



Simulating Timber Harvests in a Changing Climate: An Integrated Approach

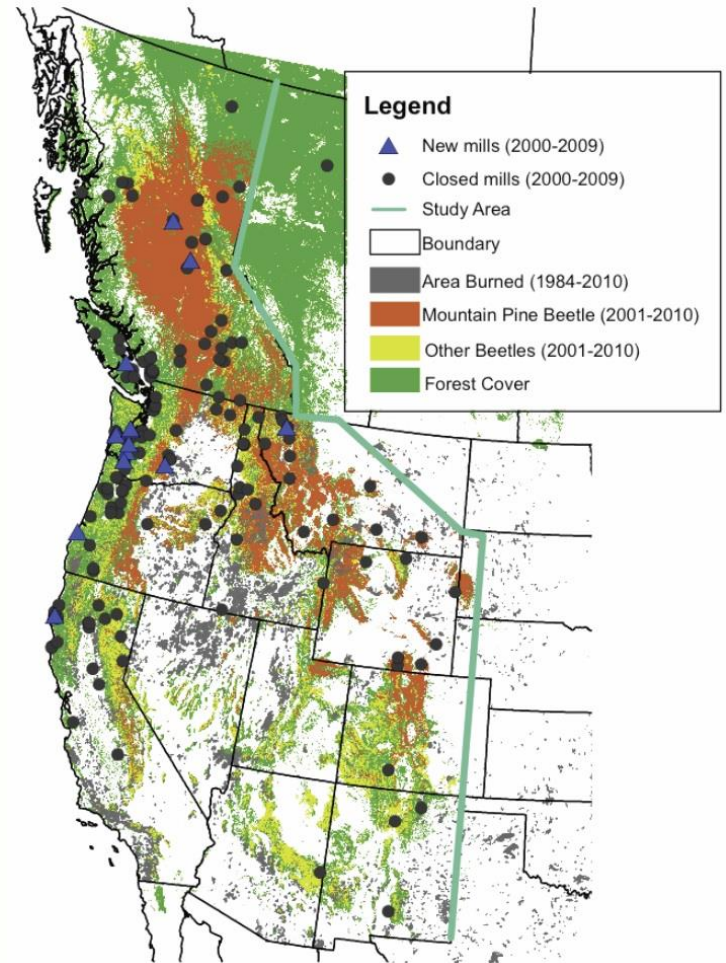
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Introduction

- Forest Mortality, Economics, and Climate (FMEC)
 - Improve CLM's capabilities of modeling land disturbances in the western U.S. (fire, draught, timber harvests, pest infestations)
- Improving wood harvests in CLM
 - Replacing prescribed harvests with flexible harvest algorithm
 - Theoretically founded, yet speedy
 - Models feedback between harvest and climate.



What is CLM?

