \( M_T \) = Mid-rotation cash flow in year \( T \)
- \( H_R \) = Final harvest revenue in year \( R \)
- \( R \) = Rotation length
- \( a \) = Annual overhead costs
- \( i \) = Interest rate

Zobrist (2005, p. 7)
Formulae...

CHEAT SHEET
Compound Interest and Discounted Cash Flow Decision Criteria Formulae

Variables:
- \( n \) = exponential function
- \( 0 \) = year zero, or present time
- \( a \) = amount of payment \((R - C)\) produced annually or periodically (i.e., every \( p \) years)
- \( B \) = Benefit (in discounted cash flow analysis, revenue or cash receipt)
- \( C \) = Cost (in discounted cash flow analysis, Cost of cash expenditure)
- \( D / C \) = Demand/Cost ratio
- \( CRR \) = Composite Rate of Return (discounted)
- \( EAE \) = Equal Annual Equivalent
- \( IRR \) = Internal Rate of Return (discounted)
- \( i \) = interest rate (discounted, a.k.a. discount rate, alternative rate of return, or guiding rate of return)
- \( j \) = annual bare land value rate of increase (discounted)
- \( k \) = reinvestment rate of return (discounted)
- \( LEV \) = Land Expectation Value (a.k.a. Soil Expectation Value or SEV)
- \( ln \) = logarithmic function (i.e., natural logarithm)
- \( n \) = number of years (e.g., “year \( n \)” is number of years from the present time)

Net Present Value … \[ NPV = \sum_{t=0}^{n} \frac{R_t - C_t}{(1+i)^t} \text{ or } \sum_{t=0}^{n} R_t (1+i)^t - \sum_{t=0}^{n} C_t (1+i)^t \]

Land Expectation Value … \[ LEV = NPV (1+i)^r / ((1+i)^r - 1) \text{ or } NPV + NPV / ((1+i)^r - 1) \]
3. Using a guiding rate of return of 5% (see REF [1] p. 18-22, 96), determine the NPV and LEV for the four plantation management alternatives (Sheets 3-6) (see REF [1] p. 16-18; [2] p. 5-6) and then determine which alternative is preferred from the financial point of view.

Note: The guiding rate or return is also called the alternative rate of return, hurdle rate, or discount rate. LEV is closely related to NPV. It is a perpetual periodic series of NPVs from the same timber management regime repeated again and again (see REF [1] p. 16-18, 50-52; [2] p. 7).

Proceed by copying the standing volume at ages 60, 70, etc., in column B one-by-one into the appropriate cell in columns O through S. Then enter unit values for $/mbf (use $175), $/green ton (use $1), interest rate (use .05), planting costs in year 0 (use $175) and pre-commercial thinning costs in year 20 (use $150). The costs should be entered as a negative value.

A. Determine the optimal harvest age for the no-thin alternative (Sheet 7 _____), the pre-commercial thin only alternative (Sheet 8 _____), the thin-from-below alternative (Sheet 9 _____) and the thin-from-above alternative (Sheet 10 _____). Which is better financially? _____
B. Determine the NPV and LEV for the four alternatives at the optimal rotation age @ 5%:

NPV @ 5%: Sheet 7 _________ Sheet 8 _________ Sheet 9 _________ Sheet 10 _________
LEV @ 5%: Sheet 7 _________ Sheet 8 _________ Sheet 9 _________ Sheet 10 _________

Redo the NPVs and LEVs at an interest rate of 3%:

NPV @ 3%: Sheet 7 _________ Sheet 8 _________ Sheet 9 _________ Sheet 10 _________
LEV @ 3%: Sheet 7 _________ Sheet 8 _________ Sheet 9 _________ Sheet 10 _________

Which alternative is best from a financial point-of-view? _______
Table 3: Comparison of a single rotation NPV with SEV between a 50-year Douglas-fir rotation and a 30-year red alder rotation. Because of different rotation lengths, SEV provides the more accurate assessment of economic performance.

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Single rotation NPV @ 5%</th>
<th>SEV @ 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-year Douglas-fir</td>
<td>$599</td>
<td>$656</td>
</tr>
<tr>
<td>30-year red alder</td>
<td>$562</td>
<td>$731</td>
</tr>
</tbody>
</table>
OUTLINE

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   Who’s here & what do participants want to know?
   Difference between financial analysis and economic analysis
   Financial analysis process steps
   Returns to a forest management investment (see REFERENCE [1] p. 32-38)
   Review EXAMPLE PROBLEMS (see below)
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Problem 4 . . .

CHEAT SHEET

**Compound Interest and Discounted Cash Flow Decision Criteria Formulas**

*Jay O. Laughlin, Ph.D., University of Idaho, Feb. 3, 2012*

**Variables**
- \( e \) = exponential function
- \( t = 0 \) = year zero, or present time
- \( n = \) amount of payment \((R - C)\) produced annually or periodically (i.e., every \( p \) years)
- \( B = \) Benefit (in discounted cash flow analysis, Revenue or cash receipt)
- \( C = \) Cost (in discounted cash flow analysis, Cost or cash expenditure)
- \( D / C = \) Degree Return/Cost ratio
- \( CRR = \) Composite Rate of Return (decimalized)
decimalized if interest rate is 5\% then decimalized interest rate is 0.05
- \( EAR = \) Equal Annual Equivalent
- \( IRR = \) Internal Rate of Return (decimalized)
- \( i = \) interest rate (decimalized, i.e., discount rate, opportunity cost or required rate of return)
- \( j = \) annual real rate of increase (decimalized)
- \( k = \) reinvestment rate of return (decimalized)
- \( L/EV = \) Loan Expectation Value (i.e., Loan-to-Value or LTV)
- \( LTV = \) Loan Value (i.e., Loan-to-Value or LTV)
- \( n = \) number of years (i.e., "year n" is number of years from the present time)
- \( NPV = \) Net Present Value

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4. Calculate the IRR for the optimal harvest age determined above for all four alternatives:

**Note:** IRR is the interest rate at which \( NPV = 0 \) (REF [1] p. 17)

Sheet 7 _____ Sheet 8 _____ Sheet 9 _____ Sheet 10 _____

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**Internal Rate of Return**

\[
0 = \sum_{t=0}^{n} \frac{R_t - C_t}{(1 + IRR)^t} \quad \text{or} \quad \sum_{t=0}^{n} R_t (1 + IRR)^t - \sum_{t=0}^{n} C_t (1 + IRR)^t
\]
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Financial Analysis for Forest Resource Managers

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