

**STEP #1 of the FRA**

**CREATING A SUITABLE  
ROOTING MEDIUM**

**Skousen, Zipper, Burger, Angel, Barton**

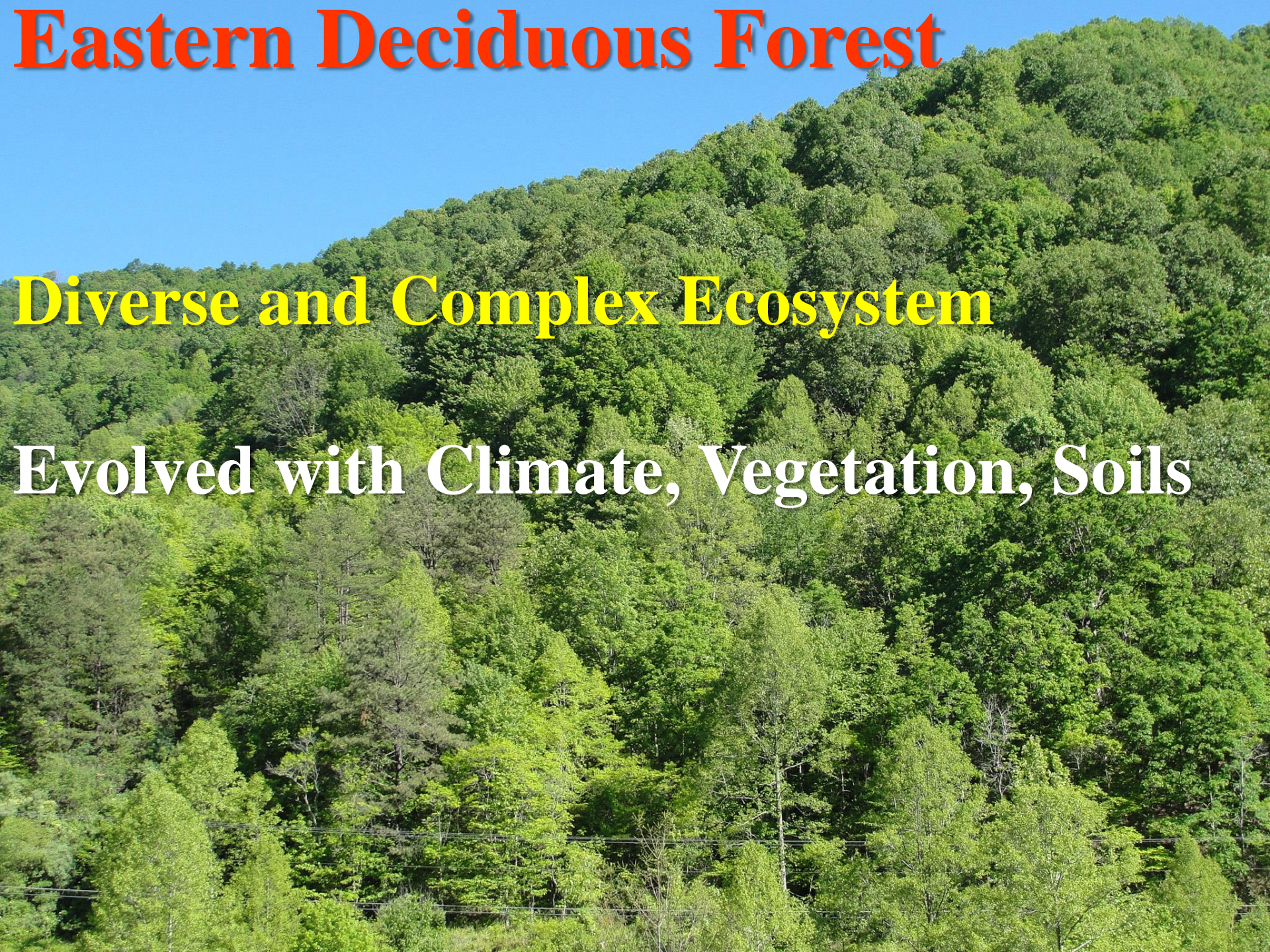




# **Eastern Deciduous Forest**

**Diverse and Complex Ecosystem**

**Evolved with Climate, Vegetation, Soils**





**About 75% of pre-mined land in  
Appalachia is forest**



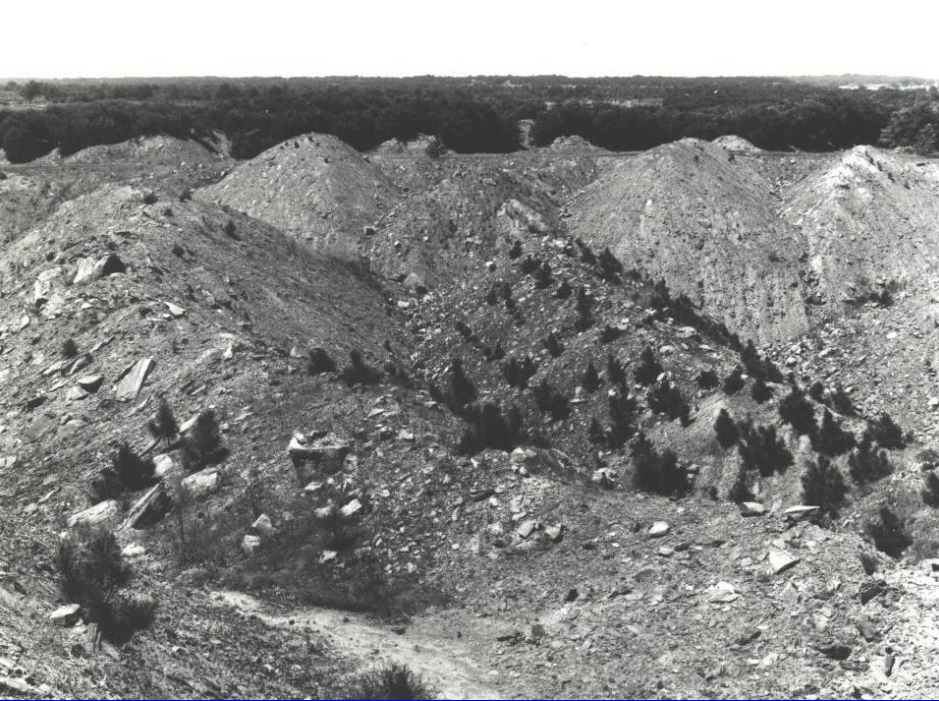


# Surface mining started in US in early 1940's -little reclamation





# Early mining methods were suitable for tree re-colonization



*Good Substrate – Near Surface*  
*No Grading*  
*No Seeding or Fertilizer*





**Abandoned Mined Land -  
Natural Reclamation to Trees**

**Rapidness and species recruitment  
based on mine soil properties**

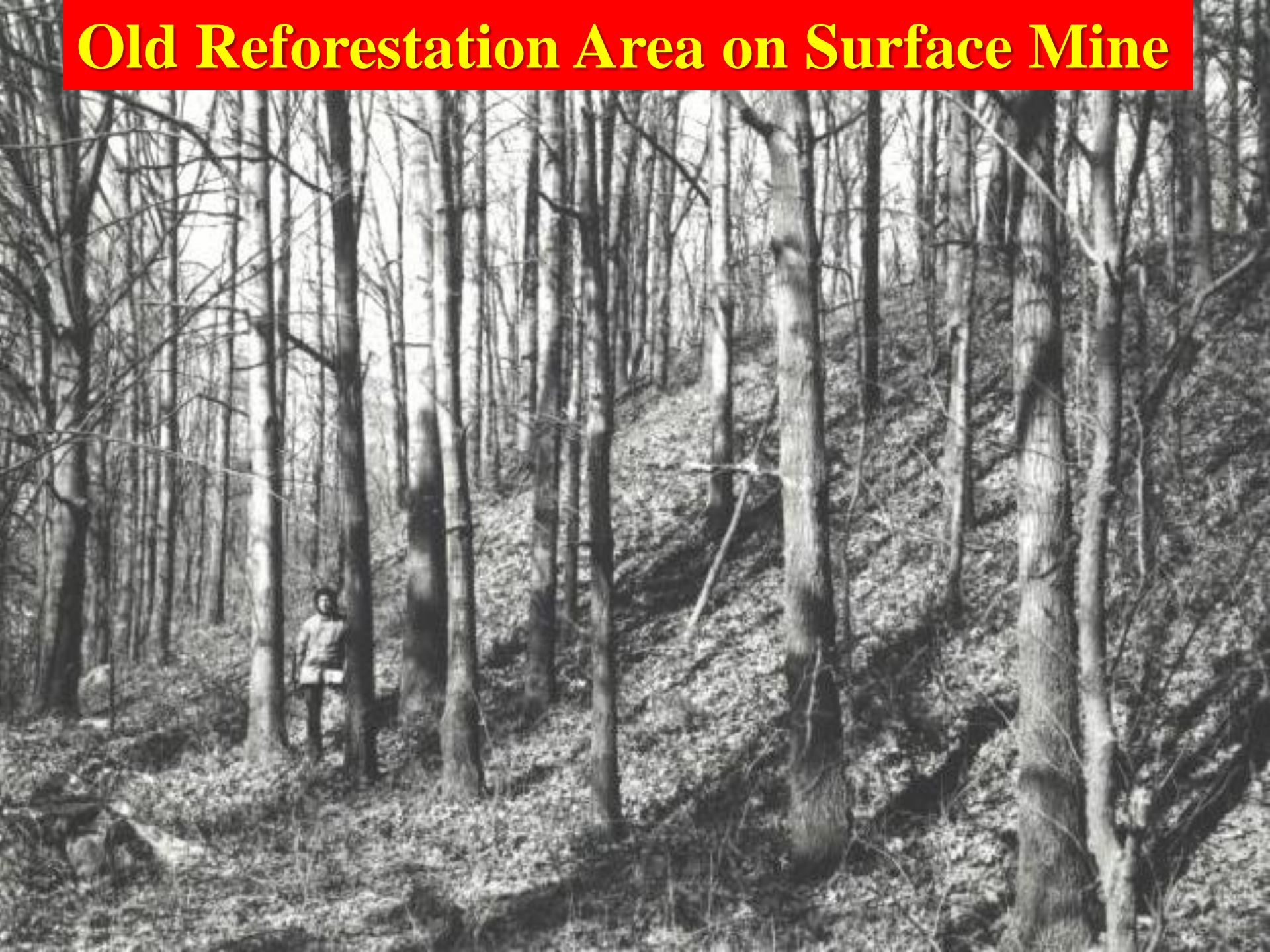


**Some of these old mined sites have the best tree growth!**





# Old Reforestation Area on Surface Mine





# Old Contour Jobs







**Readily reverted back to trees!**



# **1977 - Surface Mining Control and Reclamation Act (SMCRA)**

**Act was intended to:**

**Enhance human safety**

**Control erosion**

**Improve water quality**

**Return the land to AOC**

**Land was largely put back to pasture and hay land with soil compaction and heavy seeding rates**



**Reclaim to smooth compacted surfaces  
with little topsoil for**

