Survival and Growth of Restored Piedmont Riparian Forests as Affected by Site Preparation, Planting Stock, and Planting Aids

Sponsored by:
• Wetlands Studies and Solutions Incorporated,
• R.J. Reynolds Forest Research Extension Center,
• Virginia Tech Forest Resources and Environmental Conservation Department

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Introduction

- Created wetlands and restored wetlands are used to offset wetlands destroyed or severely disturbed by permitted activities.

- Wetland creation projects for forested wetlands have a relatively poor record of success and mitigation ratios of 2:1 or 3:1 have been used.
Introduction

- Common causes of forested wetland creation failures (e.g., low survival rates) include:
  - Poor species selection
  - Compacted soils
  - Excessively wet site
  - Lack of microtopography
  - Low soil organic matter
  - Acid conditions

(Daniels 2012)
Rationale

- Forest managers have successfully used mechanical site preparation to offset very poorly drained site conditions, severe soil compaction, and lack of microtopography since the 1950’s. (≈ 60,000 acres in 2010).
- Little transfer of forest management research to forested wetland restoration projects.
Objectives

**Subproject 1**
Determine the influence of seed source and/or preconditioning treatments on survival and growth of *P. occidentalis* and *Q. phellos* on Piedmont riparian wetland mitigation sites.

**Subproject 2 (Todays Talk)**
Quantify effects of site preparation treatments, regeneration source, and/or planting aids on survival and growth of *P. occidentalis* and *Q. phellos* on Piedmont riparian wetland mitigation sites.
Species selection based on availability and desire to have species of rapid growth and mast production

- Sycamore (*Platanus occidentalis*)
- Willow Oak (*Quercus phellos*)
Study Site: RJ Reynolds Forest Research Extension Center

- Piedmont physiographic province, Patrick Co., Va.
- Tobacco plantation from 1840’s 1950’s
Study Site: RJ Reynolds Forest Research Extension Center

- Piedmont Physiographic province, Patrick Co., Va.
- Tobacco plantation from 1840’s 1950’s
- Study site is excessively wet, compacted by agriculture, research, and lacking microtopography.
Subproject 1

- Seed Source and Preconditioning Study
  - Objective: Determine the influence of seed source and/or preconditioning on survival and growth of *P. occidentalis* and *Q. phellos* on Piedmont riparian wetland mitigation sites.
Seed Sources

- Appomattox, Pittsylvania, and Nelson Counties
  - All located in the Piedmont region of Virginia
- Sources:
  - Dry (Upland areas)
  - Wet (Bottomland areas)
Cultural Treatments

- Control: Seedlings watered daily
- Flood: Seedlings saturated in water for multiple days, followed by one day of drying.
- Drought: Seedling drought stressed to visible wilting
Seedling Establishment

- Seedlings were established in the Virginia Tech greenhouse in January 2011
- Seedlings were allowed to grow for 2 months before preconditioning treatments were started
- Preconditioning occurred from March-April 2011
- Seedlings were transplanted to Reynolds Homestead in mid-April 2011
Project Location
Data Analysis

- Conducted after greenhouse treatments
- 5 sample seedlings from each seed source * treatment
  - Height, diameter, leaf area, and root length were obtained and used for preliminary analysis
Outplanting Data Collection

- January – February 2012, November 2012
- Measured Survival (Yes/No), heights (cm), and diameters (cm)
Results

- Fincastle upland site had the best survival and growth for Sycamore. Provenance matters.

- Few significant effects of cultural treatments during Year one.

- No significant effects of cultural treatments by end of second growing season.
<table>
<thead>
<tr>
<th>Nursery</th>
<th>Sycamore</th>
<th>Willow oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia Tech</td>
<td>83%</td>
<td>86%</td>
</tr>
<tr>
<td>WSSI</td>
<td>71%</td>
<td>45%</td>
</tr>
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</table>
Subproject 2 Objectives

Quantify effects of **site preparation** treatments, **regeneration source**, and/or **planting aids** on survival and growth of *P. occidentalis* and *Q. phellos* on Piedmont riparian wetland mitigation sites.
Experimental Design for each species