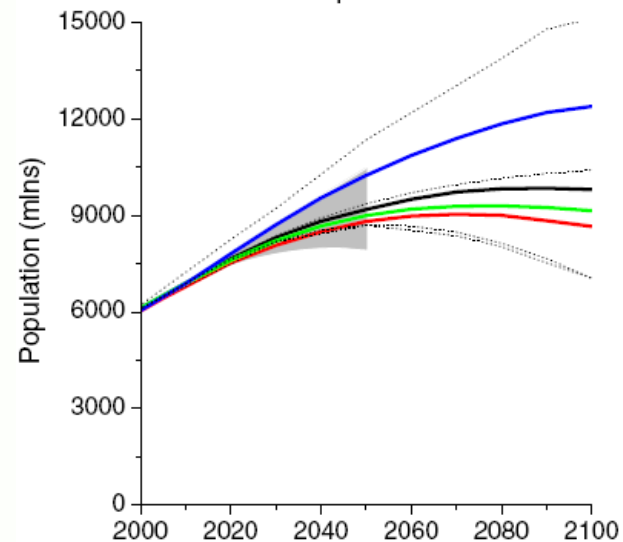
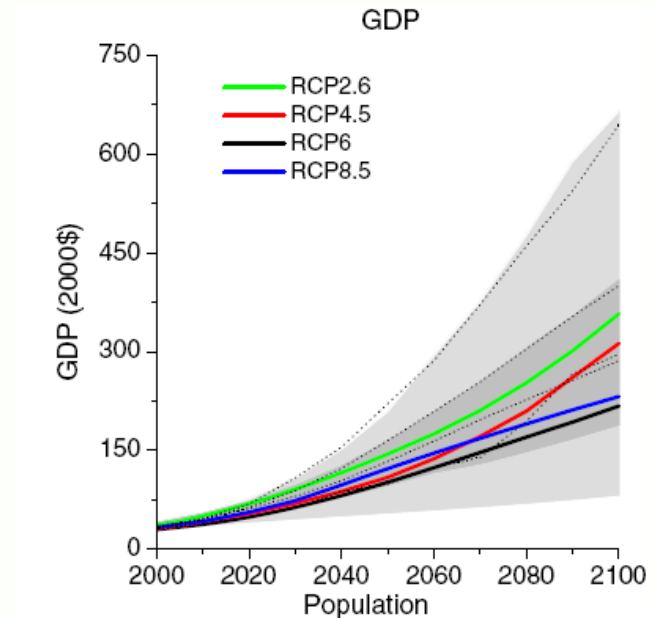
- The Community Land Model (CLM) is a fine-scale model of land-processes
- Generally coupled with atmospheric models as part of the Community Earth System Model (CESM)
- Breaks the world into “grid-cells”, and models vertical fluxes within those grid-cells.
- Does not have a built in way to hand horizontal fluxes between grid-cells
 - Though for some things it can handle horizontal fluxes within grid-cells

Model Overview

- Pre-Processing
 - Transportation Cost
 - Crow Flies versus transportation network
 - Ownership
 - Economic Parameters and data
- Processing (*4km x 4km res.*)
 - Reads restart file
 - Derives harvest levels and spatial distribution of harvest by calculating a spatial market equilibrium (Supply=Demand).
- Edits restart file/ provides outputs
 - Edits harvest input in restart file
 - Obtains a variety of module specific output