**Grass and Hay Land Pastures**



04/26/2011



**Hydroseed heavy rates of**

- Ag grasses and legumes**
- Fertilizer**
- Mulch**







**SMCRA interpretation led to most post mined land  
being reclaimed to pasture and hayland**

**Economic benefit from grazing and hay production**

**Easier to get bond release because...**



# Reclamation evolved into large tracts of pasture





**But if the land is not managed in a pasture or hayland use,  
then ...**



**Grass and Invasive Shrub Wasteland**



**Back to Forest...**

**How Long?**





# What do we do? How to Reforest?



08/04/2014



# What do trees want from soil?

## 1. Physical properties

- At least 4 feet deep
- Non-compacted

## 2. Chemical properties

- Low to moderate levels of soluble salts
- pH of 5.5 to 6.5

## 3. Fertility

- Adequate levels of essential nutrients



# Appalachian Regional Reforestation Initiative

## ARRI





# 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.





## SELECTING MATERIALS FOR MINE SOIL CONSTRUCTION WHEN ESTABLISHING FORESTS ON APPALACHIAN MINE SITES

Jeff Skousen, Carl Zipper, Jim Burger, Christopher Barton, and Patrick Angel

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest (FRA Advisory #2, Burger and others 2005). The FRA is based on research, knowledge, and experience of forest soil scientists and reclamation practitioners. Forest Reclamation Advisories are guidance documents that describe state-of-the-science procedures for mined land reforestation (see <http://arri.osmrc.gov/FRA/FRA.shtml>).

The FRA's first step is: "create a suitable rooting medium for good tree growth that is no less than 4 feet deep and comprised of topsoil, weathered sandstone and/or the best available material." This Advisory provides guidance on how to execute step 1 of the FRA.

Selection and placement of a suitable rooting medium is critical for successful reforestation on surface mines. Constructing mine soils using suitable materials enhances and accelerates development of diverse forest ecosystems. This Advisory is intended to inform mining operators who are seeking to re-establish native forest as a post-mining land use on coal surface mines.

