Low-density management of even-aged eastern white pine stands appears to be a viable alternative to conventional B-line thinning. By substantially increasing crown sizes, low-density trees grew larger, faster, and had more desirable stem form than conventionally thinned trees. Gross stand volume growth rates were not reduced in the low-density regime in proportion to the amount that stand densities were reduced below the conventional level; therefore, sacrifices in total yield were nominal in light of significant gains in valuable clear timber on low-density crop trees.
Project Summary

To address a deficiency in the understanding of the effects of thinning on even-aged eastern white pine (*Pinus strobus* L.) stands, patterns of leaf area, tree growth, bole form, stand-level volume growth, and growth efficiency – volume increment per unit leaf area – were examined over a 17-year period in a thinning study in central Maine designed to contrast conventional B-line management with low-density thinning. Using simulated growth over a 100-year period, preliminary comparisons of financial returns were made. Further work is needed in this area because the FVS model was found to be inaccurate when projecting the growth of thinned stands. Most analyses, therefore, focused on the measured, 17-year results.

At the tree-level, low-density thinning resulted in significantly larger crowns with greater leaf area than equivalent trees in both the conventional and unthinned control treatments. These changes explained higher rates of diameter and volume growth, and only slightly, but significantly, reduced the growth efficiency of the larger trees. Surprisingly, lower stem form was more desirable on low-density trees, with conventional trees showing depauperate diameter growth up to 5 meters. It is thus apparent that pruning-wound occlusion would be hampered under B-line thinning. At the stand-level, significant reductions in stand leaf area explained reductions in the gross volume growth of thinned stands. Growth rates between the treatments, however, were similar until a second thinning entry. Following this thinning, low-density stand growth was reduced, but not in proportion to the reduction in stand density because low-density stands utilized growing space as efficiently as the other treatments.

These findings revealed the potential for greater use of low-density management in the Northeast. Further, the response of white pine crop trees to heavy release in pure stands would be similar in mixed or uneven-aged stands.
Background and Justification

- Eastern white pine stands are common throughout the Northeast.

- High-quality, and thus high-value, lumber is only found on large trees.

- Therefore, thinning is commonly recommended to hasten growth; pruning crop trees will improve lumber quality and increase financial returns (Smith and Seymour 1986; Page and Smith 1994).

- Consensus as to the optimal management regime for even-aged stands, however, has not been reached after nearly 40 years of debate (Leak 2004; Seymour 2007).

- The two primary choices are conventional B-line and low-density thinning.
Background and Justification

- Conventional management:
  - Follows regional guidelines (Lancaster and Leak 1978), which advocate repeatedly thinning to - but not below - the B-line on the Philbrooks et al. (1973) white pine stocking guide.
  - B-line thinning yields high volumes of sawtimber (Leak 2004), but may produce many low-value, black-knotted logs (Seymour 2007).
Background and Justification

- Low density management:
  - Heavy thinning of high-density stands once crowns recede above one log
  - Crop trees are kept at a spacing of roughly half the stand height
  - Final harvest of around 75 trees per hectare (30 tpa)
  - Sacrifices in stand yield may be offset by gains in financial returns from highly valuable crop trees (Seymour 2007)
Background and Justification

“The ability to explicitly link the objectives of silvicultural practices with the processes underlying their effects should enhance the efficacy of silvicultural prescriptions.”

- Monitoring leaf area and growth will aid in improving thinning treatments
- The debate between the management regimes will be well informed with detailed, scientific analyses of the effects of each treatment on ecophysiological responses
White Pine Thinning Study

- 60-year-old plantation located in Old Town, ME
- Study design consists of replicate blocks with thinning treatments assigned at random

Stand attributes at study initiation in 1991

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (tph)</td>
<td>$1550 \pm 347$ (Avg. ± SE)</td>
</tr>
<tr>
<td>BA (m² ha⁻¹)</td>
<td>$45.8 \pm 4.29$</td>
</tr>
<tr>
<td>QMD (cm)</td>
<td>$21.7 \pm 1.72$</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>42</td>
</tr>
<tr>
<td>Site index (m)</td>
<td>19.2</td>
</tr>
</tbody>
</table>
Eastern white pine stocking guide showing the development of the WPTS treatments. Time progresses from right to left. After the initial thinning in the fall of 1991, there was a second thinning entry in 2001 (after third plotted point).
Methods

- **Leaf area**
  - Litterfall collected in traps throughout study period
  - Allometric equations fit to stand inventory data and measured sapwood basal area

- **Volume growth**
  - Volumes were estimated with a regional taper equation for white pine (Li and Weiskittel *in press*)
  - Growth was measured between stand inventories in 1992, 2001, and 2008

- **Lower stem form**
  - Reconstructed Girard form class by climbing paired sample of crop trees and extracting increment cores
17-year pattern of leaf area index (LAI) shows effects of stochastic events – most notably the 1998 ice storm.

