Economic Valuation of Larch Plantations

JAMES L. ANDERSON, M.S.
SCHOOL OF FOREST RESOURCES
UNIVERSITY OF MAINE
JAMES.L.ANDERSON@MAINE.EDU
## Plum Creek Larch Plantation Data

<table>
<thead>
<tr>
<th>Site</th>
<th>ID</th>
<th>No. of Trees</th>
<th>DBH Measurement Ages</th>
<th>HGT Measurement Ages</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chase Stream</td>
<td>SR 8801</td>
<td>370</td>
<td>5, 10, 16, 20</td>
<td>3, 5, 10, 16, 20</td>
<td>All (EL, HL, JL, TL)</td>
</tr>
<tr>
<td>Carrying Place</td>
<td>SR 8801</td>
<td>359</td>
<td>3, 5, 10, 16</td>
<td>3, 5, 10, 16</td>
<td>All (EL, HL, JL, TL)</td>
</tr>
<tr>
<td>Brighton</td>
<td>SR 8801</td>
<td>472</td>
<td>3, 5, 10, 16</td>
<td>3, 5, 10, 16</td>
<td>All (EL, HL, JL, TL)</td>
</tr>
<tr>
<td>Lily Bay</td>
<td>SR 8801</td>
<td>355</td>
<td>3, 5, 10, 15</td>
<td>3, 5, 10, 15</td>
<td>All (EL, HL, JL, TL)</td>
</tr>
<tr>
<td>West Forks</td>
<td>SR 9004</td>
<td>232</td>
<td>6, 10, 15</td>
<td>2, 5, 6, 10, 15</td>
<td>Hybrid</td>
</tr>
<tr>
<td>Brighton/Hartland</td>
<td>TI 9801</td>
<td>900</td>
<td>3, 5, 10</td>
<td>1, 2, 3, 5, 10</td>
<td>Hybrid</td>
</tr>
<tr>
<td>Hartland</td>
<td>TI 9802</td>
<td>1800</td>
<td>3, 5</td>
<td>1, 2, 3, 5</td>
<td>Hybrid</td>
</tr>
<tr>
<td>North Anson</td>
<td>SR 9004</td>
<td>194</td>
<td>6, 10, 15</td>
<td>2, 5, 6, 10, 15</td>
<td>Hybrid</td>
</tr>
</tbody>
</table>
Completing the Data

Using Regression Imputation, we fill in missing Heights and Diameters

\[
DBH = \begin{cases} 
DBH \text{ if } DBH \text{ is recorded} \\
\min(E[DBH|Height, Age, Species, Unit] + \epsilon_{Hgt}, 0.0001) \text{ if } Height \text{ is recorded} \\
\min(E[DBH|Age, Species, Unit] + \epsilon, 0.0001) \text{ otherwise}
\end{cases}
\]

\[
Height = \begin{cases} 
Height \text{ if } Height \text{ is recorded} \\
\min(E[Height|DBH, Age, Species, Unit] + \epsilon_{DBH}, 0.0001) \text{ if } DBH \text{ is recorded} \\
\min(E[Height|Age, Species, Unit] + \epsilon, 0.0001) \text{ otherwise}
\end{cases}
\]
Operational Property Assumptions

Tree stems are narrow paraboloids

DBH measurement height, DBH.Hgt = 4.5 ft

Minimum Diameter at small end for saw logs, sawDSE = 9.0 in

Minimum Diameter at small end for biomass, bioDSE = 3.5 in

Fraction of Unusable Sawlog Volume, cull = 0.100

Density of Larch, ton.p.ft3 = .024 tons/ft³

We can earn 3% yield on 30yr US bonds, so we want a 4% IRR on our stands
Calculating Stand and Tree Statistics

**Base Diameter**, \( DLE = \frac{DBH}{\sqrt{1-\frac{DBH\cdot Hgt}{Hgt}}} \)

**Max Product Height**, \( \text{Saw.Hgt} = Hgt \times (1 - \left(\frac{\text{sawDSE}}{DLE}\right)^2), \text{Bio.Hgt} = Hgt \times (1 - \left(\frac{\text{bioDSE}}{DLE}\right)^2) \)

