FRA Step 4
Tree and Shrub Species Selection for Reforestation of Reclaimed Mineland

Ron Rathfon, Extension Forester
Purdue University
Historical Perspective

- Reclamation mid 20th century:
  - Reclamation synonymous with reforestation
  - 1941 state law required tree planting
Historical Perspective

- Reclamation mid 20th century:
  - Early studies focused on species trials
Historical Perspective

- Reclamation later in the 20th century:
  - 1967, Indiana 1st state to require grading and contouring
  - 1977, SMCRA
  - 1980’s, difficulty establishing and maintaining tree plantings
  - Many operators opted to reclaim to “higher and better uses.”
Reclaimed mine conditions pre-FRA

Relative importance of site factors different on mined vs. native sites.

- Compaction
- Poor internal drainage
- High soluble salt level
- Aggressive ground covers

Novel Site Conditions

Limited species selection
Reclaimed mine conditions on FRA

Relative importance of site factors different on mined vs. native sites.

- Improved rooting depth
- Improved soil texture and internal drainage
- Optimal pH
- Tree-compatible ground cover

Sometimes improved over prior natural site conditions

Expanded species selection
4. Plant two types of trees - early succession species for wildlife and soil stability, and commercially valuable crop trees.
Species Selection Factors

- Bond release
- Site/adaptation
- Seed Source
- Succession
- Nurse species
- Species compatibility
- Landscape considerations
- Long-term forest health
- Deer
- Planting stock availability
- Long-term landowner objectives
- Exotic species
450 living trees and shrubs per acre at bond release

Long term success

- Healthy stand
- Acquiring attributes and functions of natural forest
- Likely to produce wood products
- Likely to produce environmental amenities ascribed to forest
Site

The sum total of the effects of all the factors of a location on the reproduction, establishment, growth, decline, and death of the trees and forest of that location.
Site Factors

CLIMATE
- radiation, air temperature, rainfall, relative humidity, fog, wind, lightening, fire, etc.

TOPOGRAPHY
- physiography, aspect, slope

SOIL
- texture, structure, pH, ground water, temperature, minerals, organic matter, etc.

BIOTIC FACTORS
- associated plants, animals above and below soil, humans

Factors Directly Available to Trees

LIGHT
- As source of energy for photosynthesis

HEAT
- As energy for metabolic processes

WATER
- Maintains cell function, component in photosynthesis, and transports nutrients

CHEMICAL FACTORS
- CO₂, O₂, pH, pollutants, nutrients, allelopathic compounds

MECHANICAL FACTORS
- Damage through wind, fire, snow, animals

Climate

Southern Red Oak

Quaking Aspen
Topography

Aspect

- Cool
- Moist
- Hot
- Dry
Aspect

**Good:** Red oak, sugar maple, yellow poplar, black cherry.

**Excellent:** All “good site” hardwoods, white pine.

**Fair:** Hickories, white and black oak, white ash.

**Poor:** Chestnut oak, scarlet oak, Virginia pine, pitch pine.

**Good:** Red oak, yellow poplar, sugar maple, black cherry.

**Fair:** Hickories, white and black oak, white ash.
Topography

Slope

Rise \[ \frac{\text{Run}}{\text{Run}} \times 100 = \% \text{ slope} \]

deeper topsoil
more water infiltration

low erosion

thinner topsoil
less water infiltration

high erosion
Topography

Aspect - Slope

deep soil  cool, moist
shallow soil  hot, dry
Topography

Position

ridgetop

shoulder

sideslope

toeslope or cove

bottom
Position

Bottomland: Very moist (receives water from large areas; retains soil moisture)

Lower slopes: Moist (receives water from upper slopes) but often with poor internal drainage

Bench: Moist (receives water from upper slopes)

Upper slopes: Dry (high runoff)

Broad ridgetop: Moist, but often with poor internal drainage. (Narrow ridgetops can be dry due to high runoff).

