An economic analysis of controlling root and butt rot disease: Douglas-fir and western red cedar

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Key Points

• Stump removal for root rots shifts growth and yields upwards
• Stump removal for butt rot leads to increased cedar yields in older stands, especially larger logs
Key Points

• Stump removal is economically feasible under certain economic and ecological conditions
• Inclusion of carbon prices improves expected economic returns
• Stump removal to treat butt rot in western red cedar stands economically limited
Western Red Cedar and Douglas-fir

Cedar
• Slow growing initially
• Highest internal decay volume of any conifer (field) – most decay resistant in service
• Deer browse young trees on coast only
• Rarely attacked by insects

Douglas-fir
• Fast growing
• Highly susceptible to several root rots and one insect
Interior Cedar Hemlock and Coastal Western Hemlock zones
Most productive in Canada
Site Productivity

• Site indices describes productivity of a site
• Usually given as tree height in meters at age 50 for the tallest trees in the stand
• Productivity of sites a key factor in economic analysis

Good site index (SI) for:

<table>
<thead>
<tr>
<th>Site</th>
<th>ICH</th>
<th>CWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>WRC</td>
<td>22</td>
<td>26</td>
</tr>
</tbody>
</table>

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Root disease and butt rot effects

1) Growth loss – both
2) Mortality – root disease mainly
3) Butt decay
4) Wind throw/stem breakage- both
5) Wood quality downgrades - both
Biology of Armillaria root disease

- Present on roots of trees for years
- Colonizes stumps after cutting or root system after killing tree
- Transfers from stump to roots by root contact—rarely by spores
- Travels to root collar, girdles the stem and kills tree
- Host range - all trees
- Geographic range A. ostoyae—circumpolar northern hemisphere
- More than 30 Armillaria species cover globe
- Increased hazard in younger sites with temperature and temperature and rainfall in older sites
A. ostoyae belowground incidence over time in planted stands

25-year-old planted Douglas-fir

18-year-old planted Douglas-fir
Timing of Armillaria root disease mortality

Douglas-fir plantations

Douglas-fir natural stands
Biology of cedar butt rot

- 25 species of basidiomycete fungi
- Four white rot and two brown rot most common
- Half spread by spores and half by spores and root contacts
- How these fungi enter tree has never been studied
- Armillaria root rot creates infection courts for butt rot
- Wounds probably infection courts
Western Redcedar Butt-rot

- Conical decay at the base of the tree
- Positioned at the center of the basal logs
- Often renders high quality logs at base of tree unusable
- High presence in first-growth stands
Root and butt rot control

Root disease

- **Sanitation** - stump removal
- **Resistance**
  - within susceptible species possible but not deployed yet
  - Alternate resistant species

Butt rot — no active control program

- **Sanitation** - stump removal currently not done
- **Resistance**
  - possible within species by heartwood extractives or other mechanisms like active defense

- **Wound** control
Stump removal strategy: Sanitation tactic: stump removal (inoculum)

Reduce quantity of primary inoculum after harvest-lowers incidence and impact

Benefits- works for all impacted tree species -physical control- >80% efficient

Problems- site limited (slope <30%), expensive

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Effects of stump removal on yield and decay

Butt Rot

Root disease
Biology simulated in TASS/ROTSIM – Collaboration of BC forestry, CFS and contractors

Armillaria on Douglas-fir at 1600 st/ ha SI=25

- high inoculum
- no disease
- low inoculum
- medium inoculum

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Economic Methods

• Maximum net present value of discounted cash flow from timber or carbon over infinite horizon
  – Faustmann-Hartman-vanKooten et al. methodology: soil expectation value (SEV)/land expectation value (LEV)/site value (SV)
  – Carbon payments received (expensed) when carbon sequestration (emissions) occurs: balanced treatment of emissions and removals

• Compare LEV for stumped scenarios and unstumped scenarios for Douglas-fir and Western red cedar plantations

• Consider different levels of disease and economic conditions for different forest site conditions
# Interior Douglas-fir data and assumptions

<table>
<thead>
<tr>
<th>Economic Factors/Conditions</th>
<th>Good</th>
<th>Base</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stumping costs ($/ha): Cs</td>
<td>700</td>
<td>850</td>
<td>1000</td>
</tr>
<tr>
<td>Planting costs ($/ha): Cp</td>
<td>650</td>
<td>800</td>
<td>950</td>
</tr>
<tr>
<td>Timber prices ($/m3) (maximum): Pt</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Carbon prices ($/t CO2): Pc</td>
<td>25</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Interest rates (%): r</td>
<td></td>
<td>3 to 6</td>
<td></td>
</tr>
</tbody>
</table>

