# Economics of the Spruce-Fir Forest

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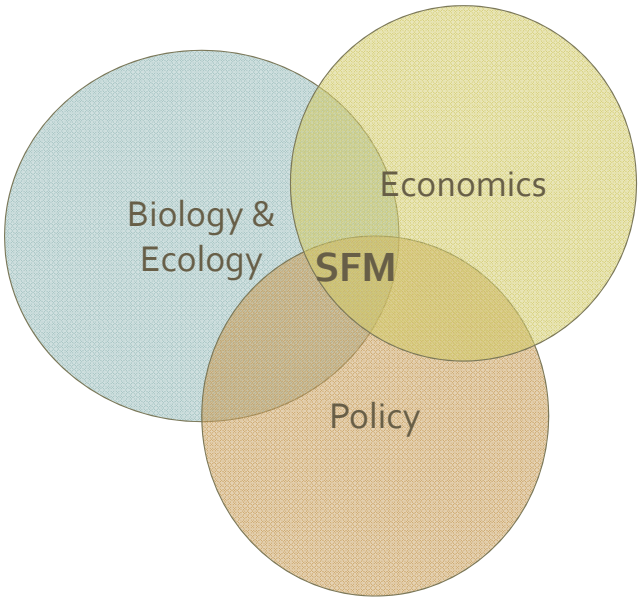
## Overview

- Principles: forest economics & management
- Current conditions: Where are we now?
- Frontiers: new ways of thinking
- Research: expanding our options

## Sustainable Forest Management




1. principles

## Forest Management is all about GOALS & OBJECTIVES

## Economics is all about INCENTIVES

- 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

1. principles

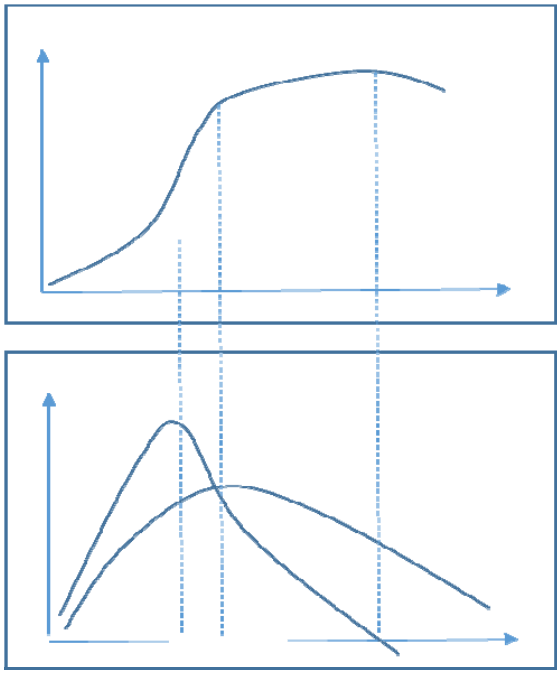
## Why do we use financial analysis?

- To value forest-based assets
- To determine whether or not to make an investment
  - *NPV >o, IRR>hurdle rate*
- To choose between different investments
  - *NPV1 > NPV2*

*To allocate scarce resources! (a.k.a. $)*

1. principles

## Volume vs. Value



Maximize the volume produced where MAI = PAI

1. principles

## Volume vs. Value

*from: Lutz, Jack, 2012. What makes a softwood tree valuable? Forest Research Notes,2012, 9(1) . Forest Research Group.*

**Figure 1. Product Yield for Loblolly Pine, Hypothetical Stand**

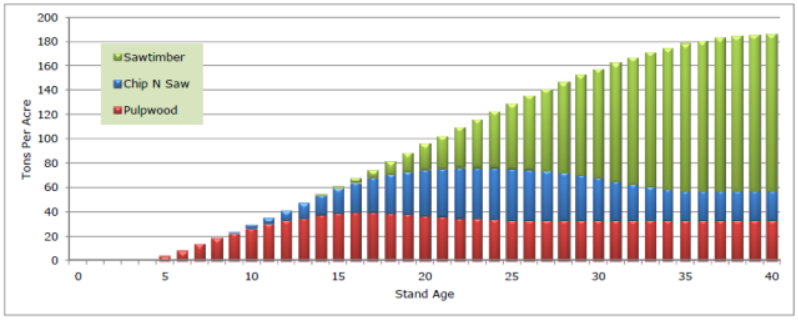
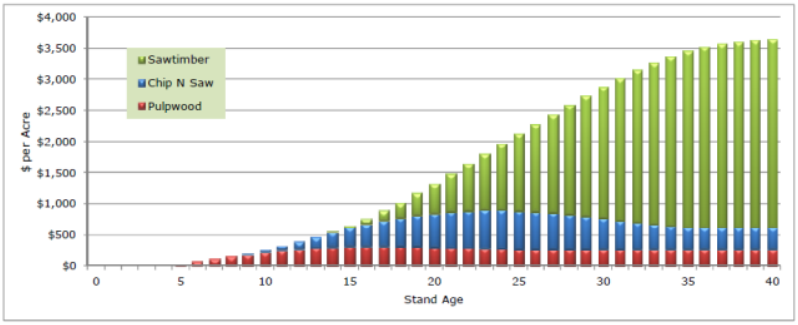