### Background

Soil is a mixture of weathered rocks, organic material, water, air, and living creatures. Its properties provide the structural support and other resources necessary for plant and animal life in a forest. The soil is the foundation of a forest ecosystem. Indeed, the health

and productivity of a forest is determined by the nature and properties of the soil.

The eastern USA's Appalachian Mountains are among the world's most ancient landscapes. The region's soils have developed from the rocks that form these landscapes over long time periods in response to climate, plants and animals, and landscape position (Jenny, 1941). Throughout the Appalachians, diverse plant communities have evolved over millennia on these weathered rock and soil materials (Figure 1).

Weathering is the process of changing rocks into soil-like materials. During surface mining, unweathered rocks are often excavated and placed on the surface as growth media. These rocks react with air and water and break down physically and chemically, releasing soluble salts and changing mineral forms (Sencindiver and Ammons, 2000). Plants can establish and grow in these pre-soil materials, producing organic matter to aid soil development and making the materials more favorable for colonization by microorganisms and other plants (Johnson and Skousen, 1995). These processes are well known, occur naturally, and can be accelerated by reclamation activities such as fertilizing and seeding. However, when starting with unweathered rocks, very long time periods are required to produce a soil that can support a plant community like the one which existed before mining (Figure 2).





# 1. Suitable Rooting Medium

## Why 4 feet?

MAY 14 2004



# Mine soil wedge experiment:

Down slope  
< 2 ft



Up slope  
> 5 ft







**<2 feet**

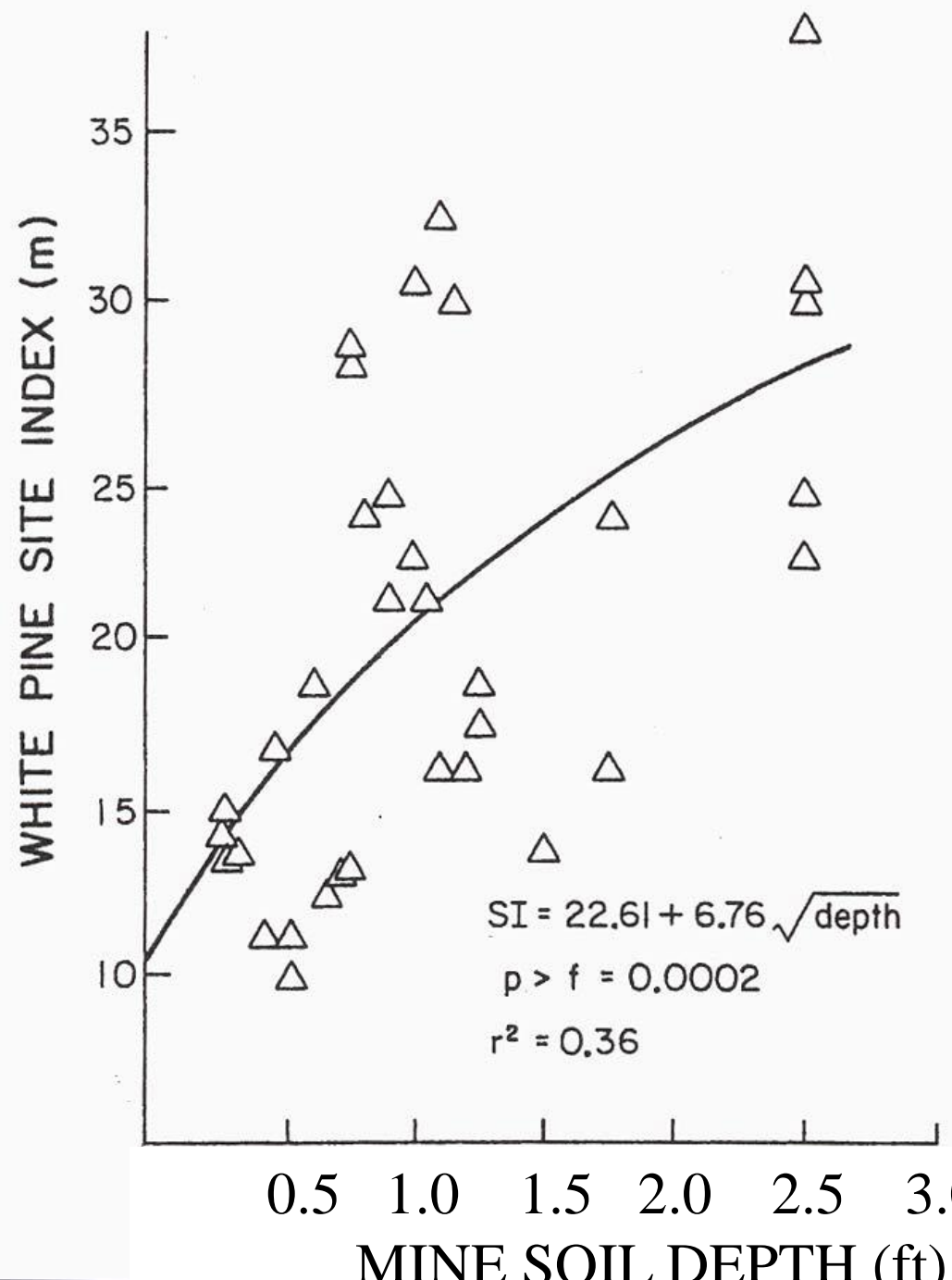


**>5 feet**



# White pine site index (age 50) as a function of rooting depth

(Torbert et al. 1988  
Jour. Environ. Qual.)





**Ohio**



**Kentucky**



**West Virginia**



**Tennessee**





**Some forest soils are thin  
over bedrock**







**But support diverse ecosystem ...  
evolved over long time periods**

2007 8 8



**Salvage Any and All Topsoil**





**Get all you can!**





**...with all the stumps, and woody debris**









**Rocks are also OK!**













**Substitute material may be used in lieu of topsoil**

**Where available and of suitable quality, weathered spoil materials, and most especially sandstones, should be salvaged and re-spread to supplement topsoil**





