Seedling quality in relation to field performance in Aspen (*Populus tremuloides*)

**Dr. Simon Landhäusser** – Department of Renewable Resources, University of Alberta

**Kaitlin Schott** – Department of Renewable Resources, University of Alberta

**Dr. Brad Pinno** – Canadian Forest Service, Northern Forestry Centre

**Amanda Schoonmaker** - Boreal Research Institute, NAIT
Seedling quality: why should we be concerned?
• Root growth
• Leaf area development
• Shoot dieback and tree form
• Increased susceptibility to insects and disease

= Poor out-planting performance
Role of Aspen in reclamation

- Aspen is a dominant tree across the boreal region and is broadly distributed across North America.

- Establishment from natural seeding events does occur but is not consistent.

- Therefore, establishment on reclamation sites should involve more intentional efforts (e.g., planting).
Challenges of establishing Aspen in the field

• Primarily reproduces from root suckers following removal of aboveground mass (harvesting or fire)

• Greenhouse stock has historically shown poor performance under field conditions (eg- Van den Driessche et al 2003)

• Seedling performance measures used on other species may not be appropriate indicators of a ‘good’ seedling

• Aspen is shade-intolerant and does not tolerate intense competition
Indeterminate versus determinate growth strategy

Termination triggered by stresses:

- Drought
- Shortened day length
- Cold soil and air temperatures
- Hormones

Indeterminate species may, however, resume growth when limiting conditions become favorable again…. 
Result of the kitchen sink approach -

D) one growing season after outplanting of the different planting stock types. Different letters indicate significant differences (except height growth N = 20). Significance between outside and inside-grown stock are indicated by *** p<0.001; ** p<0.01; * p<0.05.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Height growth (cm)***</th>
<th>Diameter growth (mm)***</th>
<th>Stem mass growth (g)***</th>
<th>Root mass growth (g)***</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
<td>28.3 (17.1) bcd</td>
<td>2.9 (1.0) bc</td>
<td>8.0 (2.9) abc</td>
<td>6.2 (3.0) ab</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>42.6 (17.2) ab</td>
<td>4.2 (1.1) ab</td>
<td>10.9 (4.0) a</td>
<td>7.7 (4.4) a</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>45.1 (14.4) a</td>
<td>4.4 (1.2) a</td>
<td>9.4 (3.5) ab</td>
<td>6.1 (3.3) ab</td>
<td>15</td>
</tr>
<tr>
<td>Out</td>
<td>28.4 (18.0) bcd</td>
<td>3.2 (1.0) abc</td>
<td>4.4 (1.8) cdef</td>
<td>3.3 (1.5) b</td>
<td>7.6</td>
</tr>
<tr>
<td>Fertility</td>
<td>4.4 (0.7) a</td>
<td>3.5 (1.2) abc</td>
<td>3.8 (2.2) def</td>
<td>4.4 (2.9) ab</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>32.5 (21.2) abcd</td>
<td>4.4 (0.7) a</td>
<td>6.0 (1.7) bcdef</td>
<td>5.4 (1.6) ab</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>15.2 (10.5) d</td>
<td>2.7 (0.8) c</td>
<td>4.8 (2.9) cdef</td>
<td>5.9 (2.3) ab</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>20.0 (13.5) cd</td>
<td>2.6 (0.9) c</td>
<td>6.5 (2.7) bcde</td>
<td>4.0 (2.5) b</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>30.5 (17.1) abcd</td>
<td>4.4 (0.9) a</td>
<td>7.1 (2.3) bcd</td>
<td>4.9 (2.1) ab</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>20.7 (13.7) cd</td>
<td>2.9 (0.6) bc</td>
<td>3.5 (1.1) def</td>
<td>3.9 (1.5) b</td>
<td>7.4</td>
</tr>
<tr>
<td>Out</td>
<td>22.2 (12.3) cd</td>
<td>2.1 (0.7) c</td>
<td>2.7 (1.2) f</td>
<td>2.5 (1.2) b</td>
<td>5.2</td>
</tr>
<tr>
<td>Fertility</td>
<td>19.3 (15.2) cd</td>
<td>2.3 (1.1) c</td>
<td>2.8 (1.9) ef</td>
<td>2.7 (1.6) b</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Landhäusser et al. 2012 For Ecol Manage 275: 43–51
Out-planting growth response

\[ y = 1.7582x - 25.278 \]

\[ R^2 = 0.7962 \]

Landhäusser et al. 2012 For Ecol Manage 275: 43–51
$y = 4.59x + 20.52$

$r^2 = 0.579$

$p = 0.003$
Nutrient loading definition- process of providing nutrients to a seedling in excess of requirements for growth (luxury consumption).