**Figure 2. Value Yield for Loblolly Pine, Hypothetical Stand**




1. principles

## Optimal Even-aged

## Optimal Uneven-aged

Even-aged management decision:

When to harvest (rotation age)

- Well-solved answer: Faustmann rotation age

Uneven-aged management decisions:

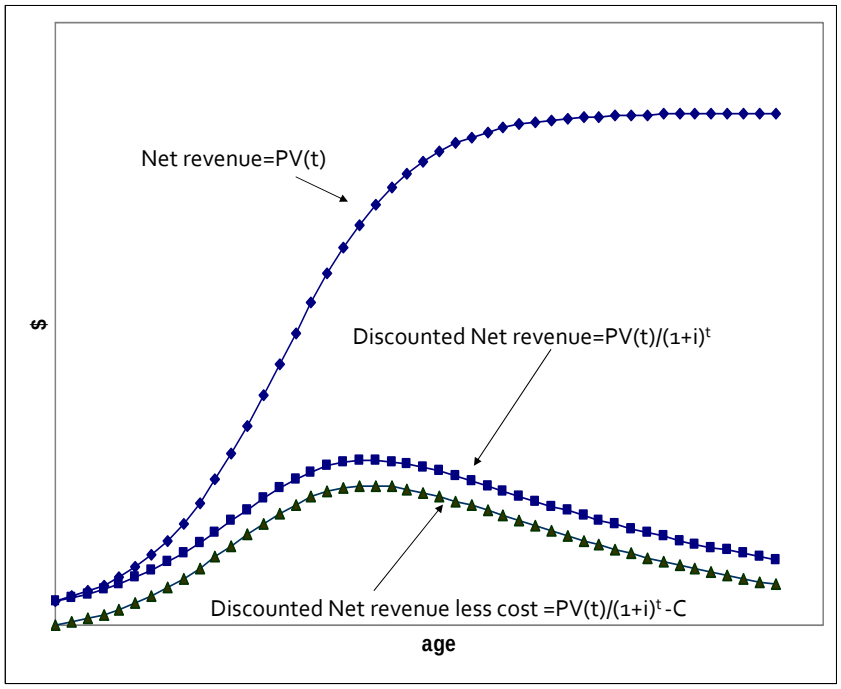
How much growing stock to hold, *and*

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

# Important concepts

$$NPV_1 = \frac{PV(t) - C(1+i)^t}{(1+i)^t}$$

Marginal Benefit

Marginal Cost

$$max_t\ NPV_1 \rightarrow P * PAI = i * PV(t)$$

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

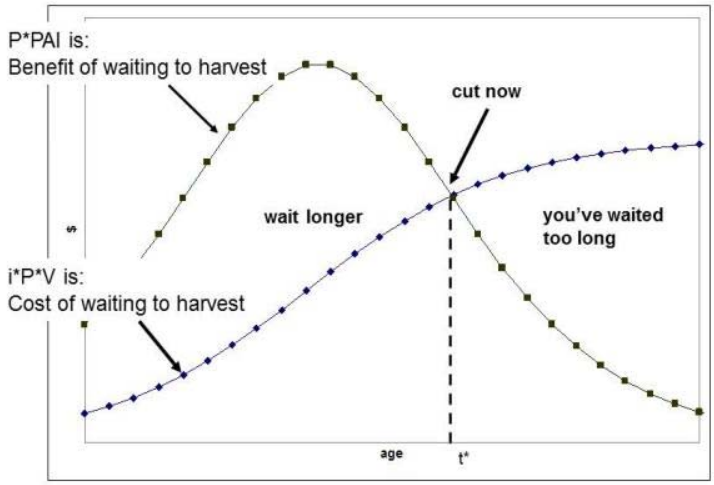
$$SEV_t = \frac{PV(t) - C(1+i)^t}{(1+i)^t - 1}$$

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.