Subsurface compaction, if present, restricts internal drainage

Slopes will often have better internal drainage, especially if loose dumped.
Virginia (southern Appalachia)

Soil

Soil Texture

Sand
Silt
Clay

- Sandy loam (moisture deficient)
- Clay loam
- Heavy clay (aeration deficient)
Soil

Spoil or Growth Medium

High

sycamore
green ash
red maple

Virginia pine
pitch x loblolly pine

Alkaline
pH 6.5-8.5
shales and siltstones

Compaction

Bur oak
sycamore
hybrid poplar
sugar maple

Low

All native hardwoods &
conifers
e.g.: red, white, black oaks
sugar maple
white ash
tulip poplar
black cherry

Burger and Zipper,
Powell River Project,
Site:

1. Dry (xeric)
2. Moist (mesic)
3. Wet (hydric)
Site

Dry (xeric)
Limiting factor: Moisture (lack of)

Results from:
1. South aspect
2. Shallow and/or sandy soil

Forest characterized by:
1. Drought tolerant
2. Slow growth
3. Lower stocking
4. Low quality timber
Site

Moist (mesic)
Limiting factor: Light

Results from:
1. North aspect
2. Deep, moisture accumulating and retentive soil (not wet)
Moist (mesic) Forest characterized by:
1. Moisture and nutrient demanding trees
2. Fast growth
3. High stocking
4. Good quality timber
Wet (hydric)
Limiting factor: Moisture (too much)

Results from:
1. Frequent, semi-permanent, or permanent flooding
2. High water table
3. Restrictive layer

Patoka River - oxbow
Wet (hydric)

Forest characterized by:
1. Flood tolerant trees
2. Shallow rooted
3. Fast to slow growth
4. High to low stocking
5. Good to poor quality timber
Seed Source

Northern Red Oak

Latitude

Elevation
Three major stages

1. Pioneer

2. Intermediate/Transitional/Subclimax

3. Climax
<table>
<thead>
<tr>
<th>Habitat</th>
<th>Pioneer</th>
<th>Transitional</th>
<th>Climax</th>
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</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Aspen, sassafras, cedar, Virginia pine</td>
<td>Oak, hickory</td>
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<tr>
<td>Mesic</td>
<td>Many, tulip, cherry, aspen, sassafras</td>
<td>Oak, hickory, ash, elm, walnut</td>
<td>Beech, maple, basswood</td>
</tr>
<tr>
<td>Wet (bottomland)</td>
<td>Ash, cottonwood, boxelder, willow, sycamore</td>
<td>Sycamore, silver maple, hackberry, bur oak, swamp white oak, American elm, ash</td>
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</tr>
</tbody>
</table>
Accelerate Succession

Land stabilization and erosion control

Bond release

Economic returns to land owner

Nurse Species

Improve site conditions and crop tree growth and quality

- N-fixing
- Shade/cooling
- Train
- Contribute to bond release
- Early successional
- Compatible with crop trees
- Wildlife
Monocultures vs. Mixed Stands
Forest Health
Wildlife Habitat
Natural seed sources

Yellow-poplar – 300,000 to 600,000 seed/acre up to 600 feet.

Cottonwood – 48 million seeds on one tree, 100’s of feet to miles.

vs.

heavy-seeded species
Indiana mines reclaimed 1988 - 1995
- Over 86% of sites dominated by two tree species
- B. locust most abundant species on 15 of 22 sites.
Black Locust

Black locust borer

*Megacyllene robinia*

Trees under stress most susceptible
Green Ash

Emerald Ash Borer
Deer

Oak –

Yum, Yum!
**Planting Stock Availability**

### Conifer Seedlings - 3 Year Seedlings

<table>
<thead>
<tr>
<th>Species</th>
<th>Order Code</th>
<th>Price Per 100 Seedlings</th>
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<tbody>
<tr>
<td>White Pine 3-0</td>
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<td>$35.25</td>
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### Conifer Seedlings - 1 & 2 Year Seedlings

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<th>Species</th>
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<th>Price Per 100 Seedlings</th>
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<tr>
<td>Tamarack 2-0</td>
<td>15</td>
<td>$26.05</td>
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<tr>
<td>Norway Spruce 2-0</td>
<td>38</td>
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<tr>
<td>Virginia Pine 1-0</td>
<td>39</td>
<td>$26.05</td>
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### Deciduous Tree Seedlings - 1 Year Seedlings