**Native Soil in background**  
**Brown subsoil/rock at top**  
**Gray material lower down**







**University of Kentucky  
Bent Mountain Research Complex**



# Topsoil Placement





# Demonstration Plots

**Brown Sandstone**



**Gray Sandstone**





## Brown Sandstone

Lower pH ~ 6.0

Greater % Fines



## Gray Sandstone

High pH ~ 8.0

High Soluble Salts





# 11 Tree Species planted

## Commercial Planting Company



2.5 by 2.5 m spacing



**Brown SS**

**2007**

**3<sup>rd</sup> yr**



2007 7 31



Gray SS

2007

3<sup>rd</sup> yr



2007 7 30



**Brown SS**

**2009**

**5<sup>th</sup> yr**







**Gray SS**  
**2009**  
**5<sup>th</sup> yr**



**Brown SS**  
**2010**  
**6<sup>th</sup> yr**





# Gray SS 2010 6<sup>th</sup> yr





**Brown SS**  
**2011**  
**7<sup>th</sup> yr**

05/26/2011





# Gray SS 2011 7<sup>th</sup> yr



05/26/2011



8<sup>th</sup> Year





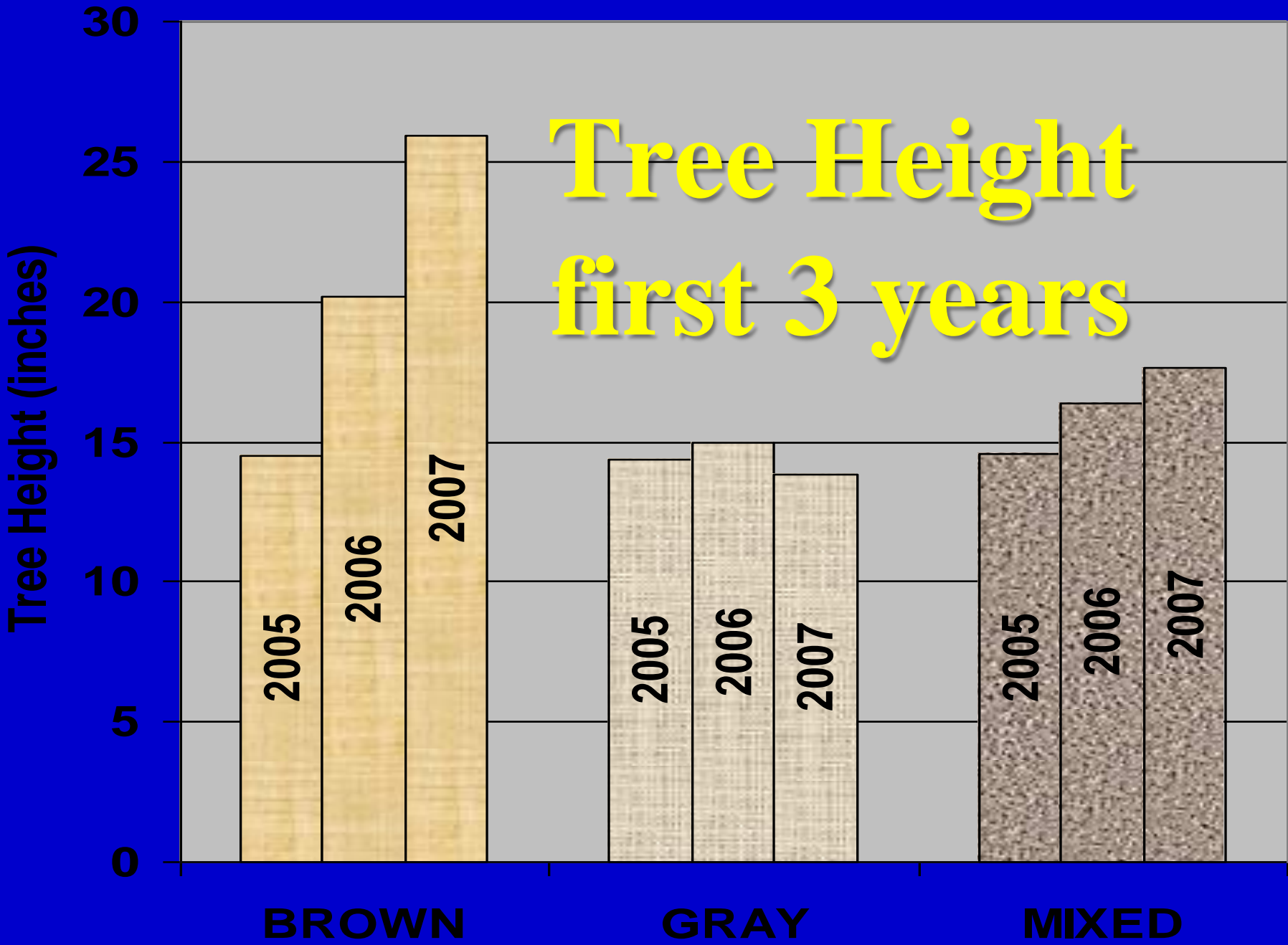
**Growth after 15 years**



2008 6 10