1991 thinning reduced LAI by 60%; thinning treatments had nearly equal LAIs

After 2001 thinning, the B-line LAI reaches a plateau as the crowns closure was re-attained

Low-density LAI was nearly equal to the B-line at end of study period, but the stands had reached crown closure
Results: Tree leaf area

- Thinning significantly increased tree leaf area (PLA)
- Low-density trees showed an increased rate of crown-building after 10 years
- B-line trees had steady PLAs after 2001 as crowns receded due to crown closure; this is a similar pattern to the control
Results: Tree volume growth

- Thinning significantly increased tree volume growth
- As expected, low-density trees grew most rapidly
- Low-density trees experienced a substantial increase in their growth rates between growth periods (follows increased tree leaf area)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Volume increment (dm³ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1992-2001</strong></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>12.8 ± 0.57</td>
</tr>
<tr>
<td>B-line</td>
<td>17.1 ± 0.90</td>
</tr>
<tr>
<td>Low Density</td>
<td>25.1 ± 1.16</td>
</tr>
<tr>
<td><strong>2001-2008</strong></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>15.6 ± 0.78</td>
</tr>
<tr>
<td>B-line</td>
<td>24.9 ± 1.34</td>
</tr>
<tr>
<td>Low Density</td>
<td>43.7 ± 2.99</td>
</tr>
</tbody>
</table>
Results: Gross stand volume growth

- Thinning reduced gross volume growth rates
- B-line and low-density growth rates were nearly equal during the first growth period
- The increase in the B-line growth rate was attributed to increased LAI during the second period
- Low-density growth rates remained constant despite removal of nearly half the trees in the 2001 thinning

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Volume increment (m³ ha⁻¹ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13.8 ± 1.52</td>
</tr>
<tr>
<td>B-line</td>
<td>8.3 ± 0.38</td>
</tr>
<tr>
<td>Low Density</td>
<td>7.4 ± 0.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Volume increment (m³ ha⁻¹ yr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13.0 ± 1.08</td>
</tr>
<tr>
<td>B-line</td>
<td>10.6 ± 0.91</td>
</tr>
<tr>
<td>Low Density</td>
<td>7.4 ± 0.18</td>
</tr>
</tbody>
</table>
Results: Lower stem form

- Stem form – quantified as Girard form class (GFC) – increased in all treatments
- Surprisingly, B-line GFC was lowest; the low-density GFC is not statistically different from the other treatments
- Why do B-line trees have the most taper / undesirable stem form?
Results: Lower stem form

- Diameters at 5m (scaling height) did not increase on B-line trees, but DBH grew significantly.
- Low-density trees grew at both heights; thus they are larger and have better form than B-line trees.
- Slow growth at the top of butt-log on B-line trees means that it will be difficult to recover pruning expenses.
Preliminary Result: Financial comparison

- Projected growth and NPVs (1991 $) of the treatments using FVS (uncalibrated)

- B-line produces most sawtimber, highest NPV (in 2021)

- Low-density treatment has the highest overall NPV at end of the 100-year projection

- Further work is needed to calibrate growth model; projections to 2010 do not match measured results
Key Findings / Management Implications

- Stand leaf area was permanently reduced by thinning
  - Explains reduction in gross volume growth from thinning
- Low-density tree leaf area increased nearly 5-fold; twice the response of conventionally-thinned crop trees
- Tree volume growth rates of low-density trees were substantially higher than conventionally-thinned trees
  - Stem form was also more desirable on low-density trees
- Only a minor loss of gross stand volume growth by thinning to a low density
  - Sacrifices in total yield may be worth the increases in crop-tree size
- Contrary to previous belief, thinning below the B-line did not reduce site utilization
  - Growing space was not wasted under low-density thinning regime
Future Directions

- Continued monitoring of leaf area and growth
  - Litterfall collection, future stand inventories

- Third thinning entry planned for 2011

- Financial comparisons
  - Calibration of FVS Northeast (or newer) variant
  - Simulated merchandizing of product output
List of Products


Literature Cited