- Merchantable volume in cubic metres for utilization up to 12.5 cm tops every 5-yrs up to 125 yrs
- Above and below ground live biomass (carbon) and carbon in dead organic matter pools (tonnes)
- Carbon in dead organic pools released at a rate of 30% per year and then either 1) all carbon is released at time of harvest or 2) 75% of live carbon and 100% of dead is released to atmosphere
- Planting density 1600 stems per hectare

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Douglas-fir Growth and Yield Simulations

- Higher levels of disease greatly impact stand yields around 40 years of age
- Impacts on volume increase on more productive lands
• Stumping is feasible on highly productive sites with good economic conditions. More opportunity if disease levels are higher. Discount rates greater than 4% do not support stumping.

• Stumping on SI 25 supported if disease levels high and economic conditions are good.
Douglas-fir Carbon and Timber Results: Low disease levels and 3% discount rate

- With carbon values and average or above economic conditions stumping is feasible on sites as low as SI20.
- Stumping is feasible under higher discount rates if economic conditions good or disease levels are higher.
Interior Douglas-fir conclusions

• Stumping to control root rot diseases is economically feasible under good conditions – good site quality and good economic conditions (low costs, good timber prices)
• Carbon values improve economics of stumping.
## Western Red Cedar – Interior BC

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Good</th>
<th>Base</th>
<th>Poor</th>
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</thead>
<tbody>
<tr>
<td>Maximum stumpage price ($/m³)</td>
<td>51.47</td>
<td>40.85</td>
<td>30.23</td>
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<tr>
<td>Stumping cost ($/ha)</td>
<td>700</td>
<td>850</td>
<td>1000</td>
</tr>
<tr>
<td>Planting cost ($/tree)</td>
<td>0.85</td>
<td>0.9</td>
<td>0.95</td>
</tr>
<tr>
<td>Harvesting Fixed Cost ($/ha)</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
</tr>
<tr>
<td>Carbon Price ($/tCO2)</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>
Simulation - Damage caused by butt-rot

Volumes of Large and Medium Sawlogs with Age (Stumped Vs. Non-Stumped)

Cubic meters per ha
0 100 200 300 400 500 600 700 800 0 10 20 30 40 50 60 70 80 90 100 110 120

- Stumped - Large Sawlog
- Stumped - Medium Sawlog
- Not Stumped - Large Sawlog
- Not Stumped - Medium Sawlog

Percentage butt-rot affected vol. to total stand vol. with age

0% 5% 10% 15% 20% 25%
0 10 20 30 40 50 60 70 80 90 100 110 120

Site Index – 20; Planting density - 1000
Timber Soil Expected Value Stumped vs. Non-Stumped for Butt Rot ($ per hectare) – Interior western red cedar

Base economic conditions; Planting density - 1000
## Optimal Timber Rotation Ages (Discount Rate - 3%)

<table>
<thead>
<tr>
<th>Planting Density</th>
<th>Economic Conditions</th>
<th>Site Index - 15</th>
<th>Site Index - 20</th>
<th>Site Index - 25</th>
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<tbody>
<tr>
<td></td>
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<td>Stumped</td>
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Forest Soil Expected Value Stumped vs. Non-Stumped for Butt Rot ($ per hectare) – Interior western red cedar

Base economic conditions; Planting density - 1000
Western red cedar conclusion

• Replanting Cedar is economically viable and has a positive NPV

• Planting at higher densities may be beneficial if carbon values are considered

• Stumping is not economical, as butt-rot impacts happen too late in stand age (only under best site and economic conditions)

• Harvesting at an earlier age helps minimize the impacts of butt-rot and improve economic returns
Conclusions

• Site productivity is very important
• Economic conditions matter
• Genetically improved planting stock not considered but would improve soil expectation values on stumped sites
• Root rot results likely similar for western larch
• Further research has to be carried out on the quality and value of second growth cedar logs
Team

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And thanks to: Cynthia Lidstone (BCMF) and Jeff McWilliams (Blackwell & Associates) for sharing information and expertise on cedar log values; the BC Government stand modeling group; and Ian Cameron (Azura Formetrics), Jim Goudie (BCMF) and Robert McDonald (RAMSOFT) for modeling development