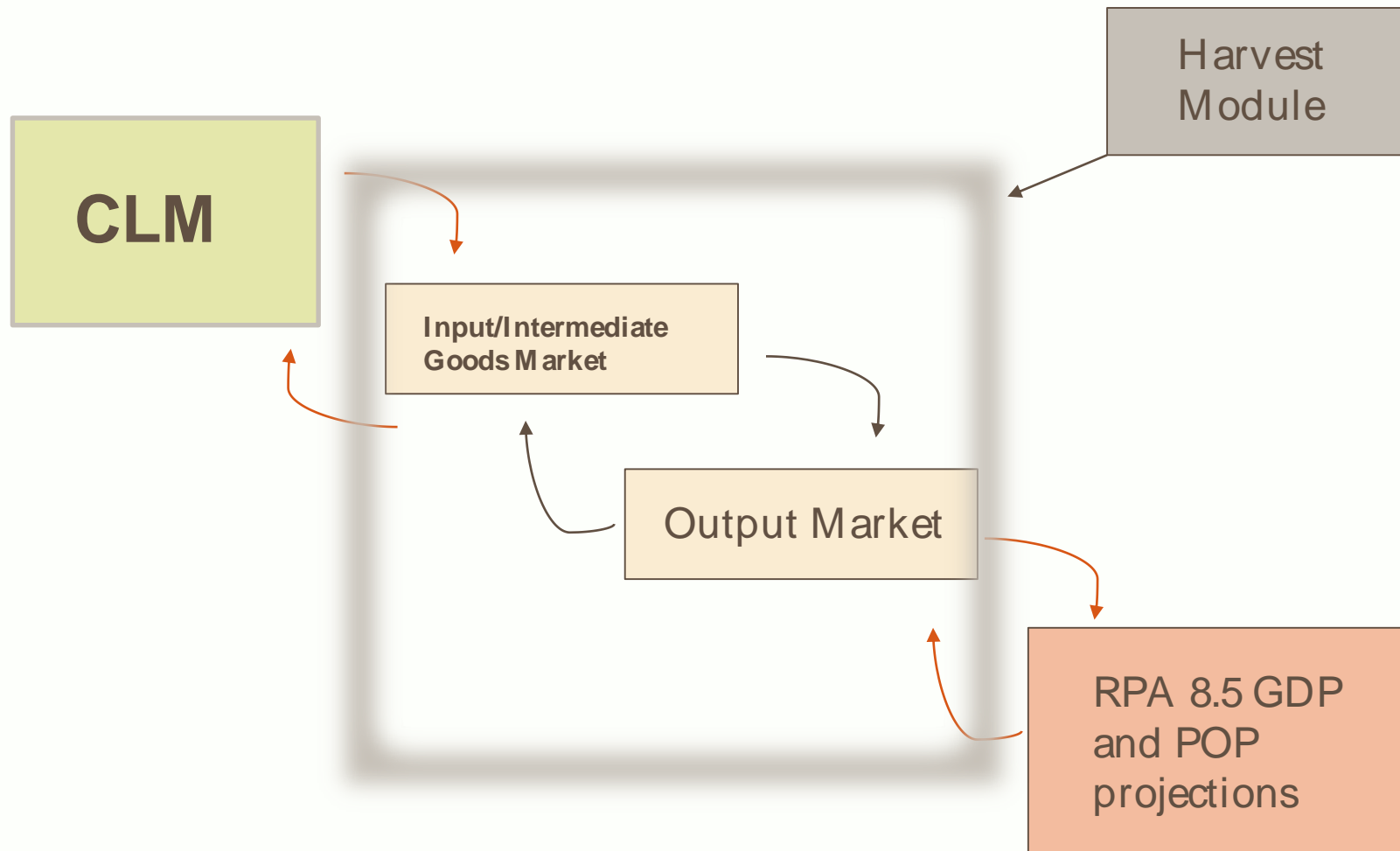
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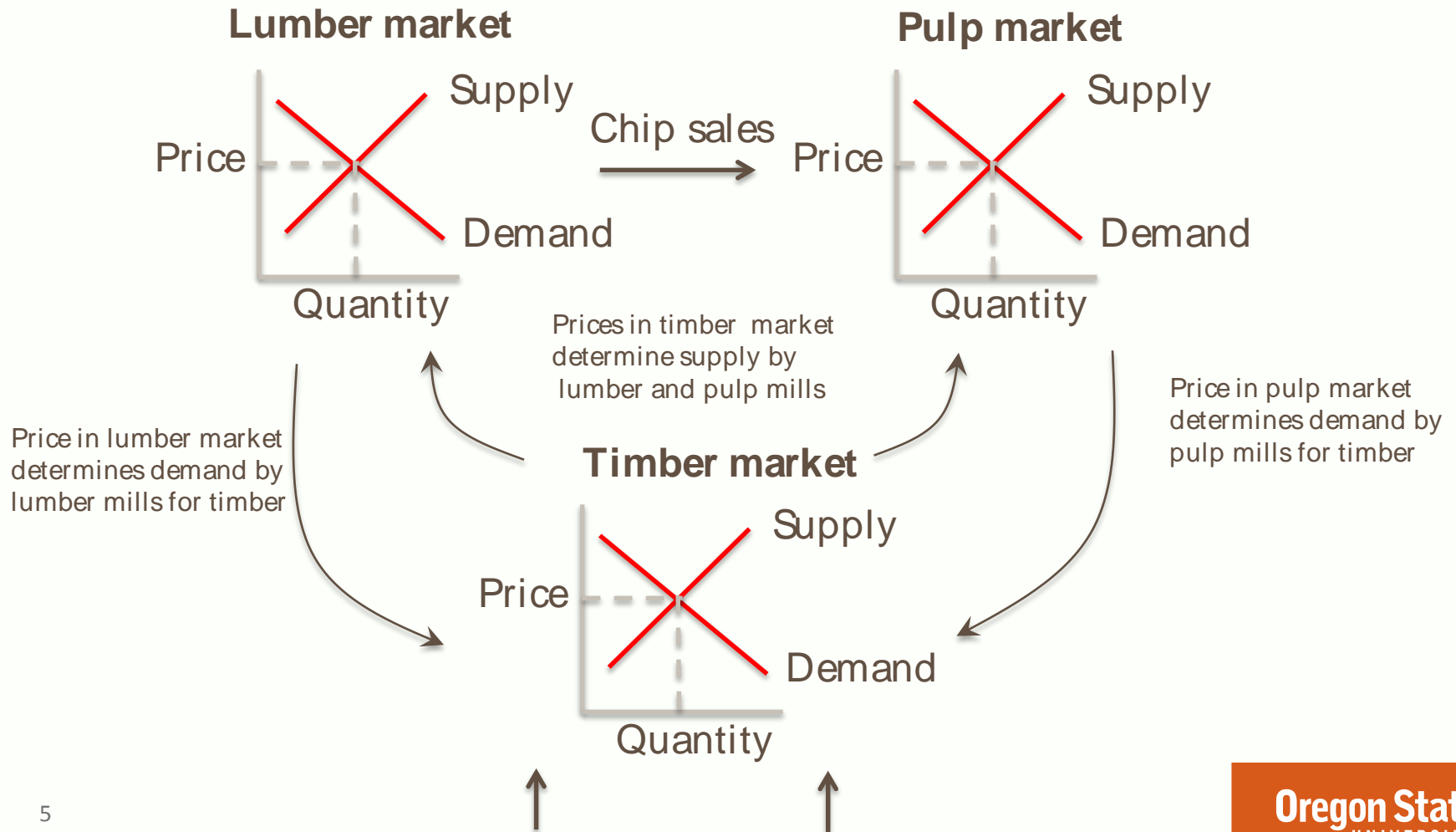