$$max_t \frac{PV(t)}{(1+i)^t} + \sum_{j=1}^{t} \frac{A(j)}{(1+i)^j}$$

1. principles

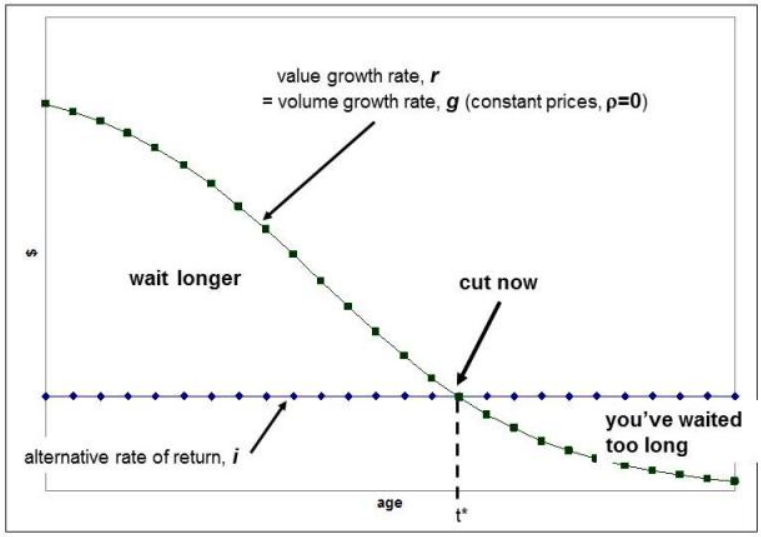
Wait to harvest as long as the **Benefit of waiting → P*PAI > i*P*V → Cost of waiting**




1. principles

**One Rotation – No land value**

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




1. principles

## Can also be used to compare management options

*OPTION 1: With PCT*

| | | |
|---|---|---|
| Plant | Age 0 | C0 = $300/ac |
| PCT | Age 15 | C15 = $120/ac |
| CT | Age 30 | R30 = 15 mbf/ac @ $200/mbf |
| FH | Age 50 | R50 = 40 mbf/ac @ $300/mbf |
| Annual taxes | yearly | $15/ac |

*OPTION 2: Without PCT*

| | | |
|---|---|---|
| Plant | Age 0 | C0 = $300/ac |
| CT | Age **35** | R35 = **12** mbf/ac @ $200/mbf |
| FH | Age 50 | R50 = 40 mbf/ac @ **$290**/mbf |
| Annual taxes | yearly | $15/ac |

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

1. principles

## Comparing options

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

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

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

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

1. principles

## Optimizing uneven-aged management across products

Adams, D. M. and A. R. Ek. 1974. Optimizing the management of uneven-aged forest stands. *Canadian Journal of Forest Research* 4(3): 274-287.

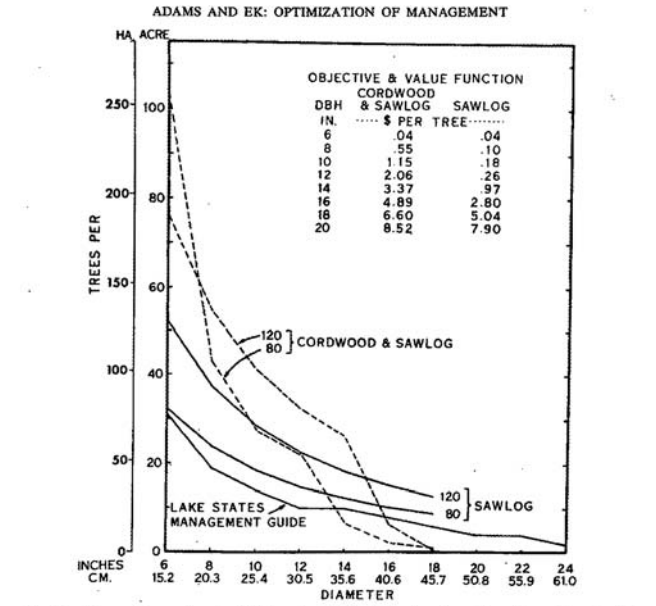



FIG. 2. Comparison of optimal diameter distributions for two alternative objective functions and basal area stocking levels and the Lake States Northern Hardwoods Management Guide.