**Parabolic Volume**, \( \text{Vol} = \frac{\pi}{2} \times \text{Bio.Hgt} \times \left(\frac{DLE}{12\times2}\right)^2 \)

**Diameter at hgt**, \( \text{Dia} = DLE \times \sqrt{1 - \frac{hgt}{Hgt}} \)

**Basal Area**, \( \text{BA} = \pi \times \left(\frac{DLE}{12\times2}\right)^2 \)

**Trees per Acre**, \( TPA = \min\left|1237.7 \times TPA^{-0.343} - TPA \times BA\right| \)
Using the maximum saw height, we calculate the number of 16-, 12- and 8 ft logs (6” trim) we might cut and the height along the stem where they are cut.

Using the Diameter equation, we can calculate the diameter at the small end of each log.

Using each log’s length and small end diameter, we can easily estimate board footage using the International ¼” Rule and removing 10% cull (IntBF).
Calculating Stand and Tree Statistics

Convert **board footage to cubic feet** using \( \frac{1 ft^3}{12 BF} \) conversion

We estimate biomass volume with

\[
\text{Biomass}(ft^3) = \text{Volume}(ft^3) - \text{IntBF} \times \frac{1 ft^3}{12 BF}
\]
Predicting Sawlog Volume
Predicting Remaining Biomass

Biomass Prediction

Biomass Yield after Sawlogs (ft^3/ac)

Stand Age

European
Hybrid
Japanese
Tamarack
90% Prediction
Matching Larch to Products on the Market

Using $k$-nearest neighbors ($k = 5$), we match six Larch lumber properties for each species reported by Koizumi, Kitagawa, and Hirai (2008), Chui and MacKinnon-Peters (1995), and Olson, Poletika, and Hicock (1947) to lumber properties of common commercial species, available in the USDA’s Wood Handbook (2010). These 10 Maine species are then mapped to stumpage prices provided by MFS.
Matching Larch to Maine Species

European
- Black Spruce, Red Pine, Eastern Hemlock, Red Spruce, White Spruce

Hybrid
- Eastern White Pine, Atlantic White Cedar, Balsam Fir, White Spruce, Northern White Cedar

Japanese
- Eastern Hemlock, Eastern White Pine, Atlantic White Cedar, Balsam Fir, Black Spruce

Tamarack
- White Spruce, Eastern Hemlock, Red Spruce, Black Spruce, Balsam Fir
Matching Larch to Commercial Species

European, $151.80
  ◦ Spruce/Fir x 3, Red Pine, Hemlock

Hybrid, $154.60
  ◦ White Pine, Cedar x 2, Spruce/Fir x 2

Japanese, $163.60
  ◦ Hemlock, White Pine, Cedar, Spruce/Fir x 2

Tamarack, $178.60
  ◦ Spruce/Fir x 4, Hemlock
Sawlog and Total Value of a Larch Stand
A Comparison with Spruce and Fir Stands

Japanese Larch
reinvested @ 3%
### Under Infinite Rotations: SEV

<table>
<thead>
<tr>
<th>Species</th>
<th>‘Optimal’ Rotation Age</th>
<th>SEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balsam Fir</td>
<td>52</td>
<td>$650</td>
</tr>
<tr>
<td>White Spruce</td>
<td>56</td>
<td>$725</td>
</tr>
<tr>
<td>Japanese Larch</td>
<td>30</td>
<td>$1180</td>
</tr>
</tbody>
</table>
Conclusions

Larch grow quite quickly

- Empirically: 2.90 ft/year on average with Hybrid growing an extra 0.41 ft/yr and Tamarack lagging by 0.73 ft/year
- DBH growth is **roughly** 0.16 in/ft of height growth or 0.47 in/year

Quality stands of Hybrid Larch may start producing some saw logs at age 18 with poorer sites lagging by about two years

Not enough data to determine the optimal financial rotation age, but just growing out to 30 years has good returns

Stand value may be even greater with PCT or mortality recovery
Comments and Questions?

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