Prediction of Wood Stiffness in White Spruce

Development and validation of models for wood stiffness for use in the Mixedwood Growth Model

Derek Sattler and Jim Stewart
Objective

- Develop a model for the prediction of pith to bark wood stiffness for White Spruce within the Boreal Plains Ecozone.
Enhanced Forest Management
Maximising the return on investment

Integrated market demands
- Pull supply mode
- Value added products

Feedback
- Wood properties demanded by markets

Forest Management
- Volume based objectives
- Wood quality based objectives

Investments
- Silvicultural treatments, etc.

Product Transformation
- Solid wood products
- Pulp and paper
- Bioenergy

Markets

Return on investments

Canadian Wood Fibre Centre
Working together to optimize wood fibre value – creating forest sector solutions with FPIInnovations

Canada
Enhanced Forest Management
Maximising the return on investment

Strategic level
• Enhanced forest inventory (volume + wood properties)
  • Growth and yield simulators

Operational level
• Tools for measurement of wood properties in the field (CT-scanner, Hitman)
  • Growth and yield simulators

• Volume based objectives
• Wood quality based objectives

Lessard et al. 2014.
Enhanced Forest Management
Maximising the return on investment

**Strategic level**
- Enhanced forest inventory (volume + wood properties)
- **Growth and yield simulators**

**Operational level**
- Tools for measurement of wood properties in the field (CT-scanner, Hitman)
- **Growth and yield simulators**

**Enhanced Forest Management**
- Volume based objectives
- **Wood quality based objectives**

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Lessard et al. 2014.

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Research Growing into Practice

Canada
Example: B.C. Tree and Stand Simulator (TASS III)
Wood Property Models for Growth and Yield Simulators

Wood property model

Growth and Yield Simulator

Wood Property: $f(Cambial\ age)$

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Natural Resources
Canada
Ressources naturelles
Canada

Canada
Wood Property Models for Growth and Yield Simulators

- Ring density
  - Lodgepole pine – Sattler et al. (in press) and Peng and Stewart 2013; White Spruce (in progress)

- Micro-fibril angle

- Wood Stiffness (MoE)
  - Lodgepole Pine – Wang and Stewart 2012; White Spruce (in progress)
Wood Property Models for Growth and Yield Simulators

- Ring density
  - Lodgepole pine – Sattler et al. (in press) and Peng and Stewart 2013; White Spruce (in progress)

- Micro-fibril angle

- Wood Stiffness ($MoE$)
  - Lodgepole Pine – Wang and Stewart 2012; White Spruce (in progress)
Wood Stiffness in White Spruce

- Key attribute for structural lumber

Sawlogs

High MOE

Optimization of processing time

Low MOE

Lumber grade

Edlund et al. (2006)
Wood Stiffness in White Spruce

- Anatomical level $f(Microfibril\ angle + cell\ specific\ gravity)$

- Wood Stiffness = $+$

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Wood Stiffness in White Spruce

- **Ring-level:** \( f(\text{Cambial age} + \text{growth rate}) \)
Wood Stiffness in White Spruce

- Ring-level: $f(Cambial \ age + growth \ rate)$

Silvicultural treatments
- Growth rate
- Wood quality objectives

Location effects?
Climate effects?
Objective

- Develop a model for the prediction of **pith to bark** wood stiffness for White Spruce for use in the **Boreal Plains Ecozone**
Models for Stiffness for the Boreal Plains Ecozone
Validation of Existing Model

- **Model/Parameters:**
  Wood stiffness from static bending

- **Validation data:**
  Wood stiffness via Silviscan-3

Static bending $< 20\%$
Validation of Existing Model

- Under-estimated
- Measurement bias?

Boreal Plains Test Locations

Observed MOE_{ss} - Predicted MOE
New Model for Wood Stiffness

- New Model (v1.0):
  \[ MoE_i = f(Cambial Age + Growth rate) \]

30% increase in growth = 20% drop in MOE
Location Effects?

Area Weighted Wood Stiffness vs Longitude

Weighted Mean MOE GPa

-118.39832 -117.4 -115.504 -108.36056

Legend
- Spruce Sample Plots
  - ABPS
  - BPR/FI
  - IWOTA

Ecoregions
- Aspen Parkland
- Boreal Transition
- Clear Hills Upland
- Intake Plain
- Mid-Boreal Lowland
- Mid-Boreal Uplands
- Peace Lowland
- Slave River Lowland
- Waskasus Lowland
- Western Alberta Upland
- Western Boreal
Climate Effects?

- Fall climate variables had greatest effect
- Agrees with previous findings (Lachenbruch et al. 2010)
  - **Wood Stiffness** influence by Latewood Density
New Model for Wood Stiffness

- New Model (v2.0):
  - \( MoE_i = f(Cambial \ Age + Growth \ rate + \ Climate + Elevation) \)

800m gain:
- \(~20\%\) drop in MOE
New Model for Wood Stiffness

<table>
<thead>
<tr>
<th>Number of trees harvested</th>
<th>Area weighted wood stiffness (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As is</td>
<td>Growth increase ~30%</td>
</tr>
<tr>
<td>Minimum for structural select</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Peng and Stewart (2013)
Application: WQ-4-MGM

Wood stiffness model

Mixedwood Growth Simulator

Wood stiffness: \( f \left( \frac{\text{Cambial age} + \text{Growth Rate} + \text{Elevation} + \text{?}}{\text{OFI}} \right) \)
Summary

- New model/parameters for the prediction of pith to bark wood stiffness in white spruce
  - \( \text{growth rate} = \downarrow \text{wood stiffness} \)
  - \( \text{elevation} = \downarrow \text{wood stiffness} \)
- Need for regional-specific parameters?
- Application via WQ-4-MGM package
Questions?