1. principles

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

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

| $ 1,000,000 | 20 |
|---|---|
| 0.02 | $ 16,351,433 |
| 0.03 | $ 14,877,475 |
| 0.04 | $ 13,590,326 |
| 0.05 | $ 12,462,210 |
| 0.06 | $ 11,469,921 |
| 0.07 | $ 10,594,014 |
| 0.08 | $ 9,818,147 |

1. principles

## That pesky discount rate

What is $10,000 in the future worth today?

| | 2% | 4% | 6% | 8% | 10% |
|---|---|---|---|---|---|
| 10 | | | | | |
| 25 | | | | | |
| 50 | | | | | |
| 75 | | | | | |
| 100 | | | | | |

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

1. principles

## 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!*

1. principles

## 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*

1. principles

## Where are we now? Changing markets & improved efficiency

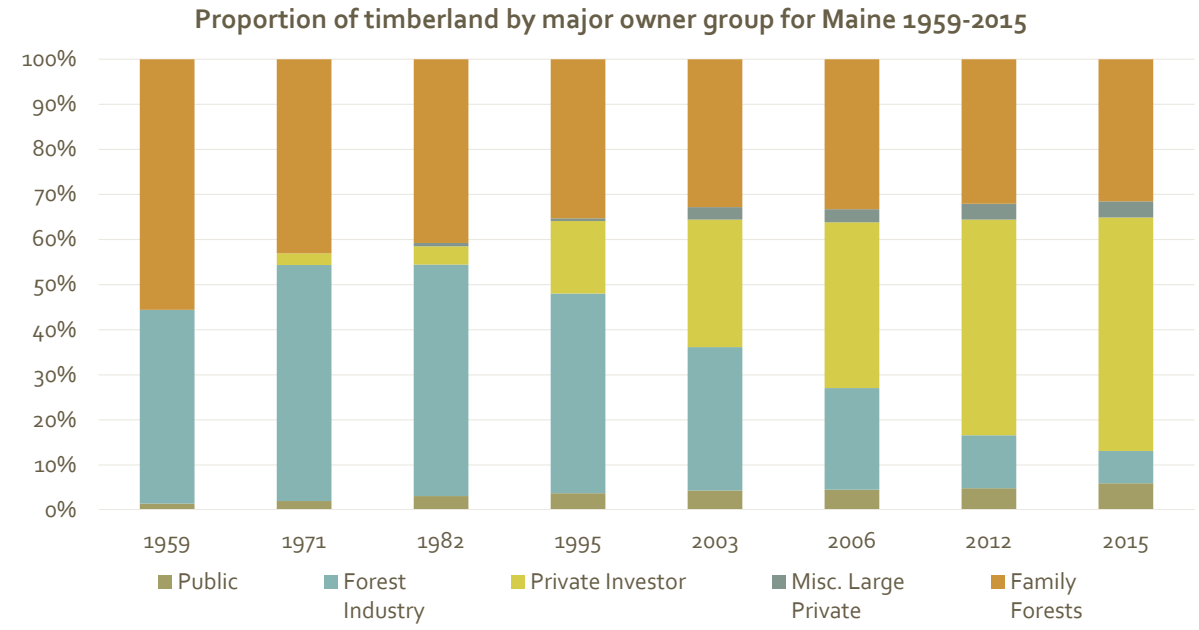
- Goals & objectives?
- Changing uses of Maine's forests
- Forest products markets

2. current

## 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 measureable units
- Without a plan, can't know if you are achieving your goals
- Landowner changes -> changes in landscape conditions

2. current




2. current

*Data Courtesy of Ken Lauston, Maine Forest Service, compiled from USFS FIA information*