(van Vuuren et al. 2011)

The Full Model Linkage



Solution Technique: Overview

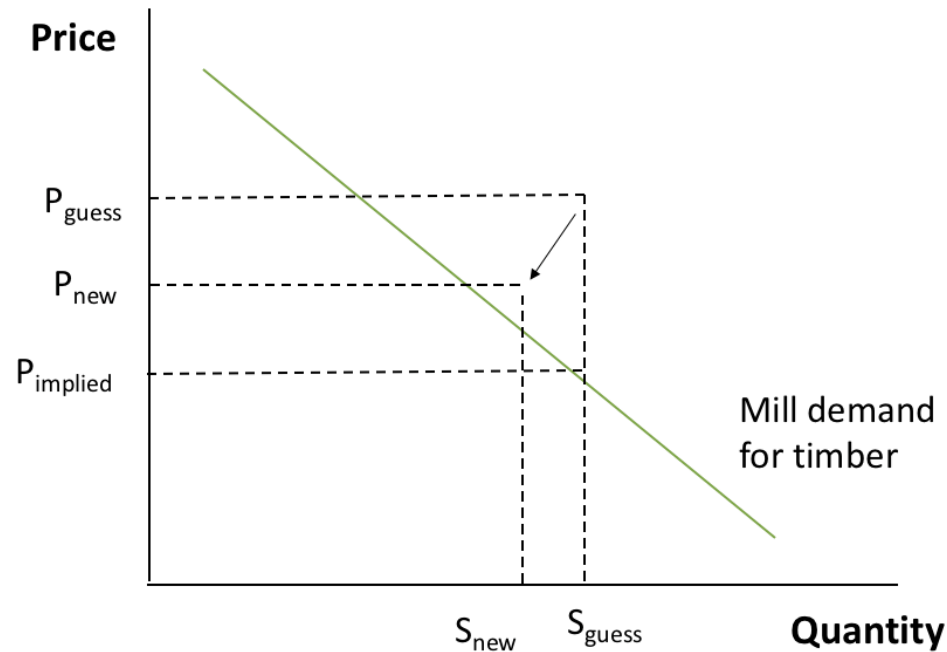


Input and Intermediate Goods Markets

- Start with a set of mill level price guesses.
- Timber Plot Owners observe all prices, transportation costs, harvest costs.
- Decide where to send timber to.
 - A function that includes all mill prices
- Decide how much timber to send.
 - A function that only includes the price of the selected mill
- The auction algorithm produces the quantity of input supplied at each mill.
 - Same thing for intermediate goods, just replace plots with mills

Price Search

- Does Supply=Demand for the mill? No? Then update prices and try again!



