Container versus Bareroot
A Five Year Study in Tree Survival on a Stream Restoration Project in Central North Carolina

Karen Hall, Jean Spooner, Jamie Blackwell
Department of Biological and Agricultural Engineering
North Carolina State University
North Carolina Cooperative Extension
College of Veterinarian Medicine Mitigation Project

- Stream, buffer, and stormwater wetland project completed in 2004
- Mitigation needs for NCSU impacts
- 213 linear meters of stream restoration
- 6,500 square meters of buffer restoration
- Restore tributary to House Creek
- Fence out cows
Experimental Design

• Randomized complete block design
• 2 treatment plots within each block (15m x 15m)
• 2 treatment types
  • (bare root, 1-gallon container)
• 5 rows per plot planted on gradient (lowland–upland)
• 5 tree species planted 2.5 m$^2$ centers
  (Betula nigra, Fraxinus pennsylvanica, Liriodendron tulipifera, Platanus occidentalis, Quercus michauxii)
• 6 replications
Experimental Design

- Total of 150 trees for each type or treatment (30 trees of each 5 species)
- Altogether 300 trees were planted in experimental plots in February 2005
- Across the entire restoration site, approximately 1112 trees per hectare (450 trees per acre) were planted.
- Height and diameter measured end of each growing season for 5 consecutive years.
July 2005 – 1st growing season

Container

Bareroot
Overall Tree Species Survival at Year 5

Percent Survival

Tree Species

BENI
FRPE
LITU
PLOC
QUMI
Overall Survival Based on Treatment at Year 5

- **Bareroot**: 43%
- **Container**: 73%

**Treatment**

- Percent Survival
Tree heights across 5 seasons

Mean(Height (cm)) vs. Season by Type

Legend

- Height (cm)

Bare Root  |  Container

Season

0 1 2 3 4 5

Mean(Height (cm))
Height of trees at Season 1 and Season 5

**Season 1**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>1</td>
<td>27928.09</td>
<td>27928.09</td>
<td>186.5452</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Error</td>
<td>189</td>
<td>282958.19</td>
<td>1497</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>190</td>
<td>562241.28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Season 5**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>1</td>
<td>8221.2</td>
<td>8221.2</td>
<td>0.4661</td>
<td>0.4957</td>
</tr>
<tr>
<td>Error</td>
<td>173</td>
<td>3051326.1</td>
<td>17637.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>174</td>
<td>3059547.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Analysis of Variance**

- **Season 1**
  - Type: 1, Sum of Squares: 27928.09, Mean Square: 27928.09, F Ratio: 186.5452, Prob > F: <.0001*
  - Error: 189, Sum of Squares: 282958.19, Mean Square: 1497
  - C. Total: 190, Sum of Squares: 562241.28

- **Season 5**
  - Type: 1, Sum of Squares: 8221.2, Mean Square: 8221.2, F Ratio: 0.4661, Prob > F: 0.4957
  - Error: 173, Sum of Squares: 3051326.1, Mean Square: 17637.7
  - C. Total: 174, Sum of Squares: 3059547.3
Tree diameters across 5 seasons

Mean(Diameter (mm)) vs. Season by Type

Legend
- Diameter (mm)
### Diameter of trees at Season 1 and Season 5

#### Season 1

![Graph showing diameter distribution for Season 1](image)

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>1</td>
<td>1950.5049</td>
<td>1950.50</td>
<td>120.7132</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Error</td>
<td>189</td>
<td>3053.8951</td>
<td>16.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>190</td>
<td>5004.4000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Season 5

![Graph showing diameter distribution for Season 5](image)

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>1</td>
<td>2945.56</td>
<td>2945.56</td>
<td>3.7295</td>
<td>0.0551</td>
</tr>
<tr>
<td>Error</td>
<td>173</td>
<td>136636.24</td>
<td>789.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Total</td>
<td>174</td>
<td>139581.81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates significance at the 0.05 level.
Tree damage
Weed effect
Gradient response—Survival

Survival

dead
alive

Upslope → Streamside

Row Rank

0.00 0.25 0.50 0.75 1.00

1 2 3 4 5
Summary

• Bareroot had 50% mortality in season 1
• Container had 25% mortality in season 1.
• Overall survivability of container trees stayed at ~75% through year 5
• Overall survivability of bareroot trees dropped to 43% by year 5
• Green ash had higher survival rates for both bare root and container types than other species.
• No significant difference in heights of bareroot and container types by year 5.
• No significant difference in diameters of bareroot and container types by year 5.
• Overall survival of all types increased from upland to streamside.
Questions?