# Forestry is ever-evolving

*Photo credit: New England Historical Society*

*Photo credit: Maine Pulp & Paper Association*

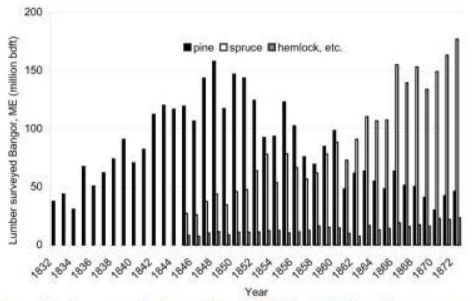


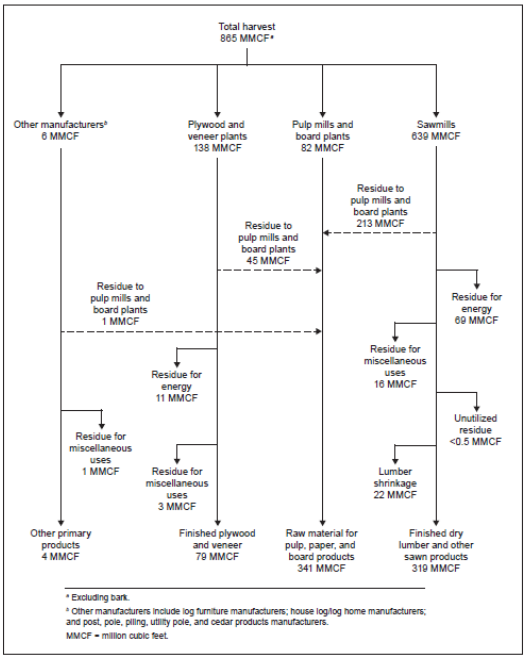

**Figure 3. Lumber surveyed in Bangor, Maine, from 1832 to 1872 (City of Bangor various dates, Whitman 1873, Roberts 1875, Defenbaugh 1907, Smith 1972). The logs for this material were driven to the Bangor area on the Penobscot River. The first spruce logging on the Penobscot River was reported in 1845 (Defenbaugh 1907, Hempstead 1931, Smith 1972). Before 1851, records do not distinguish between species. Pine proportions have been estimated for 1845 to 1850 by extrapolating post-1851 trends in species proportions.**

