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Optimization of the Stand Level Management Taking Account Climate Benefits of the Harvested Wood Products

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Third International Faustmann Symposium
28. – 31. October 2009, Darmstadt, Germany

Objective of the Study

To optimize forest management at the stand level, taking into consideration simultaneously

1. Climate benefits of using wood products instead of fossil carbon intensive products and fossil fuels
2. Temporary carbon stock of harvested wood products

   Especially the role of the quality of the wood on these two aspects
3. Temporary and dynamic carbon sequestration of the standing stock
4. Harvesting revenues

How to Analyze Wood Products' Climate Benefits?

- The length of products' lifecycle → carbon storage
  - paper vs pallets vs construction lumber
- The end use of harvested wood products' → substitution benefits
  - Building frames, beams, furnitures, casts, panels..
  - Energy use
- Attributes of the raw material affect on the end use possibilities

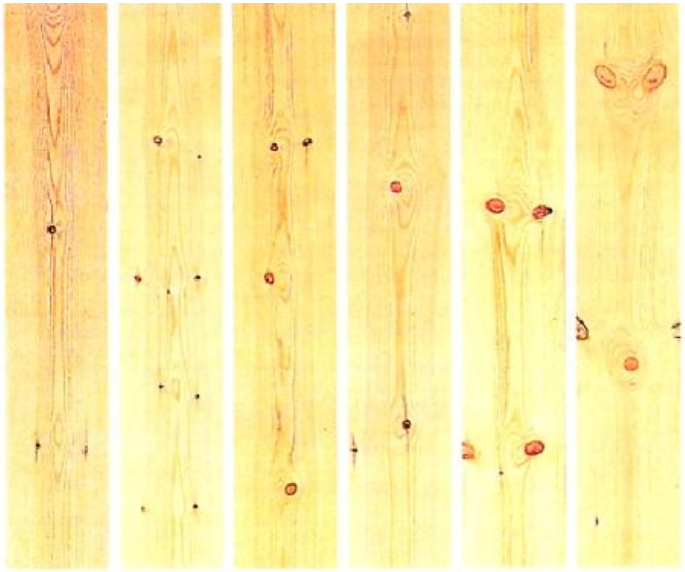
→ Row wood quality

→ Sawn wood quality distribution

→ Carbon stocks and substitution benefits

Models to Link Forest Management to the End Product Distribution (Lyhykainen et al. 2009)

- Models for predicting the proportion of the products of the sawing process, Scots pine (*Pinus Sylvestris*)
  - A, B, C and D grades, center and side boards
  - By-products: Bark, sawdust, chips
  - Pulp wood



- Explanatory variables: **Living crown height, dead branch height (Ø≥15 mm)** and **natural logarithm of stem diameter at breast height**
- Multinomial logistic regression models
- Both simulated and measured stems, sawn by sawing simulator, used as a data

Substitution Factors and Life Cycle Lengths; Link Between the Sawn Wood & Byproducts and the End Products' use

Using meta-analysis for defining substitution factors and life cycle lengths for end product classes:

1. Visual products

   furnitures, joinery, panelling…

   A

1. Constructional products

   frames, roof trusses…

   B

2. Products with low strength and visual requirements

   pallets, casts….

   C+ D

4. Paper and paperboards

   PULP WOOD, CHIPS

5. Energy

   BARK, DUST, (PULP)

Joint Production of Carbon Benefits and Timber Returns
Objective Function Formulation

$$\max \pi = \left[\sum_{t=0}^{T} \left(h_t - l_t - \sum ec_t + \sum_{k=y1}^{y9} ae_t^l + ae_t^p \right) (1+r)^{-t} - w + \sum_{t=0}^{T} cs_t (1+r)^{-t} \right] \frac{1}{1-(1+r)^{-T}}$$