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<tr>
<th>Species</th>
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<th>Price Per 100 Seedlings</th>
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<tbody>
<tr>
<td>Black Cherry 1-0</td>
<td>42</td>
<td>$31.00</td>
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<tr>
<td>Black Gum 1-0</td>
<td>43</td>
<td>$31.00</td>
</tr>
<tr>
<td>Black Locust 1-0</td>
<td>44</td>
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<tr>
<td>Black Walnut 1-0</td>
<td>46</td>
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<tr>
<td>Bur Oak 1-0</td>
<td>48</td>
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<tr>
<td>Cherrybark Oak 1-0</td>
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<td>Cheeseman Oak 1-0</td>
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<td>Pecan 1-0</td>
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<td>$31.00</td>
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<tr>
<td>Persimmon 1-0</td>
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<td>Pin Oak 1-0</td>
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<td>Red Oak 1-0</td>
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<td>River Birch 1-0</td>
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<td>Shimer Oak 1-0</td>
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<td>$31.00</td>
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<td>Silver Maple 1-0</td>
<td>69</td>
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<tr>
<td>Swamp Chestnut Oak 1-0</td>
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<td>Swamp White Oak 1-0</td>
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<td>Sweet Gum 1-0</td>
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<td>Sycamore 1-0</td>
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<td>Tuliptree 1-0</td>
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<td>White Oak 1-0</td>
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<td>Overcup Oak 1-0</td>
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<td>White Chestnut Oak 1-0</td>
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<tr>
<td>Kentucky Coffee Tree 1-0</td>
<td>92</td>
<td>$31.00</td>
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</table>

### Deciduous Tree Seedlings - 2 Year Seedlings

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<th>Species</th>
<th>Order Code</th>
<th>Price Per 100 Seedlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bur Oak 2-0</td>
<td>108</td>
<td>$37.55</td>
</tr>
<tr>
<td>Pecan 2-0</td>
<td>118</td>
<td>$37.55</td>
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<tr>
<td>Red Oak 2-0</td>
<td>123</td>
<td>$37.55</td>
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<tr>
<td>White Oak 2-0</td>
<td>137</td>
<td>$37.55</td>
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<tr>
<td>Shagbark Hickory 2-0</td>
<td>144</td>
<td>$37.55</td>
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<tr>
<td>Sugar Maple 2-0</td>
<td>145</td>
<td>$37.55</td>
</tr>
<tr>
<td>Red Maple 2-0</td>
<td>147</td>
<td>$37.55</td>
</tr>
<tr>
<td>Shellbark Hickory 2-0</td>
<td>189</td>
<td>$37.55</td>
</tr>
</tbody>
</table>

### Deciduous Small Tree and Shrub Seedling - 1 & 2 Year

#### American Plum 1-0

#### Buttonbush 1-0

#### Flowering Dogwood 1-0

#### Hazelnut 1-0

#### Redbud 1-0

#### Silky Dogwood 1-0

#### Washington Hawthorn 1-0

#### Gray Dogwood 1-0

#### Ninebark 1-0

#### Black Chokeberry 1-0

#### Paw Paw 2-0

#### Common Chokecherry 1-0

### Additional Information

- **Seeding height varies with age.**
- **The following is a general guideline:**
  - 3 year old conifer seedlings: 6-20 inches
  - 1 & 2 year old conifer seedlings: 4-12 inches
  - 1 year old deciduous seedlings: 6-20 inches
  - 2 year old deciduous seedlings: 8-30 inches
  - 1 & 2 year old deciduous small trees and shrubs: 4-2

**Note:** Minimum order is 100 seedlings per species or 1 packet.
Landowner Objectives

Contribute to local economy
Community and environmental asset
Exotics

Invasive threat!
Species Prescriptions

examples
Site
**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Moderately to steeply sloped upland

<table>
<thead>
<tr>
<th>Forest Types</th>
<th>Long Term Benefits</th>
<th>Primary Forest Canopy Species</th>
<th>Secondary Forest Canopy Species</th>
<th>Nurse Species</th>
<th>Wildlife Species</th>
<th>Planting Design Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak-hickory</td>
<td>Woodland wildlife food and cover</td>
<td>Oak: black, red, white Hickory: pignut, shagbark</td>
<td>Oak: bur, chestnut, chinkapin, scarlet American chestnut black gum red maple yellow-poplar</td>
<td>Pine: Virginia (south), pitch x loblolly hybrid, shortleaf (south) bristly locust black locust red cedar</td>
<td>serviceberry American plum Jersey-tea southern blackhawk persimmon flowering dogwood hawthorns crabapple huckleberry blueberry redbud</td>
<td></td>
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</table>