*Chart from Wilson 2005 Journal of Forestry*

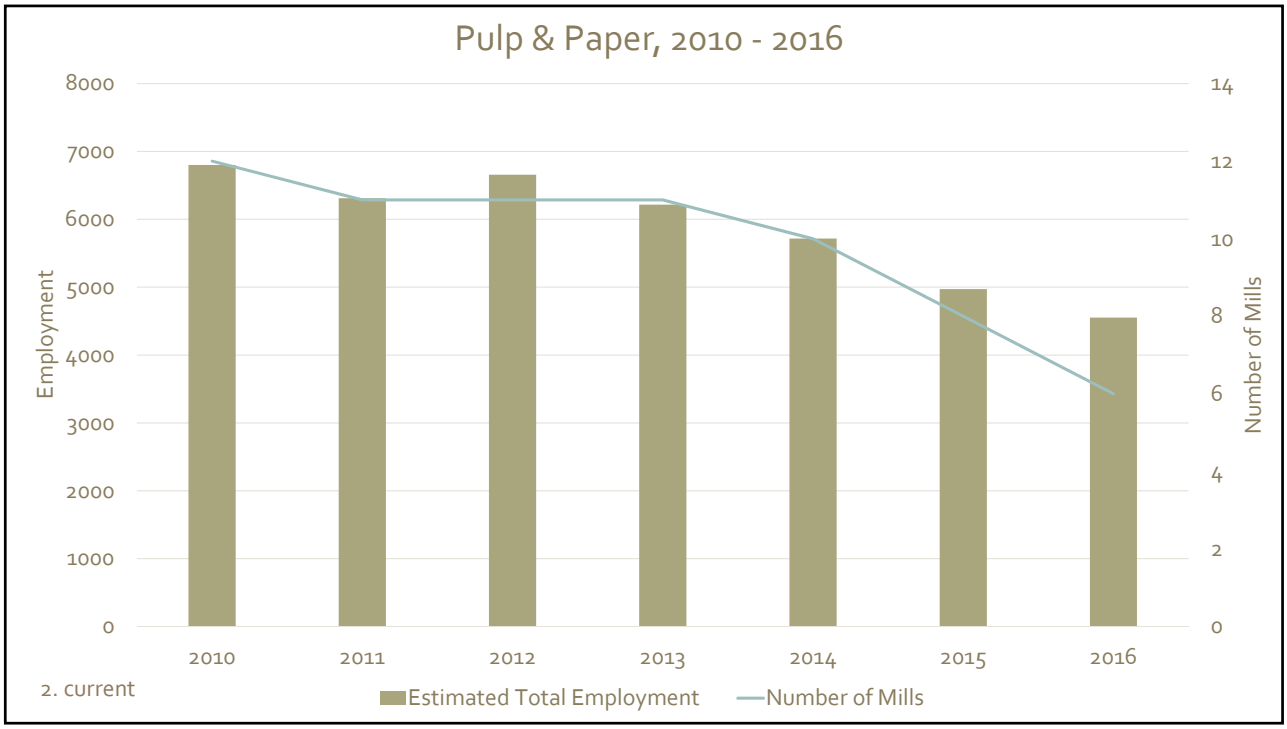
2. current

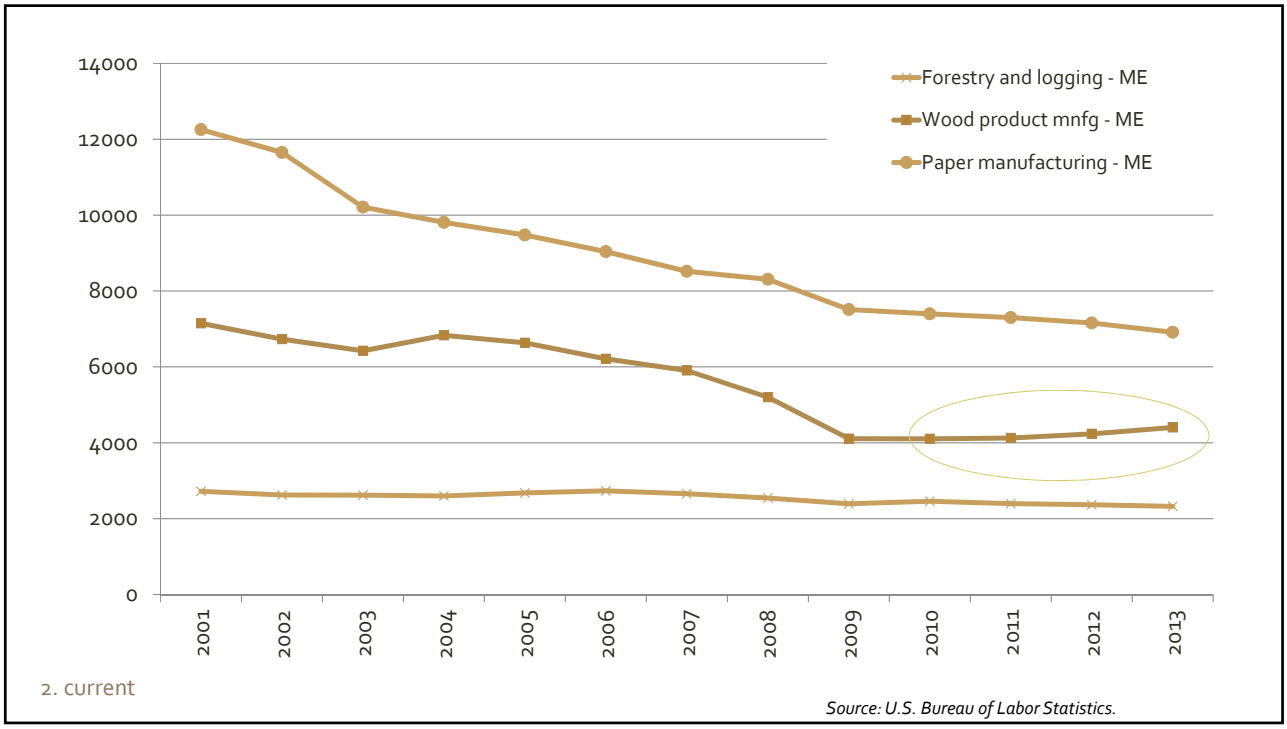
# Product Flow


Maine: 2011, Oregon: 2008




2. current


Pulp & Paper, 2010 - 2016
Employment
Number of Mills
8000
7000
6000
5000
4000
3000
2000
1000
0
14
12
10
8
6
4
2
0
2010
2011
2012
2013
2014
2015
2016
2. current
Estimated Total Employment
Number of Mills


14000
12000
10000
8000
6000
4000
2000
0
Forestry and logging - ME
Wood product mnfg - ME
Paper manufacturing - ME
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2. current
Source: U.S. Bureau of Labor Statistics.

## Frontiers in economics

| Total Economic Value of Forests | | | | |
|---|---|---|---|---|
| USE Values | | | NON-USE Values | |
| Direct Uses | Indirect Uses | Option Values | Bequest Values | Existence Values |
| Wood<br>Fruit<br>Medicinal plants<br>Hunting<br>Genetic resources<br>Education<br>Research<br>Recreation<br>Habitat | Nutrient cycling<br>Water purification<br>Air purification<br>Climate regulation<br>Carbon sequest. | Future uses, direct and indirect<br>New products<br>New knowledge | Use by future gens, direct, indirect, and option | Intrinsic value<br>Avoidance of irreversible changes |

3. frontiers

## Two common reasons why markets fail

…where "Fail" means fail to provide an efficient allocation of resources

1. Externalities

2. Public & Common Pool goods

3. frontiers

## 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

3. frontiers

## Public & common goods

| EXCLUDABLE? | RIVAL? Yes | RIVAL? No |
|---|---|---|
| Yes | PRIVATE GOODS<br>• 2x4<br>• Sweater<br>• Ice-Cream cone | "CLUB" GOODS<br>• Cable TV<br>• Fire Protection<br>• Private parks |
| No | COMMON POOL<br>• Fisheries<br>• Clean water | PUBLIC GOODS<br>• Clean air<br>• National defense |