Denote

h = Harvest return, road side value

l_t = Harvesting costs

ec = Emission costs, discounted to the time of cut**

ae^l = Avoided emissions. For each grade and by-product**

ae^p = Avoided emissions, pulpwood (if for energy, otherwise → emission cost)**

r = Interest rate

w = establisment costs

cs = Carbon subsidy, carbon stock of standing trees**

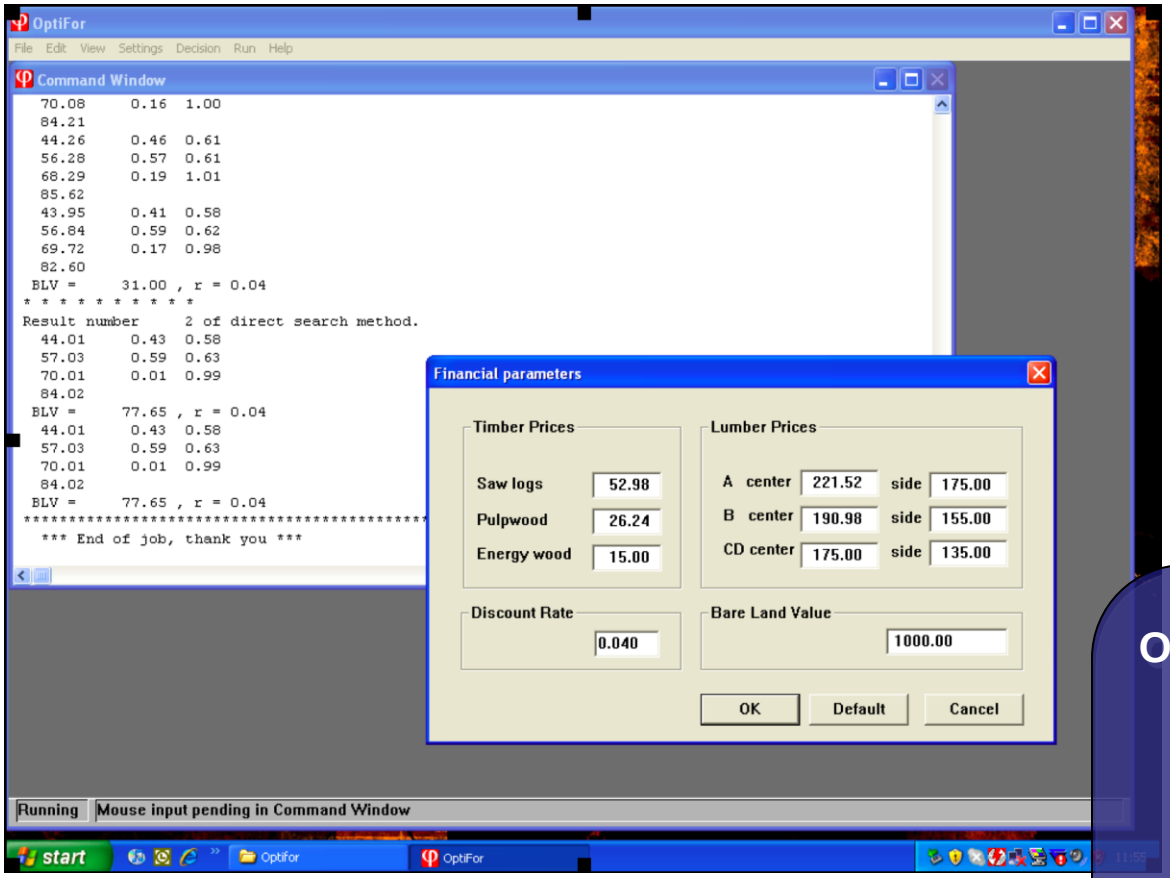
**Scaled to CO_2 price

Simulation-Optimization System, Optifor

Simulation-optimization tool developed for numerical studies on optimal forest ecosystem management and wood products in climate change. Tianjian Cao from Department of forest economics in Uni. of Helsinki has been the master mind of the developing process…

Structure

1. PipeQual
   - Process based growth model (i.e. Mäkelä, A. 2002)
2. Logging cost models (Kuitto et al. 1994, Laitila et al. 2004)
3. Yasso (Palosuo et al. 2008)
   - Stock, changes and respiration of soil carbon
4. Lumber grade and by-products' product recovery models (Lyhykainen et al. 2009)



Osyczka's direct and random search algorithm (Osyczka 1984) → combination of random search and Hooke and Jeeves' direct search

First Simulation Results Using End Product Prediction Models in Optifor

- A study where energy wood thinning regimes were optimized
  - Precommercial thinning reduced the proportions of sawn wood grades in a fertile sites significantly
  - Less fertile sites the changes were insignificant

