MATURE SUBALPINE TREE & SHRUB TRANSPLANTING AT THE CLIMAX MINE, CLIMAX, CO

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Aaron Hilshorst – Climax Molybdenum Company
Climax Molybdenum Mine: Geographic Setting
Climax Mine

Operation: 1918 - 1995 & 2012 - present
Reclamation: 1980s - present

Elevation: 11,150 – 11,300 ft
Growing Season: 6 – 10 weeks
Average Snowpack: 280 inches
Tree & Shrub Transplanting Project

- 2005 – 2007

- Mature plants transplanted into reclamation
  - 1233 Trees
  - 226 Shrubs

- Most harvested from Climax’s permitted affected area
Project Goals

• Use Trees From On-site Construction
• Visually Enhance Reclamation
• Seed Island Source
• Wildlife Cover
• Landscape Diversity
• 50% survival after 1 growing season
Project Constraints

• Steep, Shallow and Rocky Soils in Source
• Acid Rock Cover in Planting Area
• No Topsoil
• No Mycorrhizae in Soil
• High Altitude Exposed Location
• Heavy Snow and Sun Scald
• Wet Soil in Spring, Dry Soil in Summer
• Strong Winter Winds
# Transplant Species & Quantities

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Species</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engelmann Spruce</td>
<td>Picea engelmannii</td>
<td>410</td>
<td>435</td>
<td>295</td>
<td>1,140</td>
</tr>
<tr>
<td>Subalpine Fir</td>
<td>Abies lasiocarpa</td>
<td>65</td>
<td>11</td>
<td>14</td>
<td>90</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>Pinus contorta</td>
<td>2</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Trees</strong></td>
<td></td>
<td><strong>477</strong></td>
<td><strong>447</strong></td>
<td><strong>309</strong></td>
<td><strong>1,233</strong></td>
</tr>
<tr>
<td>Willow</td>
<td>Salix spp.</td>
<td>91</td>
<td>100</td>
<td></td>
<td>191</td>
</tr>
<tr>
<td>Cinquefoil</td>
<td>Dasiphora fruticosa</td>
<td>2</td>
<td>14</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Dwarf Birch</td>
<td>Betula nana</td>
<td>2</td>
<td>12</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Currant</td>
<td>Ribes spp.</td>
<td>4</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td><strong>Total Shrubs</strong></td>
<td></td>
<td><strong>97</strong></td>
<td><strong>2</strong></td>
<td><strong>127</strong></td>
<td><strong>226</strong></td>
</tr>
<tr>
<td><strong>Total Transplants</strong></td>
<td></td>
<td><strong>574</strong></td>
<td><strong>449</strong></td>
<td><strong>436</strong></td>
<td><strong>1,459</strong></td>
</tr>
</tbody>
</table>
Tree Spade Mounted on Tracked Skid-loader
Tree lifted from ground
Tree Balled and Burlapped
Trees Transported to Planting Sites
Tree Backfilled

- Topsoil
- Old Woodchips
- Compost
- Additives
  - Terrasorb
  - Mycorrhiza
Trees Mulched, Staked, & Irrigated
Tree Monitoring

• At Planting
  • GPS each location
  • Species, height, diameter, & health
  • Survival and health
• 2012 data presented here
Reclamation & Soils

- Reclaimed 1996-2008
- Variety of cap/soil materials
- With and without Class A composted biosolids
- Seeded with approved seed mixture
# Reclamation Soils

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil Type</th>
<th>Geologic Description</th>
<th>Rock Content</th>
<th>Surface Texture</th>
<th>Lime Required* (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robinson TSF E Dump</td>
<td>Pit Run</td>
<td>Decomposed granite</td>
<td>High</td>
<td>Sandy Loam</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Cirque</td>
<td>Decomposed granite</td>
<td>High</td>
<td>Sandy Loam</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Maroon</td>
<td>Conglomeratic sandstone</td>
<td>Low</td>
<td>Sandy Loam</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Brown</td>
<td>Mosquito Fault</td>
<td>Low</td>
<td>Sandy Clay Loam</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Dark Brown</td>
<td>Mosquito Fault</td>
<td>Low</td>
<td>Sandy Loam</td>
<td>0</td>
</tr>
<tr>
<td>Robinson TSF</td>
<td>Dark Grey</td>
<td>Mosquito Fault</td>
<td>Low</td>
<td>Sandy Loam</td>
<td>0</td>
</tr>
<tr>
<td>Billy Blvd</td>
<td>Fill</td>
<td>Variable</td>
<td>Moderate</td>
<td>Sandy Loam</td>
<td>0</td>
</tr>
<tr>
<td>Storke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reclamation & Soils – Robinson Tailings Pond