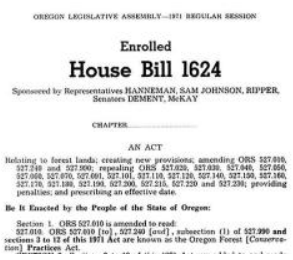
3. frontiers

## 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

3. frontiers

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



OREGON LEGISLATIVE ASSEMBLY—1971 REGULAR SESSION

Enrolled

**House Bill 1624**

Sponsored by Representatives HANNEMAN, SAM JOHNSON, RIPPER, Senators DEMENT, McKAY

CHAPTER.....

AN ACT

Relating to forest lands; creating new provisions; amending ORS 527.010, 527.240 and 527.990; repealing ORS 527.020, 527.030, 527.040, 527.050, 527.060, 527.070, 527.601, 527.101, 527.110, 527.120, 527.140, 527.150, 527.160, 527.170, 527.180, 527.190, 527.200, 527.215, 527.220 and 527.230; providing penalties; and prescribing an effective date.

Be It Enacted by the People of the State of Oregon:

Section 1. ORS 527.010 is amended to read:

527.010. ORS 527.010 [to], 527.240 [and], subsection (1) of 527.990 and sections 3 to 12 of this 1971 Act are known as the Oregon Forest [Conservation] Practices Act.




3. frontiers

## Challenges remain

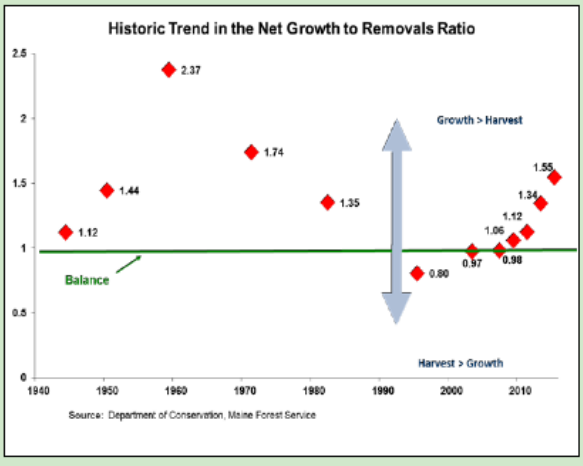
- Markets still matter the most – can't regulate/publicly provide/encourage our way to an optimal allocation
- Maine FPA + current markets don't protect from and/or may even encourage high grading
- Questions remain about certification's role in ensuring sustainable landscape level management
  - **Pros:**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

3. frontiers

## 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.*

3. frontiers

Sustainability Concepts in Forest Management Textbooks (table adapted from Straka, 2009)

| Author | Sustained Yield | Commodity Production | SY/Multiple Use | Integrated MR Mgmt | Ecological Consideration | S/E/E | Current SFM |
|---|---|---|---|---|---|---|---|
| Roth 1914 | X | X | | | | | |
| Recknagel et al 1919 | X | X | | | | | |
| Woolsey 1922 | X | X | | | | | |
| Chapman 1931 | X | X | | | | | |
| Matthews 1935 | X | X | | | | | |
| Meyer et al 1961 | X | X | | | | | |
| Davis 1966 | X | X | X | | | | |
| Duerr et al 1979 | X | | X | X | | | |
| Clutter et al 1983 | X | X | | | | | |
| Leuschner 1984 | X | X | X | | | | |
| Davis et al 1987 | X | | X | X | | | |
| Davis et al 2001 | X | | X | X | X | X | |
| Bettinger et al 2009 | X | | | X | X | X | X |

3. frontiers

## Research

- Knoke, T. & N. Plusczyk. 2001. On economic consequences of transformation of a spruce (*Picea abies* (L.) Karst.) dominated stand from regular into irregular age structure. *Forest Ecology and Management* 151: 163-179.
- Saunders, M. R. and J. E. Arseneault. 2013. Potential Yields and Economic Returns of Natural Disturbance-Based Silviculture: A Case Study from the Acadian Forest Ecosystem Research Program. *Journal of Forestry* 111(3): 175-185.
- Bothwell, K. N. 2017. Economic and Spatial Impacts of a Wildlife Habitat Policy on Forest Management. *Electronic Theses and Dissertations* 2767, University of Maine. Available online: https://digitalcommons.library.umaine.edu/etd/2767/