Randomized Complete Block Design with Split-Split Plot

- 5 blocks
- 5 site preparation methods
- 4 regeneration sources
- 3 planting aids
- 4 stems of each combination
- ≈1200 stems for each species
• Odd numbers - Sycamore
• Even numbers – Willow Oak
Soils

Augusta: fine-loamy, mixed semiactive, thermic Aeric Endoaquults

Roanoke: fine, mixed, semiactive, thermic Typic Endoaquults

French: fine loamy over sandy, mixed, active mesic Fluvaquentic Dystrudepts
4 (5*) Site Preparation Treatments –
Flat Planting/Disk

Flat Plant -Disk

Rip

Bed

Pit and Mound*
4 Regeneration Sources

Direct Seed

Gallon

Bare Root

Tubeling
3 Planting Aids

- Tubex Tubes
- None
- VisporeMats
Example of 4 Regeneration Sources x 3 Plantings Aids and 4 seedings within 1 site preparation plot.

Each of 5 site preparation treatments are replicated 5 times for each species.

<table>
<thead>
<tr>
<th>Gallon (Mat)</th>
<th>Gallon (Control)</th>
<th>Direct Seed (Control)</th>
<th>Bare Root (Mat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲</td>
<td>▲</td>
<td>X</td>
<td>●</td>
</tr>
<tr>
<td>▲</td>
<td>▲</td>
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</tr>
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<td>X</td>
<td>●</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Tubeling (Control)</th>
<th>Tubeling (Tube)</th>
<th>Tubeling (Mat)</th>
<th>Direct Seed (Tube)</th>
</tr>
</thead>
<tbody>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>X</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>X</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>X</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Direct Seed (Mat)</th>
<th>Bare Root (Tube)</th>
<th>Bare Root (Control)</th>
<th>Gallon (Tube)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>●</td>
<td>●</td>
<td>▲</td>
</tr>
<tr>
<td>X</td>
<td>●</td>
<td>●</td>
<td>▲</td>
</tr>
<tr>
<td>X</td>
<td>●</td>
<td>●</td>
<td>▲</td>
</tr>
</tbody>
</table>
Planting and Culture

- Planting conducted May 2011
- Planting Aids installed June 2011
- Minimal herbaceous control, summer 2011, 2012
- Measurements conducted in late fall 2011, 2012

- Survival
- Ground-line diameter
- Total height
- Biomass index (d²h)

May 2011 following planting
Planting and Culture

- Planting conducted May 2011
- Planting Aids installed June 2011
- Minimal herbaceous control, summer 2011, 2012
- Measurements conducted in late fall 2011, 2012

  - Survival
  - Ground-line diameter
  - Total height
  - Biomass index \((d^2h)\)
Survival % by Site Preparation

Sycamore
Yr 1 p < 0.0001, Yr 2 p = 0.0561

Willow Oak
Yr 1 p < 0.0001, Yr 2 p < 0.0001
Survival % by Regeneration Source

**Sycamore**
- Yr 1 $p < 0.0001$, Yr 2 $p = 0.0001$

**Willow Oak**
- Yr 1 $p < 0.0001$, Yr 2 $p < 0.0001$
Survival % by **Planting Aid**

**Sycamore**

Yr 1 p = 0.006, Yr 2 p < 0.0001

**Willow Oak**

Yr 1 p value < 0.0001, yr 2 p < 0.0001
Biomass Index (cm³) by Site Preparation

Sycamore
Yr 1 p = 0.0001, Yr 2 p < 0.0001

Willow Oak
Yr 1 p value < 0.0001, Yr 2 p < 0.1507
**Biomass Index (cm³) by Regeneration Source**

