Economics of the Spruce-Fir Forest

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Overview

- **Principles**: forest economics & management
- **Current** conditions: Where are we now?
- **Frontiers**: new ways of thinking
- **Research**: expanding our options
Forest Management is all about GOALS & OBJECTIVES

Economics is all about INCENTIVES

1. principles

- Management is driven by goals and objectives of the landowner....
- Which are influenced by, but usually larger than, the market context
- Economics is all about incentives & decision-making
- Different landowners have different incentives -> different goals & objectives -> different management on the ground
Why do we use financial analysis?

• To value forest-based assets
• To determine whether or not to make an investment
  • $NPV > 0, IRR > \textit{hurdle rate}$
• To choose between different investments
  • $NPV_1 > NPV_2$

To allocate scarce resources! (a.k.a. $)
Volume vs. Value


1. principles

Even-aged management decision:
When to harvest (rotation age)
  - Well-solved answer: Faustmann rotation age

Uneven-aged management decisions:
How much growing stock to hold, and
How often to harvest or how much to remove each harvest
  - More difficult to optimize mathematically, as they are jointly determined, and often include value premiums

1. principles
Maximizing the financial value of one rotation

1. principles

\[ \text{Net revenue} = PV(t) \]
\[ \text{Discounted Net revenue} = \frac{PV(t)}{(1+i)^t} \]
\[ \text{Discounted Net revenue less cost} = \frac{PV(t)}{(1+i)^t} - C \]

Important concepts

1. principles

\[ NPV_1 = \frac{PV(t) - C(1+i)^t}{(1+i)^t} \]
\[ \text{Marginal Benefit} \]
\[ \max_t NPV_1 \rightarrow P \times PAI = i \times PV(t) \]
\[ \text{Marginal Cost} \]

Land (or Soil) Expectation Value is a special type of NPV:

\[ SEV_t = \frac{PV(t) - C(1+i)^t}{(1+i)^t - 1} \]

NPV is not restricted to timber harvest – only to things that can be quantified. For example, if there is non-timber income or value that accrues over the life of the stand, it may be optimal to never harvest.

\[ \max_t \left( \frac{PV(t)}{(1+i)^t} + \sum_{j=1}^{t} \frac{A(j)}{(1+i)^j} \right) \]
1. principles

One Rotation – No land value

Wait to harvest as long as the Benefit of waiting \( P^{PAI} > iP^V \) \( \rightarrow \) Cost of waiting

1. principles

Wait to harvest as long as value growth rate of the stand, \( r > i \), your alternative rate of return

value growth rate, \( r = \) volume growth rate, \( g \) \( \text{constant prices, } p=0 \)
OPTIONS 1: With PCT

<table>
<thead>
<tr>
<th>Plant</th>
<th>Age 0</th>
<th>Co = $300/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCT</td>
<td>Age 15</td>
<td>C15 = $120/ac</td>
</tr>
<tr>
<td>CT</td>
<td>Age 30</td>
<td>R30 = 15 mbf/ac @ $200/mbf</td>
</tr>
<tr>
<td>FH</td>
<td>Age 50</td>
<td>R50 = 40 mbf/ac @ $300/mbf</td>
</tr>
</tbody>
</table>

Annual taxes yearly $15/ac

\[
SEV = \frac{NR_t}{(1+i)^t - 1} = \frac{\sum_{a=0}^{t} (R_a - C_a) * (1+i)^{t-a}}{(1+i)^t - 1}
\]

\[
SEV_{pct} = \frac{(Plant, a = 0) - (PCT, a = 15) + (CT, a = 30) + (FH, a = 50)}{(1.05^{50} - 1)} - \frac{\text{tax}}{0.05}
\]

\[
SEV_{pct} = \frac{(-300 \times 1.05^{50}) - (120 \times 1.05^{35}) + (15 \times 200 \times 1.05^{20}) + (40 \times 300)}{(1.05^{50} - 1)} - \frac{15}{0.05} = $1215/ac
\]

\[
SEV_{no\ pct} = \frac{(Plant, a = 0) + (CT, a = 35) + (FH, a = 50)}{(1.05^{50} - 1)} - \frac{\text{tax}}{0.05}
\]

\[
SEV_{pct} = \frac{(-300 \times 1.05^{50}) + (12 \times 200 \times 1.05^{15}) + (40 \times 290)}{(1.05^{50} - 1)} - \frac{15}{0.05} = $956/ac
\]

OPTIONS 2: Without PCT

<table>
<thead>
<tr>
<th>Plant</th>
<th>Age 0</th>
<th>Co = $300/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Age 35</td>
<td>R35 = 12 mbf/ac @ $200/mbf</td>
</tr>
</tbody>
</table>