Market for output goods

- Input and intermediate goods are spatial markets.
 - Transportation costs and mill/plot locations factor into equilibrium.
- The Output market is not.
 - It is assumed that mills sell their product directly to the market at a market price, ignoring all transportation costs.
- However, prices are still endogenous... to an extent

Plot Owner's Profit Max Problem

- Plot owners get revenue from selling timber
- Harvest Costs are a "generalized" exponential function
- Function of prices, harvest level, and total available harvest.

$$\pi_{\text{plot}} = [\text{Revenue} - \text{Cost}] = P_1^{\text{gate}} t_1 - K \left(\frac{t_1^\alpha}{T_1^\delta} \right)$$

Mill's Profit Max Function

- Mill can process logs directly, or turn intermediate goods into a log-equivalent input.
- Profit function reflects the mill's engagement in the intermediate goods market
- Decreasing returns to scale in inputs (short term)

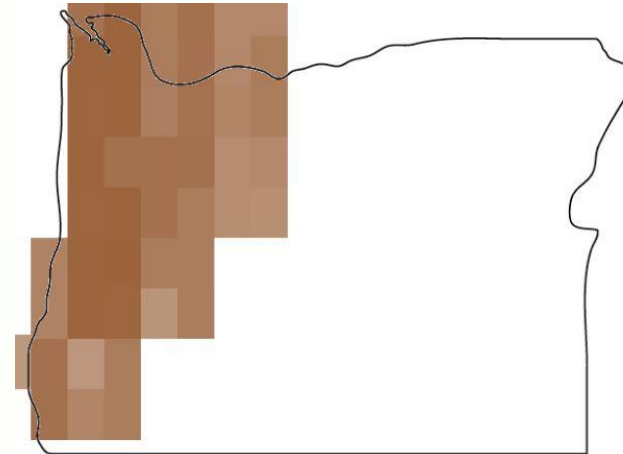
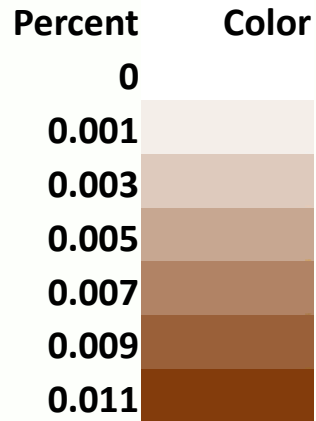
$$\pi_{\text{mill}} = P_0 A (t_1 + \gamma t_2^{\text{total}})^{\beta} + P_2^{\text{offer}} t_2^{\text{sold}} - P_2^{\text{Market}} t_2^{\text{purchased}} - P_1^{\text{Offer}} t_1 - C_1 t_1 - C_2 t_2$$

Linking Forest Product Markets and Macroeconomics

- Demand curves for the output market are national and include the following elasticities:
 - Price
 - GDP
 - Population
- GDP and Population levels are disaggregated to the study region from RPA 8.5.
- Demand curves are constant-elasticity.