Nutrient loading may offer the following benefits-
• Increased growth and survival on poor sites
• Increased competitive ability in sites with pre-existing vegetation

Question- how do we nutrient load an indeterminate species???
Table 4  Average, plus standard error in parentheses, of morphological seedlings characteristics at the end of the growing season of seedlings that were treated with different combinations of two fertilizer rates and a shoot growth inhibitor (SGI) treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Height (cm)</th>
<th>Root collar diameter (mm)</th>
<th>Root dry weight (g)</th>
<th>Stem dry weight (g)</th>
<th>Root volume (ml)</th>
<th>Root:Stem ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>100–150 SGI</td>
<td>30.8 (0.75) c</td>
<td>4.0 (0.06) c</td>
<td>3.17 (0.18) a</td>
<td>0.94 (0.05) c</td>
<td>11.72 (0.99) a</td>
<td>3.36 (0.08) a</td>
</tr>
<tr>
<td>100–150</td>
<td>40.2 (1.08) a</td>
<td>5.4 (0.13) a</td>
<td>3.05 (0.10) a</td>
<td>1.62 (0.10) a</td>
<td>14.49 (1.16) a</td>
<td>1.92 (0.15) c</td>
</tr>
<tr>
<td>100–100 SGI</td>
<td>26.2 (0.61) d</td>
<td>3.7 (0.67) d</td>
<td>2.23 (0.09) b</td>
<td>0.69 (0.03) d</td>
<td>8.23 (0.68) b</td>
<td>3.23 (0.17) a</td>
</tr>
<tr>
<td>100–100</td>
<td>36.8 (1.00) b</td>
<td>4.7 (0.12) b</td>
<td>2.91 (0.07) a</td>
<td>1.32 (0.06) b</td>
<td>12.60 (0.65) a</td>
<td>2.24 (0.23) b</td>
</tr>
</tbody>
</table>

Different letters indicate a difference between means ($P < 0.05$) ($n = 9$)

Table 6  Average, plus standard error in parentheses, of total non-structural carbohydrate (TNC) concentration and content at the end of the growing season in stem and root tissues of aspen seedlings that had been treated with different combinations of two fertilizer rates and a shoot growth inhibitor (SGI)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stem TNC concentration (%)</th>
<th>Root TNC concentration (%)</th>
<th>Stem TNC content (g)</th>
<th>Root TNC content (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100–150 SGI</td>
<td>17.20 (0.29) a</td>
<td>35.30 (0.67) a</td>
<td>0.163 (0.01) b</td>
<td>1.12 (0.08) a</td>
</tr>
<tr>
<td>100–150</td>
<td>13.40 (0.17) b</td>
<td>30.16 (0.66) b</td>
<td>0.217 (0.12) a</td>
<td>0.918 (0.04) b</td>
</tr>
<tr>
<td>100–100 SGI</td>
<td>17.54 (0.34) a</td>
<td>34.32 (0.72) a</td>
<td>0.122 (0.01) c</td>
<td>0.765 (0.04) c</td>
</tr>
<tr>
<td>100–100</td>
<td>13.50 (0.32) b</td>
<td>31.40 (0.75) b</td>
<td>0.178 (0.01) b</td>
<td>0.917 (0.04) b</td>
</tr>
</tbody>
</table>

Different letters indicate a difference between means ($P < 0.05$) ($n = 9$)
Commercially nutrient loaded seedlings compared with standard feed seedlings following the first year of out-planting:
Next steps?

• If nutrient loading can increase growth rates during early establishment phase then potential exists for tailoring container stock to more competitive sites

• The ideal stock type under high competition would most likely be initially tall and but still have baseline characteristics conducive to field establishment as described in previous slides

• More field testing!
Conclusion

- Premature shoot growth termination appears to be a prerequisite to accumulate nutrients and TNC in tissues of seedlings with an indeterminate growth strategy.
- Bud set cannot be directly followed by leaf senescence.
- Bud set has to be “strong” (seedlings will flush under high nutrient regime) - negative impact on TNC reserves.
- Seedling size does not have to be negatively correlated with TNC reserves, nursery practices could be adjusted.
- Nutrient loading shows promise as another stock type for aspen - however further work is required.
For further information- please refer to the following documents

Thank-you for listening!