• Reclaimed 1980s – Present

• Tailing with 12-36” of cap material
  • Pit Run, Cirque Pit Rock, Mosquito Fault Rock (Brown & Grey), Maroon Formation
  • 0 – 30 tons/acre lime requirement

• With and without Class A composted biosolids
Reclamation & Soils – Storke Yard

• Reclaimed 1996 & 2007
• Soil is development rock and construction debris
  • Sandy loam
  • Moderate rock content
  • No lime required
• With and without Class A composted biosolids
Reclamation & Soils – E Dump & Billy Blvd

**E Dump**
- Reclaimed 1997
- Soil is pit run
  - Sandy loam
  - High rock content
  - 30 tons/acre lime required
- No Class A composted biosolids

**Billy Blvd**
- Reclaimed 2005
- Soil is from Mosquito Fault
  - Sandy loam
  - Moderate rock content
  - No lime required
- Class A composted biosolids on surface
Results – Shrub Transplants

• 226 planted
• 218 (96%) alive in 2012
  • 97% Willows
  • 100% Birch
  • 100% Cinquefoil
  • 60% Currants

• All mortality on Robinson TSF likely due to drying
## Results – Tree Transplants

<table>
<thead>
<tr>
<th>Transplant Species</th>
<th>Transplanted 2005</th>
<th>Transplanted 2006</th>
<th>Transplanted 2007</th>
<th>All Transplants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alive</td>
<td>% Survival</td>
<td>Alive</td>
<td>% Survival</td>
</tr>
<tr>
<td>Engelmann Spruce</td>
<td>222</td>
<td>54%</td>
<td>316</td>
<td>73%</td>
</tr>
<tr>
<td>Subalpine Fir</td>
<td>22</td>
<td>34%</td>
<td>10</td>
<td>91%</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>1</td>
<td>50%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Tree Total</td>
<td>245</td>
<td>51%</td>
<td>326</td>
<td>73%</td>
</tr>
</tbody>
</table>
Results – Tree Transplants by Location

- Robinson TSF: 52%, n=659
- E Dump: 81%, n=253
- Billy Blvd: 85%, n=33
- Storke: 68%, n=279
- Other: 56%, n=9

P<0.05
Results – Tree Transplants by Height

- **Engelmann Spruce**: Dead (P<0.001)
- **Subalpine Fir**: Alive (P=0.184)
- **All Transplant Trees**: Dead (P<0.001)
# Results – Tree Transplants by Soil Type

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil Type</th>
<th>Spruce</th>
<th></th>
<th>Fir</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E Dump</td>
<td>Pit Run</td>
<td>198</td>
<td>80%</td>
<td>6</td>
<td>100%</td>
<td>204</td>
<td>81%</td>
</tr>
<tr>
<td>Robinson TSF</td>
<td>Pit Run</td>
<td>154</td>
<td>46%</td>
<td>154</td>
<td>46%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cirque</td>
<td>39</td>
<td>49%</td>
<td>6</td>
<td>38%</td>
<td>46</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td>Maroon</td>
<td>113</td>
<td>72%</td>
<td>14</td>
<td>64%</td>
<td>127</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td>Brown</td>
<td>10</td>
<td>77%</td>
<td>5</td>
<td>42%</td>
<td>15</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Dark Brown</td>
<td>5</td>
<td>71%</td>
<td>5</td>
<td>71%</td>
<td>5</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td>Dark Grey</td>
<td>1</td>
<td>100%</td>
<td>1</td>
<td>11%</td>
<td>2</td>
<td>20%</td>
</tr>
<tr>
<td>Billy Blvd</td>
<td>Dark Grey</td>
<td>28</td>
<td>85%</td>
<td>28</td>
<td>85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storke</td>
<td>Fill</td>
<td>184</td>
<td>69%</td>
<td>5</td>
<td>36%</td>
<td>189</td>
<td>68%</td>
</tr>
<tr>
<td>Native</td>
<td>Topsoil</td>
<td>1</td>
<td>33%</td>
<td>1</td>
<td>33%</td>
<td>1</td>
<td>33%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>551</td>
<td>71%</td>
<td>37</td>
<td>47%</td>
<td>589</td>
<td>69%</td>
</tr>
</tbody>
</table>
Results – Tree Transplants by Soil Type