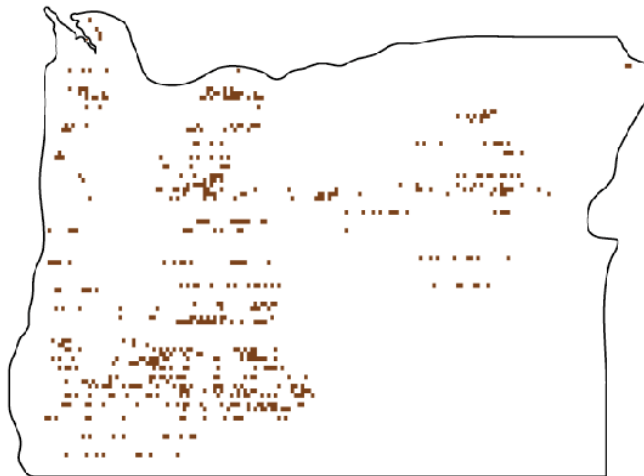
Harvest Output

Top: Default Harvest Data
Bottom: Module Generated Data



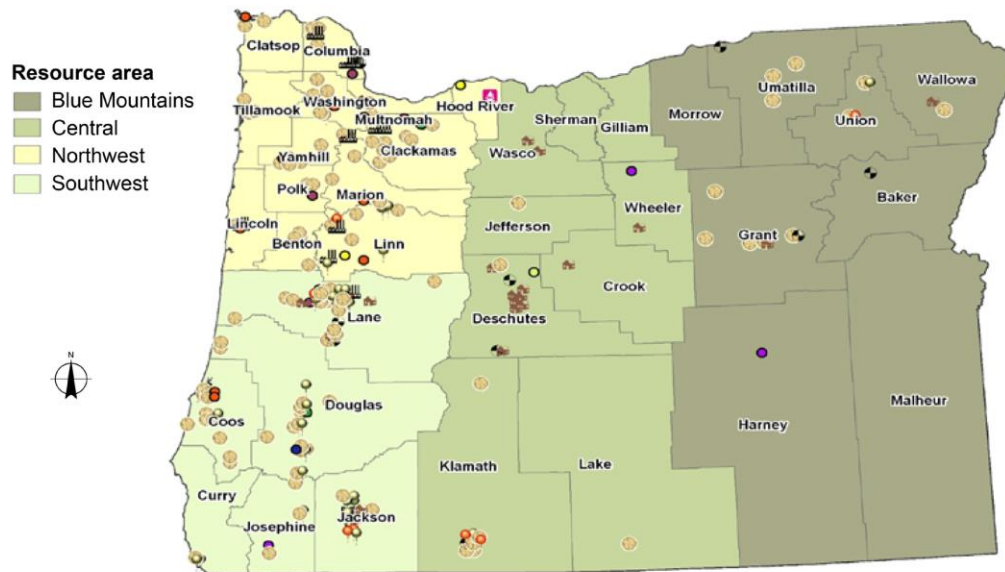
(Hurtt et al. 2006)

(van Vuuren et al. 2011)



Harvest Output

- Spatial Differences:
 - Harvesting in the east
 - Harvesting pattern driven by mill location, transportation costs, and ownership.