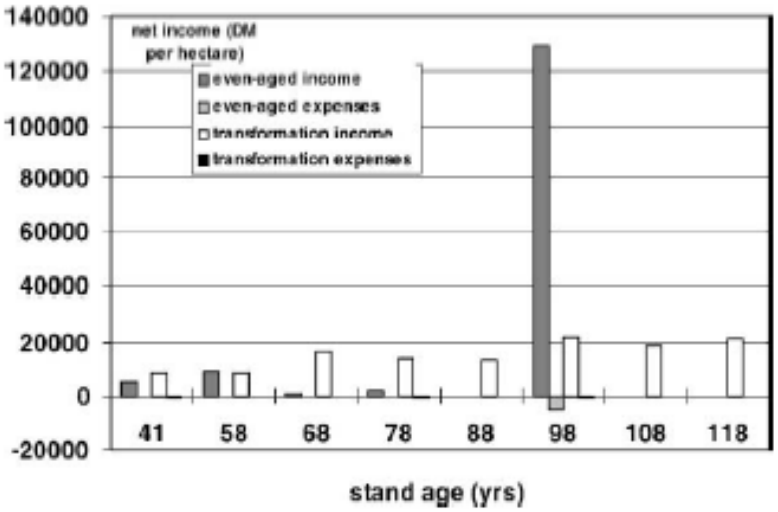
4. research

## 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

4. research

## Knoke & Plusczyk: Transforming even-aged into uneven-aged



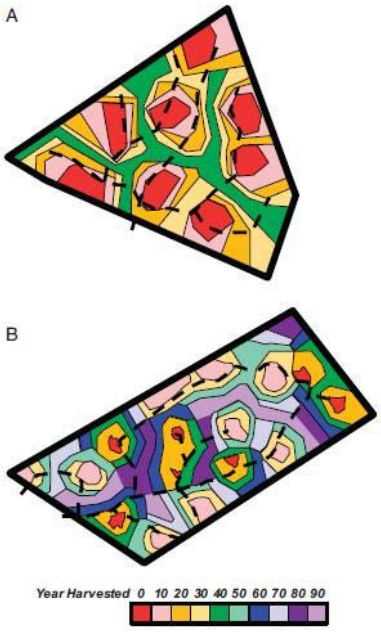

4. research

# 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



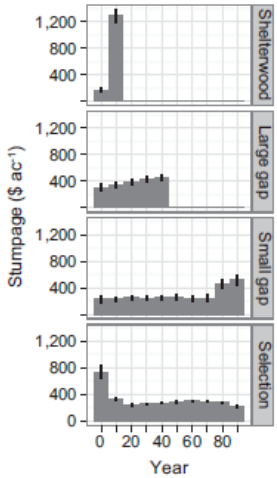




Figure 9. Total discounted stumpage returns from harvesting in a given year (constant 2000 dollars discounted at 4%) for the shelterwood, single-tree selection, large-gap, and small-gap treatments. Error bars are the 95% confidence interval.

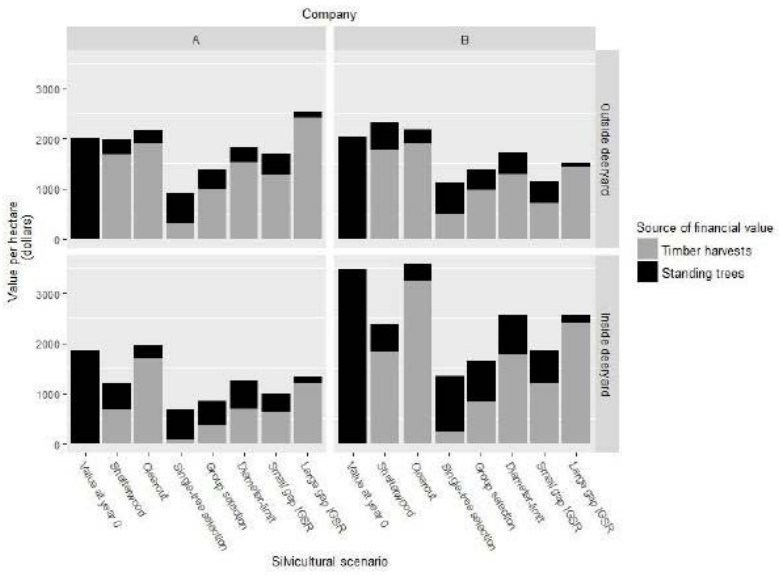
4. research

# 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

4. research

# Bothwell: comparing management across systems




4. research

## 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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