Annual taxes yearly $15/ac

\[
1. \text{principles}
\]
Optimizing uneven-aged management across products

What's worth more: $1 million a year for 20 years, or $10 million today?

\[
PV = \frac{a \cdot [(1 + r)^t - 1]}{r \cdot (1 + r)^t}
\]

<table>
<thead>
<tr>
<th>$</th>
<th>1,000,000</th>
<th>20</th>
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<tbody>
<tr>
<td>0.02</td>
<td>$16,354,433</td>
<td></td>
</tr>
<tr>
<td>0.03</td>
<td>$14,877,475</td>
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</tr>
<tr>
<td>0.04</td>
<td>$13,590,326</td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>$12,462,210</td>
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</tr>
<tr>
<td>0.06</td>
<td>$11,469,921</td>
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<tr>
<td>0.07</td>
<td>$10,594,014</td>
<td></td>
</tr>
<tr>
<td>0.08</td>
<td>$9,818,147</td>
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</table>
What is $10,000 in the future worth today?

<table>
<thead>
<tr>
<th>2%</th>
<th>4%</th>
<th>6%</th>
<th>8%</th>
<th>10%</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>8,203</td>
<td>6,756</td>
<td>5,584</td>
<td>4,632</td>
</tr>
<tr>
<td>25</td>
<td>6,095</td>
<td>3,751</td>
<td>2,329</td>
<td>1,460</td>
</tr>
<tr>
<td>50</td>
<td>3,715</td>
<td>1,407</td>
<td>542</td>
<td>213</td>
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<tr>
<td>75</td>
<td>2,265</td>
<td>528</td>
<td>126</td>
<td>31</td>
</tr>
<tr>
<td>100</td>
<td>1,380</td>
<td>198</td>
<td>29</td>
<td>5</td>
</tr>
</tbody>
</table>

Discounting represents the opportunity cost of your investment, and time preference for money.

Best Practices

1. Make the best decision possible given current knowledge
2. Be prepared to revise plans when new information is available
3. Distinguish between long run planning and short run decisions
   - Long run: look at trends
     * E.g. when buying land, investing in production, designing road systems, investing in capacity, evaluating forest policy
   - Short run: pay attention to the current markets
   * Be willing to adjust your plans to capture price fluctuations and macro-economic conditions!
Best Practices

4. All forestry is an investment! Manage for the optimal value, given the goals & objectives
5. Invest in the best – including the best sites
6. Being cost-effective means you can manage more or achieve more goals
7. Keep the long-term view!
   Recognize that short-term incentives can work against long-term needs; forest managers must always keep long-term biological and ecological sustainability in mind

Where are we now?
Changing markets & improved efficiency

- Goals & objectives?
- Changing uses of Maine’s forests
- Forest products markets
Goals & objectives 2.0

- **Goals** are broad statements about what you intend to accomplish or what the intended long-term outcome is.
- **Objectives** are concise, specific "targets" or achievements for attaining the goal, expressed in measurable units.
- Without a plan, can’t know if you are achieving your goals.
- Landowner changes -> changes in landscape conditions.

Proportion of timberland by major owner group for Maine 1959-2015

Data Courtesy of Ken Lauston, Maine Forest Service, compiled from USFS FIA information
Forestry is ever-evolving

2. current

Product Flow


2. current
Pulp & Paper, 2010 - 2016

Employment

Number of Mills

Frontiers in economics

Total Economic Value of Forests

<table>
<thead>
<tr>
<th>USE Values</th>
<th>NON-USE Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Uses</td>
<td>Indirect Uses</td>
</tr>
<tr>
<td>Wood</td>
<td>Nutrient cycling</td>
</tr>
<tr>
<td>Fruit</td>
<td>Water purification</td>
</tr>
<tr>
<td>Medicinal plants</td>
<td>Air purification</td>
</tr>
<tr>
<td>Hunting</td>
<td></td>
</tr>
<tr>
<td>Genetic resources</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td></td>
</tr>
<tr>
<td>Habitat</td>
<td></td>
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</table>

Two common reasons why markets fail

...where “Fail” means fail to provide an efficient allocation of resources

1. Externalities

2. Public & Common Pool goods
Externalities

- Positive externality: the social benefit of a good exceeds the private benefits
  - The total market demand for the good is lower than socially optimal
  - We get too little of the good
  - Ex: Old-growth forests

- Negative externality: the social cost of a good exceeds the private costs
  - The total market supply of the good is higher than socially optimal
  - We get too much of the good
  - Ex: pollution from a paper mill, sedimentation in a river from harvesting

Public & common goods

<table>
<thead>
<tr>
<th>EXCLUDABLE?</th>
<th>RIVAL?</th>
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<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2x4</td>
<td>Cable TV</td>
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<tr>
<td>Sweater</td>
<td>Fire Protection</td>
</tr>
<tr>
<td>Ice-Cream cone</td>
<td>Private parks</td>
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<tr>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>COMMON POOL</td>
<td>PUBLIC GOODS</td>
</tr>
<tr>
<td>Fisheries</td>
<td>Clean air</td>
</tr>
<tr>
<td>Clean water</td>
<td>National defense</td>
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</table>
What do forests provide?