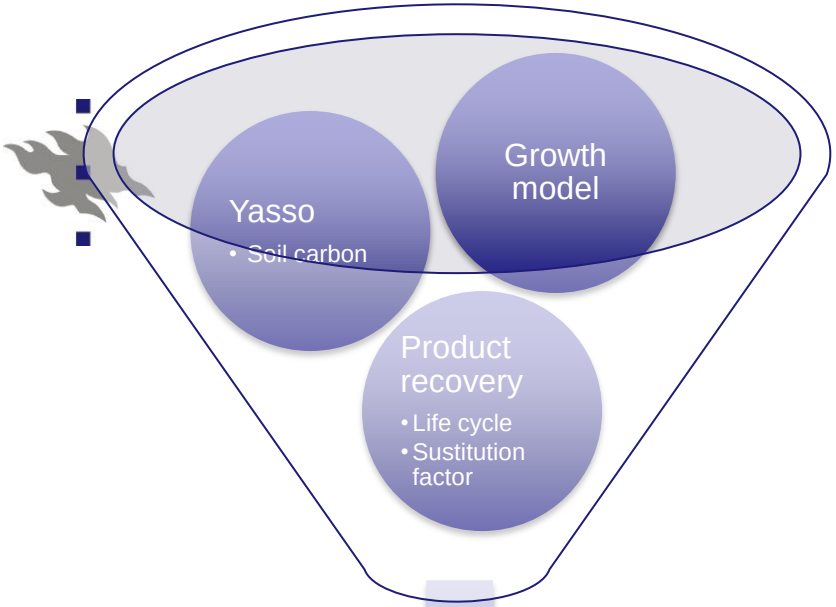
The highest reduction (from 63.55 to 51.83 m^3 ha^{-1}), 1.17% in the proportion of sawn wood grades

Less of all lumber grades, especially center sawn wood of grade A, more pulp wood

Aspects to be Considered…

- What is the climate change migation cost ?
  - SEV in optimum without climate benefits – SEV in optimum with climate benefits
- Different silvicultural treatment schedules →
  - Effects to the rotation lenght; number, intensity and timing of thinnings; planting density; energy wood thinnings ...

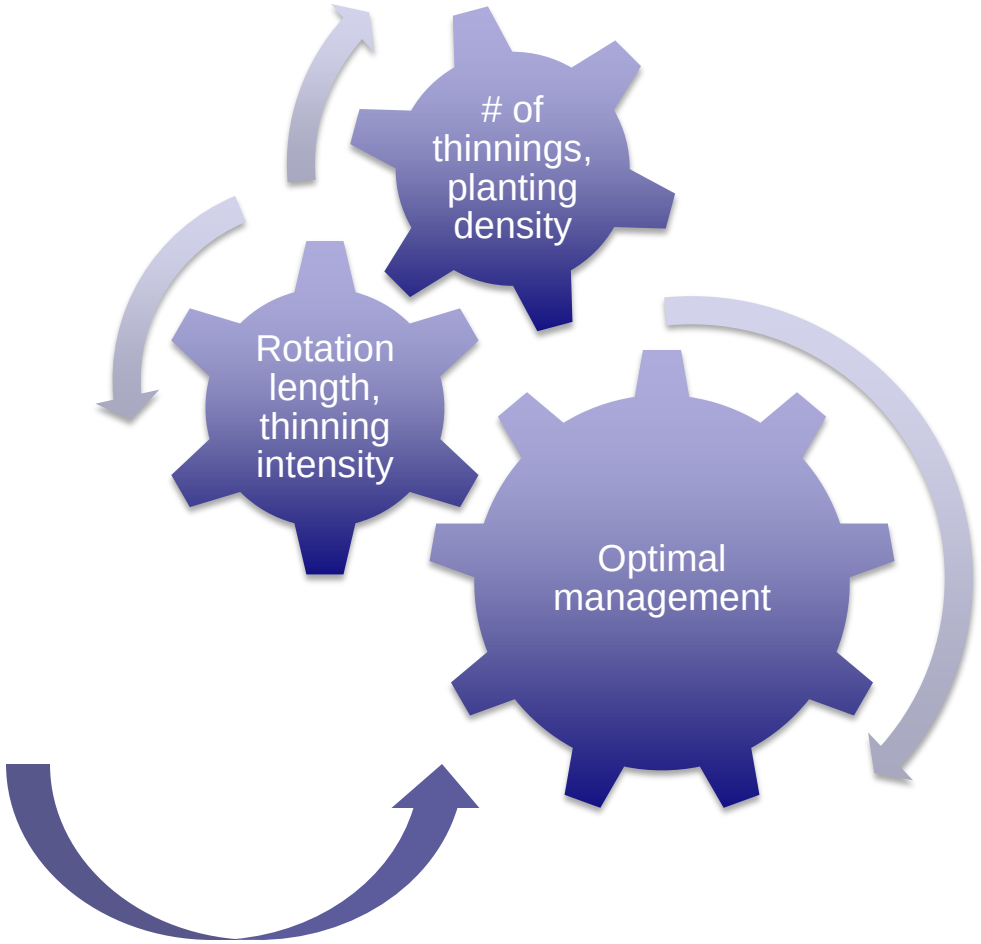
  How different from recommendations? Practise?
- Wood rawmaterial supply
  - Sawn wood grades and byproducts of the sawing process
  - Logging residues
  - Energy wood from precommercial thinnings
  - Pulpwood
  - Soil carbon



1. Carbon dynamics
1. Rawwood output

Forest management related financial data

Emission costs




Thank you for Your Attention!