Impact of Advanced Forest Inventory on Merchandizing Yard Costs

Dr./Prof. Reino Pulkki
Faculty of Natural Resources Management
Lakehead University, Ontario, Canada

Wood Flow Logistics 2014
Rotorua, New Zealand
11 June 2014

Outline

- Focus on Canada, motivation
- What is an enhanced forest inventory
- New technologies for better information
- Why merchandizing yards and their operation
- Integrating better forest inventory info into merchandizing yards operations and inventories
- Study description and methods
- Results
- Conclusion
The Canadian forest industry

- has traditionally produced commodity products
- is facing challenges of increased production costs, shifting of input factors to other sectors of the economy, lack of coordinated and integrated supply chains, and decline in capital available to improve existing facilities or build new ones
- has endured major restructuring with many mill closures and major job losses
- direct job loss 2005 to 2011 → 105,700 (NRCan) (339,600 down to 233,900)

Competiveness in the New Bio-economy

- must maximize the value of timber harvested, minimize operating costs and improve supply chains
- variability in species, stem size and wood quality can produce a variety of products with a range of values
- log sorting/merchandizing by Canadian mills has been minimal except on the B.C coast
Competiveness in the New Bio-economy

- merchandizing yards have the potential to increase the value of timber harvested by ensuring that the correct species, stem size and grade/quality is allocated to the appropriate mill to achieve maximum value

- integration of an Enhanced Forest Inventory (EFI), with information on the variability of species, stem quality attributes and fibre quality, with merchandizing yards, will potentially allow value addition along the forest products supply chain
Competiveness in the New Bio-economy

- this will allow us to obtain the maximum value from our forest resources
- some values given by Dr. Tom Browne of FPInnovations in regard to the petroleum industry:
  - 4% of product volume generates 42% of value
  - 70% of product volume generates 43% of value

Potential Benefit

- merchandizing yards need sufficient inventory to meet customer demand, but must also minimize inventory costs
- EFI have the potential to reduce inventory costs by reducing uncertainty in the species, stem size and wood quality delivered to the merchandizing yard
### Potential Benefit

- Managers using current forest inventory information will have difficulty planning for specific log characteristics and may require a larger inventory in the yard to deal with demand.
- An EFI will reduce uncertainty in the logs harvested and delivered to the merchandizing yard, and thus provide for a smaller inventory, and thus smaller handling and holding costs.

<table>
<thead>
<tr>
<th>Supply Chain Value</th>
<th>Cost</th>
<th>Detail</th>
<th>Management Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td></td>
<td>Detailed tree scan with simulated Product Value Recovery (PVR)</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td></td>
<td>PVR using select variables (DBH, height, form, branchiness, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Volume by species and diameter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stand volume</td>
</tr>
</tbody>
</table>

(Shorthouse, 2012)
Data Tracking (Shorthouse, 2012)

Quality Variables (Shorthouse, 2012)
On-the-Ground Inventory $$$$$  (Shorthouse, 2012)

- Enhanced timber cruise
- Point-sample method
- Created stem profiles:
  - Taper
  - Form
  - Quality

Stem Profile

- Diameter Profile
- Sweep Profile
- Quality Features

(Shorthouse, 2012)
Ontario’s Enhanced Digital Aerial Imagery

- started 2007 and re-done on a 10-yr cycle
- used to produce the new forest inventories
- the digital imagery has the following resolution:
  - 20 cm resolution panchromatic stereo and orthoimagery
  - 40 cm resolution multispectral stereo and orthoimagery;

Enhanced Aerial Photography (Bilyk, 2012)
Aerial Lidar Inventory

Source: http://ngom.usgs.gov/task4_2/images/eaarl2a.png

Ground-based Lidar Inventory

Source: Murphy and Acuna 2010
**Merchandizing yards**

- merchandizing yards are of different types depending on the purpose of log sorting and merchandizing, and their location:
  - mill yards
  - concentration yards
  - log reload yards
  - interface terminals in multi modal transport
  - remote log processing yards
  - log sort yard
Interest in merchandizing yards and NSERC Strategic Network projects

- 1.4 VCO-56 - Optimal Facility Location and Supply Chain Design for the BC Coastal Forest Sector using Agent-Based Integrated Production Modeling
- 2-3.2 VCO-15-16 - Wood Fibre and Merchandizing Yard: How to Ensure Collaboration when Partners Compete for the Same Resource?

