FRA Step #1

“CREATE A SUITABLE ROOTING MEDIUM”

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THE FORESTRY RECLAMATION APPROACH

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The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest under the Surface Mining Control and Reclamation Act (SMCRA). The FRA is based on knowledge gained from both scientific research and experience (Photo 1). The FRA can achieve cost-effective regulatory compliance for coal operators while creating productive forests that generate value for their owners and provide watershed protection, wildlife habitat, and other environmental services.

The purpose of this Advisory is to describe the FRA, which is considered by state mining agencies and US Office of Surface Mining to be an appropriate and desirable method for reclaiming coal-mined land to support forested land uses under SMCRA (Angel and others, 2005). The FRA is also supported by members of the ARRI’s academic team, which is drawn from Universities in nine states, and by other groups and agencies.

The FRA’s Five Steps

The FRA can be summarized in five steps:

1. Create a suitable rooting medium for good tree growth that is no less than 4 feet deep and

   Photo 1. A white oak stand that grew on a pre-SMCRA surface mine in southern Illinois. Observations by reclamation scientists and practitioners of soil and site conditions on reclaimed mines such as this, where reforestation was successful, have contributed to development of the Forestry Reclamation Approach.
The 5 Steps of FRA

1. Create a suitable rooting medium...
2. Loosely grade the rooting medium...
3. Use compatible ground covers...
4. Plant two types of trees...
5. Use proper tree planting techniques.

Are they all equally important?
Step 1.

Create a suitable rooting medium:

Tree survival and growth can be hindered by highly alkaline or acidic soils.
Step 1. Create a suitable rooting medium:

During mining and reclamation, all highly alkaline materials with excessive soluble salts and all highly acidic or toxic material should be covered with a suitable rooting medium that will support trees.
Growth media:
- Low levels of **soluble salts**,  
- **pH** of 5.0 to 7.0,  
- Low pyritic S content,  
- Loamy textures.

What about Rocks? How much?
Such soils can be formed from overburden materials comprised of:

- weathered Brown SS
- unweathered Gray SS
- especially if mixed with natural soils.

Why natural soil material?
Mixture of Brown and Gray SS
We planted Chestnuts on this Massey site

Mixture of Brown and Gray SS
After two growing seasons…
No seeding!
What about this?
Suitable Mixture?
Suitable Mixture?
One stop on ARRI Field Trip VA 2007
One stop on
ARRI Field Trip
KY 2009
Reclamation materials can come from any geologic interval!

Convenience and Cost versus Best
5 Cs of Reforestation

1. Composition of Material
2. Compaction
3. Competition – Ground Cover
4. Consumption – Animals
5. Commercial Trees and Planting
1. Composition of Material
Brown vs Gray Sandstone
The real deal is getting a suitable mixture
Experimental Plots

Brown Sandstone

Gray Sandstone
Results - pH

Gray SS - pH around 8!
What do trees prefer?

- 2005
- 2007
- 2009

pH

<table>
<thead>
<tr>
<th>Treatments</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>4B-C</td>
<td></td>
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<tr>
<td>4B-NC</td>
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<tr>
<td>5B-NC</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5G-C</td>
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<tr>
<td>5G-NC</td>
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</tbody>
</table>
Results - EC

All show leaching over time

EC (dS/m)

2005  2007  2009

4B-C  4B-NC  5B-C  5B-NC  5G-C  5G-NC

0.1

0.2

0.3

0.4

0.5

0.6
Results - Ca

Ca (cmol/kg)

2005  2007  2009

4B-C  4B-NC  5B-C  5B-NC  5G-C  5G-NC
Results - K

K (cmol/kg)

<table>
<thead>
<tr>
<th>Year</th>
<th>4B-C</th>
<th>4B-NC</th>
<th>5B-C</th>
<th>5B-NC</th>
<th>5G-C</th>
<th>5G-NC</th>
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</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.2</td>
<td>0.2</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
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<tr>
<td>2007</td>
<td>0.2</td>
<td>0.2</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
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<tr>
<td>2009</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Results - P

Gray SS P around 2-3 times higher!
## Results - % Fines

### Treatments

<table>
<thead>
<tr>
<th>Size</th>
<th>4B C</th>
<th>4B NC</th>
<th>5B C</th>
<th>5B NC</th>
<th>5G C</th>
<th>5G NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>49 a</td>
<td>48 a</td>
<td>50 a</td>
<td>53 a</td>
<td>40 a</td>
<td>36 a</td>
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<tr>
<td>2007</td>
<td>59 a</td>
<td>61 a</td>
<td>64 a</td>
<td>60 a</td>
<td>34 b</td>
<td>34 b</td>
</tr>
<tr>
<td>2009</td>
<td>56 a</td>
<td>55 a</td>
<td>60 a</td>
<td>47 a</td>
<td>37 b</td>
<td>37 b</td>
</tr>
</tbody>
</table>

Is there a difference in breakdown?
Brown Sandstone
Lower pH ~ 6.0
Greater % Fines

Gray Sandstone
High pH ~ 8.0
Greater Phosphorus
Trees grow in both!
But...how well?
Red oak

[Bar chart showing % Survival over years for different categories of Red oak trees]

[Bar chart showing Volume (cm³) over years for different categories of Red oak trees]

Red oak
## Growth and Survival by substrate, treatment, and depth

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Survival ( % )</th>
<th>Growth (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray</td>
<td>71 a</td>
<td>73 b</td>
</tr>
<tr>
<td>Brown</td>
<td>67 a</td>
<td>600 a</td>
</tr>
</tbody>
</table>
Soil Properties

- % Fines greater in Brown vs Gray

- Soil pH is 8 with Gray, 6 with Brown

- Phosphorus is greater in Gray vs Brown
With only 5 yrs of data

- **Tree Survival** is similar between Brown and Gray SS

- **Volume** was significantly better in Brown vs Gray SS
ARRI Advisory #2:

Such soils can be formed from overburden materials comprised of:

- weathered Brown SS
- unweathered Gray SS
- especially if mixed with natural soils.
A mixture of Brown and Gray?

2 Brown : 1 Gray
1 Brown : 1 Gray
1 Brown : 2 Gray
Experiments to test Mixtures
Experiments to test Mixtures
You Got Any Questions?