**Forest Productivity Level:** low to medium (site index: 65 - 70 ft.)

Site Condition: dry to moist
Aspect: southeast and northwest; Landscape Position: upper-, mid-, and lower- and slopes; Slope: > 10%; Soil Depth: 2 – 4 ft.; Soil Drainage: well-drained; Soil Texture: sandy loam to silt loam.
**General Prescriptions**

**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Moderately to steeply sloped upland

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<tbody>
<tr>
<td>Mixed oak</td>
<td>High grade sawtimber and veneer</td>
<td>oak: red, white yellow-poplar, black cherry, black walnut</td>
<td>oak: black, chinkapin American chestnut black gum butternut hickory butternut Kentucky coffee tree maple: red, sugar</td>
<td>Pine: white black alder bristly locust black locust</td>
<td>hazelnut spicebush hawthorn (native) American plum flowering dogwood gray dogwood blackhaw arrowwood crabapple persimmon redbud</td>
<td>Black walnut for timber production should only be planted on the most nutrient rich sites with the deepest, well-drained soils.</td>
</tr>
<tr>
<td>Poplar-ash-cherry Mixed hardwoods</td>
<td>Forest wildlife</td>
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</tbody>
</table>

**Forest Productivity Level:** high (northern red oak site index > 70 ft.)

- **Site Condition:** Moist
- **Aspect:** northwest to east
- **Landscape Position:** lower, concave slopes, coves
- **Slope:** >10%
- **Soil Depth:** > 4 ft.
- **Soil Drainage:** well-drained to moderately well-drained
- **Soil Texture:** loam to silt loam
### General Prescriptions

**Region:** Midwest coal fields (The Illinois Coal Basin located in southern Indiana, southern Illinois, and western Kentucky)

**Site Type:** Flat bottomland and riparian

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<tr>
<td>Bottomland Oak-hickory</td>
<td>High grade sawtimber wildlife</td>
<td>oak: swamp white, swamp chestnut, bur, cherrybark, shumard shellbark hickory</td>
<td>maple: red, silver sycamore, <strong>river birch</strong>, sweet gum</td>
<td>cottonwood hybrid poplar sycamore</td>
<td>hazelnut spicebush hawthorn (native) dogwood: gray, silky, red osier deciduous holly speckled alder elderberry arrowwood ninebark American cranberry bush</td>
<td>An elevation change of 2 – 4 ft. in river bottoms can change the hydrology of the soil from well-drained to wet. These sometimes subtle changes should be noted and species matched accordingly.</td>
</tr>
<tr>
<td>Industrial plantation</td>
<td>Carbon sequestration Biomass /bioenergy and pulpmill feedstock</td>
<td>cottonwood hybrid poplar sycamore</td>
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Site Conditions: **well-drained bottomland flat**

- Forest Productivity Level: medium to high
- Soil Depth: > 3 ft.; Soil Drainage: well-drained; Soil Texture: sandy loam to silt loam.

An elevation change of 2 – 4 ft. in river bottoms can change the hydrology of the soil from well-drained to wet. These sometimes subtle changes should be noted and species matched accordingly.
## West Virginia

<table>
<thead>
<tr>
<th>MOISTURE REGIME</th>
<th>Wet</th>
<th>Moist - Moderate</th>
<th>Moderate</th>
<th>Moderate - Dry</th>
<th>Dry</th>
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### TREES

- **White Ash**
- **Yellow Poplar**
- **Sycamore**
- **Black Willow**
- **Black Walnut**
- **Butternut**
- **Silver Maple**
- **Red Maple**
- **American Beech**
- **River Birch**
- **Persimmon**
- **Eastern Hemlock**

### SHRUBS

- **Black Alder**
- **Willow**
- **Silver Maple**
- **Sycamore**
- **Black Willow**
- **American Bech**
- **Red Pine**
- **Eastern Hemlock**

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### SHRUBS

- **Black Alder**
- **Willow**
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Stand Stocking

Understocked

Well stocked
Field Application

- Map
- Reclamation
- Close field supervision
Functioning Forest Ecosystems