**Wood fiber**
- Habitat for wildlife
- Clean water (filtration)
- Stream habitat
- Carbon sequestration
- Rainfall interception
- Shade

**Soil production/maintenance**
- Medicines
- Food
- Recreation

- Visual beauty (aesthetics)
- Cultural values
- Climate regulation

How have we ensured provision of non-private goods from forests?
Challenges remain

- Markets still matter the most – can’t regulate/publicly provide/encourage our way to an optimal allocation
- Maine FPA + current markets don’t protect from and/or may even encourage high grading
- Questions remain about certification’s role in ensuring sustainable landscape level management
  - Pros:
    - Comprehensive
    - Trusted
    - Widely adopted
  - Cons:
    - Voluntary
    - Rewards “good” practices, doesn’t punish offenses
    - Doesn’t apply everywhere

What is sustainability?

It used to be very simple for foresters:
Sustainability = sustained yield = harvest of wood fiber not more than growth

Source: Maine Forest Service, Department of Conservation.
### Sustainability Concepts in Forest Management Textbooks (table adapted from Straka, 2009)

<table>
<thead>
<tr>
<th>Author</th>
<th>Sustained Yield</th>
<th>Commodity Production</th>
<th>SY/Multiple Use</th>
<th>Integrated MR Mgmt</th>
<th>Ecological Consideration</th>
<th>S/E/E</th>
<th>Current SFM</th>
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<tr>
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<tr>
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<tr>
<td>Chapman 1931</td>
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<td>Matthews 1935</td>
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<tr>
<td>Meyer et al 1961</td>
<td>X</td>
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<td></td>
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<tr>
<td>Davis 1966</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Duerr et al 1979</td>
<td>X</td>
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<td>X</td>
<td></td>
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<tr>
<td>Clutter et al 1983</td>
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<tr>
<td>Leuschner 1984</td>
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<tr>
<td>Davis et al 1987</td>
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<td>X</td>
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<tr>
<td>Davis et al 2001</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Bettinger et al 2009</td>
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</tbody>
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3. frontiers

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### Research


4. research
Knoke & Plusczyk: Transforming even-aged into uneven-aged

- At a stand age of 41 years, took an even-aged spruce stand on a 98-year rotation and gradually transformed it into an uneven-aged stand
- Compared outcomes from both strategies for 77 years
- During the transformation, there was lower volume harvested and lower income earned compared to the even-aged strategy
- But, the income during transformation occurred earlier and more uniformly over time
- NPV of the transformation > EA management over 77 years at a 2.6% discount rate
Saunders & Arseneault: Economic returns from AFERP

- Compared projected harvest yields, stumpage values, and resulting stand structures for four treatments: shelterwood, single-tree selection, small gap, and large gap AFERP
- Selection system had more than double the NPV of the shelterwood at a 4% discount rate
  - Largely due to the relatively high value of the initial selection harvest
- Two gap systems were intermediate in NPV
- NPV of standing timber at the end of the rotation inversely related to volume harvested
  - If you don’t cut it now, you can cut it later!
- Looking at just the harvested treatments, NPV was highest for large gap, followed by shelterwood, small gap, then selection

4. research

Saunders & Arseneault: Economic returns from AFERP

Figure 9. Total discounted stumpage returns from harvesting in a given year (constant 2000 dollars discounted at 4%) for the shelterwood, single-tree selection, large-gap, and small-gap treatments. Error bars are the 95% confidence interval.
Bothwell: comparing management across systems

- Modeled management for two companies for inside- and outside-deer yards
- Compared financial outcomes for shelterwood, clearcut, single-tree selection, group selection, diameter-limit, and small and large gap irregular group shelterwood with reserves (AFERP)
- Existing stand characteristics and landowner objectives (past management) had strong impact on current value
- Irregular group shelterwood with reserves had potential to achieve comparable revenues and better wildlife habitat outcomes
Take homes

- **Best practices:**
  - Make the best decision possible, and revise when you can
  - Think long-term
  - Forestry is an investment – invest in the best!
  - Being cost-effective allows you to manage more and manage better

- **What’s coming next?**
  - Consider total economic values
  - The more markets and prices we put on things, the better our outcomes will be

- **Research highlights:**
  - Assumptions really matter for economic analysis
  - Big difference in results if you look long term v short, one rotation v many, harvest only v standing timber volume
  - Novel systems can have great returns

Thank you!

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