# Tree Height first 3 years





# Native plant emergence on different spoil types



**Brown**

**42%**

**40 species**

**Mixed**

**3%**

**21 species**

**Gray**

**<1%**

**6 species**



# Brown SS

## 2<sup>nd</sup> yr



06/29/2010



# Gray SS

## 2<sup>nd</sup> yr



06/29/2010



# CONCLUSIONS

**1. Create a suitable rooting medium that is no less than 4 feet deep and comprised of topsoil, weathered sandstone and/or the best available material**





**2. Topsoil is better than  
brown weathered sandstone**

**3. Brown weathered sandstone  
is better than gray  
unweathered sandstone**



# 4. Avoid surface placement of materials that are unsuitable as growth media for native trees

- Too many rocks
- pH <4 or >7.5
- Soluble Salts >1,000  $\mu\text{S}/\text{cm}$
- Black Shales



**We want something that will look  
like this is 8 to 10 years**





# Forest Products and Services

- **Products**

- Wood, fiber and paper

- **Ecosystem Services**

- Water quality

- Flood control

- Erosion control

- Biodiversity

- Wildlife habitat

- Carbon sequestration

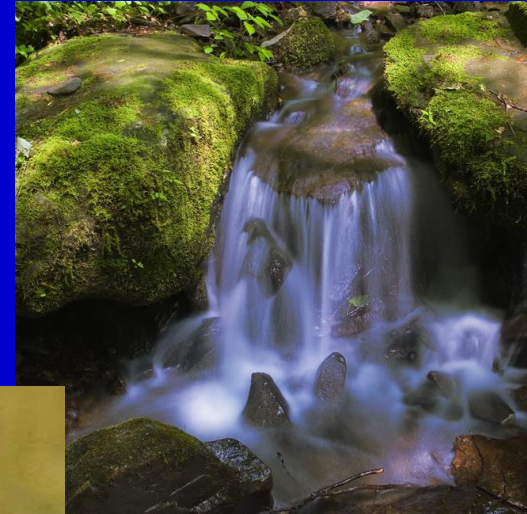


Photo: Richard Calmes



Photo: Jim Burger







# Tree Height (ft.)