Interest in merchandizing yards and NSERC Strategic Network projects

- 4.5 VCO-53 - Assessing the Impact of Advanced Forest Inventory Data on Merchandizing Yard Costs
- 4.13 - Optimization Modeling of the Log Merchandising and Sort-Yard Location Problem (part 1)
- 4.14 - Optimization Modeling of the Log Merchandising and Sort-Yard Location Problem (part 2)
General Goal

- determine whether additional information on compartment tree attributes will allow the better management of merchandizing yard inventories and potentially smaller inventories, while ensuring promised deliveries, while minimizing:
  - procurement costs, including transport
  - handling costs
  - holding cost
  - stock out and thus lost sales costs
Purpose for the study

• use an optimization model to analyze economic impact of EFI information on a merchandizing yard in the forest products industry supply chain:
  ➢ to develop an optimization model that maximizes gross profit of a merchandizing yard,
  ➢ to compare gross profit from this model using five scenarios having 0%, 25%, 50%, 75% and 100% certainty in tree quality in forest inventory information
  ➢ to compare per unit profit from each log grade in order to understand the contribution of each product in gross profit

<table>
<thead>
<tr>
<th>Log grades</th>
<th>Average availability per cell (%)</th>
<th>Weekly demand (m³/week)</th>
<th>Gross profit ($/m³)</th>
<th>Inventory carrying cost ($/m³/week)</th>
<th>Lost sales cost ($/m³/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>500</td>
<td>100</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>2,000</td>
<td>75</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>C</td>
<td>30</td>
<td>1,500</td>
<td>50</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>1,000</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Flow Chart of Optimization Model (50 week/1 year time frame)

The Model

Max \( TGP = \sum_{i=1}^{50} \sum_{j=1}^{4} (XSA_{ij} \cdot TGP) - \sum_{i=1}^{50} \sum_{j=1}^{4} (XEI_{ij} \cdot TGP) - \sum_{i=1}^{50} \sum_{j=1}^{4} (XLO_{ij} \cdot TGP) \) \[1\]

Subject to:

\[ \sum_{j=1}^{4} XLG_{ij} \geq \sum_{j=1}^{4} DLG_{i} \] \[2\]

\( XSA_{ij} \leq DLG_{i} \) \[3\]

\( XBI_{i_{i+1}} = XEI_{j} \) \[4\]

\( XBI_{1} = 0 \) \[5\]

\( XEI_{ij} = XBI_{ij} + XLG_{ij} - XSA_{ij} \) \[6\]

\( DLG_{ij} - XSA_{ij} = XLO_{ij} \) \[7\]

\( XLG_{ij}, XSA_{ij}, XEI_{ij}, XLO_{ij} \geq 0 \) \[8\]

Variables:

- \( XLG_{ij} \) = harvested volume of jth log grade in ith week (m³)
- \( TGP \) = total annual gross profit of merchandizing yard ($)
- \( XEI_{ij} \) = end inventory of jth log grade in ith week (m³)
- \( XBI_{ij} \) = beginning inventory of jth log grade in ith week (m³)
- \( XSA_{ij} \) = sales volume of jth log grade in ith week (m³)
- \( XLO_{ij} \) = lost sales volume of jth log grade in ith week (m³)
Hypothetical Merchandizing Yard Location

Research Area and Annual Planned Forest Depletion Spatial Data
Variable Transport Cost Zones
($5 per tonne increments)

Forest cells selected for supplying log grades over one year planning horizon

<table>
<thead>
<tr>
<th>Tree quality information certainty</th>
<th>Total number of forest cells selected</th>
<th>Forest cells selected with certainty in log quality inventory information</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>650</td>
<td>0</td>
</tr>
<tr>
<td>25%</td>
<td>634</td>
<td>152</td>
</tr>
<tr>
<td>50%</td>
<td>618</td>
<td>293</td>
</tr>
<tr>
<td>75%</td>
<td>586</td>
<td>417</td>
</tr>
<tr>
<td>100%</td>
<td>549</td>
<td>549</td>
</tr>
</tbody>
</table>
Total annual gross profits of the merchandizing yard for log grades

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tree quality information certainty</th>
<th>Total Profit ($)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>0%</td>
<td>1,679,110</td>
<td>4,965,785</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>25%</td>
<td>1,932,380</td>
<td>5,599,257</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>50%</td>
<td>2,159,690</td>
<td>6,561,750</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>75%</td>
<td>2,338,900</td>
<td>7,192,733</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>100%</td>
<td>2,500,000</td>
<td>7,500,000</td>
</tr>
<tr>
<td>Additional profit with 100% information</td>
<td></td>
<td>820,890</td>
<td>2,534,215</td>
</tr>
</tbody>
</table>

Percentage gross profit gain with tree quality information certainty

![Graph showing percentage gross profit gain with tree quality information certainty]
Conclusion

- even with the simplified situation (4 log grades) the study shows having better knowledge of tree quality can significantly increase gross profit
- using a merchandizing yard and improved knowledge through an EFI helps:
  - maximize total value of wood fibre by allocating the right log to the right product
  - reduce fluctuations in raw wood fibre supply
  - minimize wood inventory holding costs
  - reduce lost sales at mills

Conclusion

- both public and private forest sectors of Canada can benefit from accurate EFI information to make right strategic and operational business decisions
- further study is required to determine the optimal level of EFI that maximizes overall value (i.e., inventory cost vs improved profit)
- further work continues utilizing a more complex situation with many more log grades and mills
Acknowledgements

This research has been funded and supported by:

- NSERC and NSERC Strategic Network on Value Chain Optimization
- Resolute Forest Products Inc.
- Macri Logging
- Central Computer Services Inc.
- Buchanan Group
- Lakehead University