![Bar chart showing survival rates of tree transplants by soil type with and without compost.](chart)

- **Compost**
  - Pit Run: 40%
  - Cirque: 60%
  - Maroon: 80%
  - Brown: 70%

- **No Compost**
  - Pit Run: 50%
  - Cirque: 70%
  - Maroon: 90%
  - Brown: 80%

- Statistical significance:
  - $P(\text{compost}) > 0.25$
  - $P(\text{no compost}) < 0.005$
Results – Tree Transplants & Elk Damage
Results – Tree Transplants & Elk Damage

<table>
<thead>
<tr>
<th>Location Planted</th>
<th>Trees Damaged By Elk</th>
<th>% of Planted Trees Damaged</th>
<th>Dead Elk Damaged Trees in 2012</th>
<th>% of Elk Damaged Trees Killed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robinson TSF</td>
<td>220</td>
<td>33%</td>
<td>73</td>
<td>33%</td>
</tr>
<tr>
<td>E Dump</td>
<td>44</td>
<td>17%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Storke</td>
<td>48</td>
<td>17%</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td>Total</td>
<td>312</td>
<td>25%</td>
<td>80</td>
<td>26%</td>
</tr>
</tbody>
</table>
Results – Tree Transplants & Elk Damage

<table>
<thead>
<tr>
<th>Monitoring Year</th>
<th>Elk Damaged Trees</th>
<th>September Minimum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>4%</td>
<td>0°</td>
</tr>
<tr>
<td>2006</td>
<td>10%</td>
<td>2°</td>
</tr>
<tr>
<td>2007</td>
<td>5%</td>
<td>1°</td>
</tr>
<tr>
<td>2008</td>
<td>2%</td>
<td>-1°</td>
</tr>
<tr>
<td>2010</td>
<td>25%</td>
<td>4°</td>
</tr>
<tr>
<td>2012</td>
<td>20%</td>
<td>2°</td>
</tr>
</tbody>
</table>
Results – Tree Transplants & Elk Damage

![Graph showing average height in feet for different areas and conditions]

- Robinson TSF: P=0.040
- E Dump: P=0.639
- Storke: P=0.006
- All: P<0.001

Legend:
- Elk Damaged
- Not Elk Damaged
Project Costs

• Project Cost $650,000

<table>
<thead>
<tr>
<th>Root Ball Size</th>
<th>Height Range</th>
<th>2005-2006*</th>
<th>2007*</th>
<th>2013 Estimated Retail **</th>
</tr>
</thead>
<tbody>
<tr>
<td>32&quot;</td>
<td>2 – 6 ft</td>
<td>$275</td>
<td>$330</td>
<td>$330 – $490</td>
</tr>
<tr>
<td>44&quot;</td>
<td>6 – 10 ft</td>
<td>$425</td>
<td>$510</td>
<td>$550 – $1,010</td>
</tr>
<tr>
<td>60&quot;</td>
<td>10 – 16 ft</td>
<td>$550</td>
<td>$660</td>
<td>$1,070 – $1,560</td>
</tr>
<tr>
<td>72”</td>
<td>&gt; 16 ft</td>
<td>$695</td>
<td>n/a</td>
<td>Variable</td>
</tr>
</tbody>
</table>

* includes labor, equipment, and materials
** range depends on tree height and includes a 2x factor on retail purchase price for delivery and planting
Conclusions

• 68% of all individuals transplanted still living in 2012
  • 96% of shrubs
  • 63% of trees
• Goal of 50% first year survival surpassed
Conclusions

• Locally harvested trees more successful than those trees imported from Wyoming
• Shorter trees were more successful than tall trees
• Trees planted into locally stripped subsoil materials were more successful than those transplanted into rocky pit run material
• Trees planted in areas reclaimed without compost were more successful than those planted into compost
• 6% loss to elk damage represents a preventable loss of $20,000 to $50,000 in trees
• Spring watering before the monsoons start may have been beneficial
Conclusions

• Mature trees and shrubs provide...
  • Vegetation Structure
  • Visual cover for bird and mammal populations
  • Hunting perches for raptors
  • Seed island effect
  • Willows provide wetland community establishment and soil stabilization
  • Aesthetic view from the public highway.
Questions?