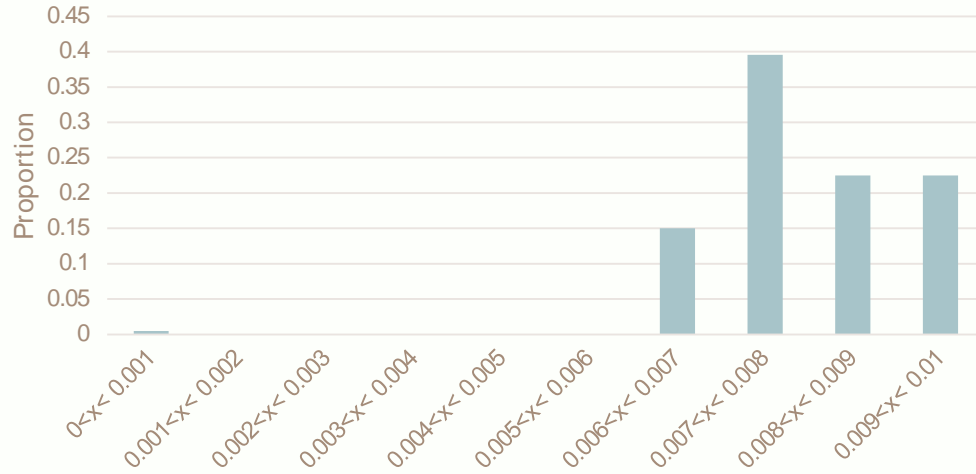


Oregon wood processing facilities, 2008

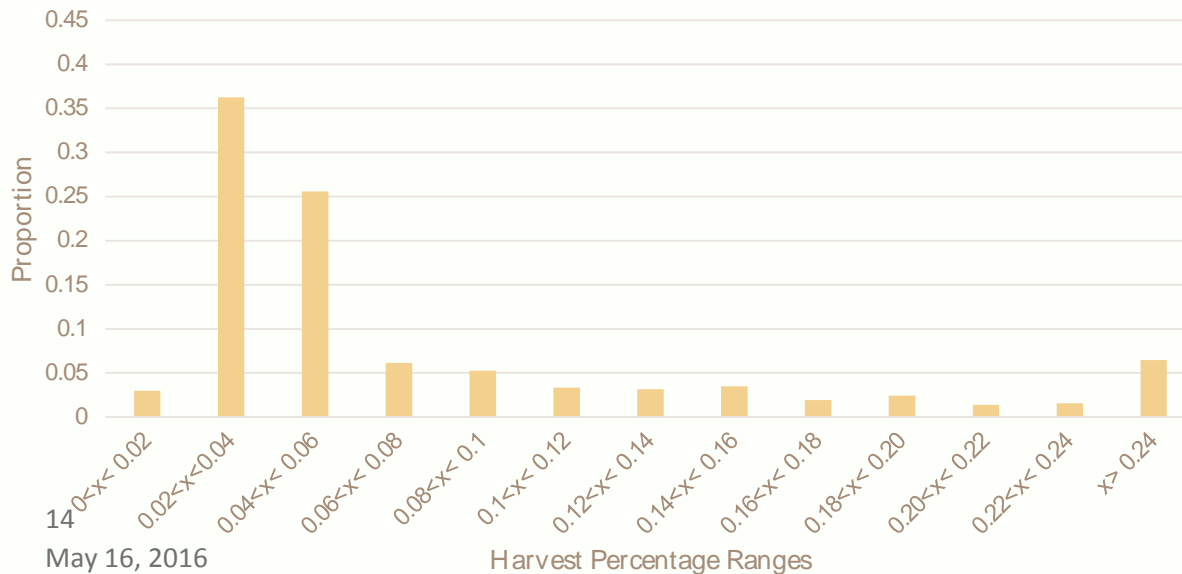
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|----------------------------|----------------------------|-----------------|----------------------------------|
| • Bark products | ■ Firewood | ○ Other | ● Roundwood pulp chip conversion |
| ■ Biomass/energy | ● Fuel pellets/Presto logs | ● Particleboard | ● Sawmill |
| ● Cedar products | ■ House log/log home | ■ Post & pole | ● Veneer/plywood |
| ● Engineered wood products | ● Log furniture | ■ Pulp/paper | |

(Gate et al. 2012)

Proportion of Harvest Percentages within a given range



- Default
 - Count: 7680
 - Max: .009
 - Mean: 0.0079



- Module Generated
 - Count: 571
 - Max: ~.87
 - Mean: ~.085

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Module Output and Future Use

Elgin Lumber Mill in Union County, Oregon



Photo Credit: Gary Halvorson, Oregon State Archives

- Carbon Policy Scenarios
- Economic effects and responses to Beetle Outbreaks and Wildfires
- Changes in land values and productivity

Thank You!

References

- Gale, Charles B., E. Charles III, Erik C. Berg, Jean Daniels, Glenn A. Christensen, Colin B. Sorenson, Todd A. Morgan, and Paul Polzin. "Oregon's forest products industry and timber harvest, 2008: industry trends and impacts of the Great Recession through 2010." (2012).
- Hurtt, G. C., S. Froking, M. G. Fearon, B. Moore, E. Shevliakova, S. Malyshev, S. W. Pacala, and R. A. Houghton. "The underpinnings of land-use history: Three centuries of global gridded land-use transitions, wood-harvest activity, and resulting secondary lands." *Global Change Biology* 12, no. 7 (2006): 1208-1229.
- Van Vuuren, Detlef P., Jae Edmonds, Mikiko Kainuma, Keywan Riahi, Allison Thomson, Kathy Hibbard, George C. Hurtt et al. "The representative concentration pathways: an overview." *Climatic change* 109 (2011): 5-31.