**Sycamore**

Yr 1 $p = 0.0001$, Yr 2 $p < 0.0001$

**Willow Oak**

Yr 1 $p$ value $< 0.0001$, Yr 2 $p < 0.2038$
Biomass Index (cm³) by Planting Aid

**Sycamore**
Yr 1 p = 0.6370, Yr 2 p < 0.0144

**Willow Oak**
Yr 1 p value < 0.3323, Yr 2 p < 0.0011
# Sycamore performance index at 2 years (biomass x % survival)

<table>
<thead>
<tr>
<th>Source-Aid</th>
<th>FLAT</th>
<th>RIP</th>
<th>BED</th>
<th>PIT</th>
<th>MOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed-None</td>
<td>1</td>
<td>156</td>
<td>17</td>
<td>1</td>
<td>337</td>
</tr>
<tr>
<td>Seed-Mat</td>
<td>1</td>
<td>438</td>
<td>112</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Seed-Tube</td>
<td>2</td>
<td>3</td>
<td>25</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Bare-None</td>
<td>557</td>
<td>550</td>
<td>670</td>
<td>138</td>
<td>2023</td>
</tr>
<tr>
<td>Bare-Mat</td>
<td>426</td>
<td>530</td>
<td>770</td>
<td>257</td>
<td>1370</td>
</tr>
<tr>
<td>Bare-Tube</td>
<td>402</td>
<td>451</td>
<td>250</td>
<td>92</td>
<td>852</td>
</tr>
<tr>
<td>Tubeling-None</td>
<td>645</td>
<td>1523</td>
<td>2238</td>
<td>382</td>
<td>2234</td>
</tr>
<tr>
<td>Tubeling-Tube</td>
<td>721</td>
<td>831</td>
<td>1084</td>
<td>443</td>
<td>874</td>
</tr>
<tr>
<td>Tubeling-Mat</td>
<td>893</td>
<td>1616</td>
<td>1799</td>
<td>875</td>
<td>3119</td>
</tr>
<tr>
<td>Gallon-None</td>
<td>2192</td>
<td>2208</td>
<td>1923</td>
<td>1803</td>
<td>3113</td>
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<tr>
<td>Gallon-Tube</td>
<td>1684</td>
<td>2038</td>
<td>2735</td>
<td>1393</td>
<td>3456</td>
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<tr>
<td>Gallon-Mat</td>
<td>1592</td>
<td>1905</td>
<td>3532</td>
<td>2042</td>
<td>6234</td>
</tr>
</tbody>
</table>
## Willow oak performance index at 2 years
(biomass x % survival)

<table>
<thead>
<tr>
<th>Source-Aid</th>
<th>FLAT</th>
<th>RIP</th>
<th>BED</th>
<th>PIT</th>
<th>MOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed-None</td>
<td>111</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Seed-Mat</td>
<td>20</td>
<td>86</td>
<td>10</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Seed-Tube</td>
<td>1</td>
<td>10</td>
<td>15</td>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>Bare-None</td>
<td>398</td>
<td>748</td>
<td>1541</td>
<td>145</td>
<td>1624</td>
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<tr>
<td>Bare-Mat</td>
<td>2173</td>
<td>516</td>
<td>1015</td>
<td>76</td>
<td>1025</td>
</tr>
<tr>
<td>Bare-Tube</td>
<td>669</td>
<td>674</td>
<td>787</td>
<td>237</td>
<td>1424</td>
</tr>
<tr>
<td>Tubeling-None</td>
<td>52</td>
<td>127</td>
<td>33</td>
<td>0</td>
<td>153</td>
</tr>
<tr>
<td>Tubeling-Tube</td>
<td>101</td>
<td>108</td>
<td>38</td>
<td>45</td>
<td>118</td>
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<tr>
<td>Tubeling-Mat</td>
<td>116</td>
<td>53</td>
<td>13</td>
<td>8</td>
<td>390</td>
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<tr>
<td>Gallon-None</td>
<td>727</td>
<td>1067</td>
<td>987</td>
<td>287</td>
<td>1480</td>
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<tr>
<td>Gallon-Tube</td>
<td>676</td>
<td>985</td>
<td>1157</td>
<td>518</td>
<td>1354</td>
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<tr>
<td>Gallon-Mat</td>
<td>888</td>
<td>972</td>
<td>1168</td>
<td>446</td>
<td>1201</td>
</tr>
</tbody>
</table>
Conclusions after 2 growing seasons

- For Sycamore
  - Mound > Bed >>> Rip >>> Flat>>> Pit
  - Gallon >>> Tubelings = Bare root > Seed
  - Planting aid results were not convincing

- For Willow Oak
  - Mounding and Bedding performed well
  - Overall, Bare root with mats and Gallon performed well.
Why Mounding?

Microsites

- Greater rooting volume of loosened soil
- Mixed horizons caused coarser texture
- Provided some competition control
- Enhanced survival
- Additional faunal habitats
- Potential Problems:
  - Cost and available contractors
Questions