HEIGHT OF THREE HARDWOOD SPECIES GROWING ON MINE SITES COMPARED TO NATURAL CONDITIONS

KARA DALLAIRE, JEFF SKOUSEN, JAMIE SCHULER

JUNE 11, 2015

Coal Mining

West Virginia largest coal producer in the Appalachian region

90 active surface mines in 2013

Over 30 million Mg coal

Sources: Bise, 2013; U.S EIA, 2014

WV Forests

78% Eastern deciduous forests

Wood production

Ecosystem functions

Wildlife habitat

Source: Burger, 1999

Forestry Reclamation Approach

5 Steps:

1. Create suitable rooting medium
2. Do not compact
3. Use tree compatible ground cover
4. Plant at least two types of trees
5. Use proper planting techniques

Source: Burger et al., 2005

Brown vs. Gray Sandstone

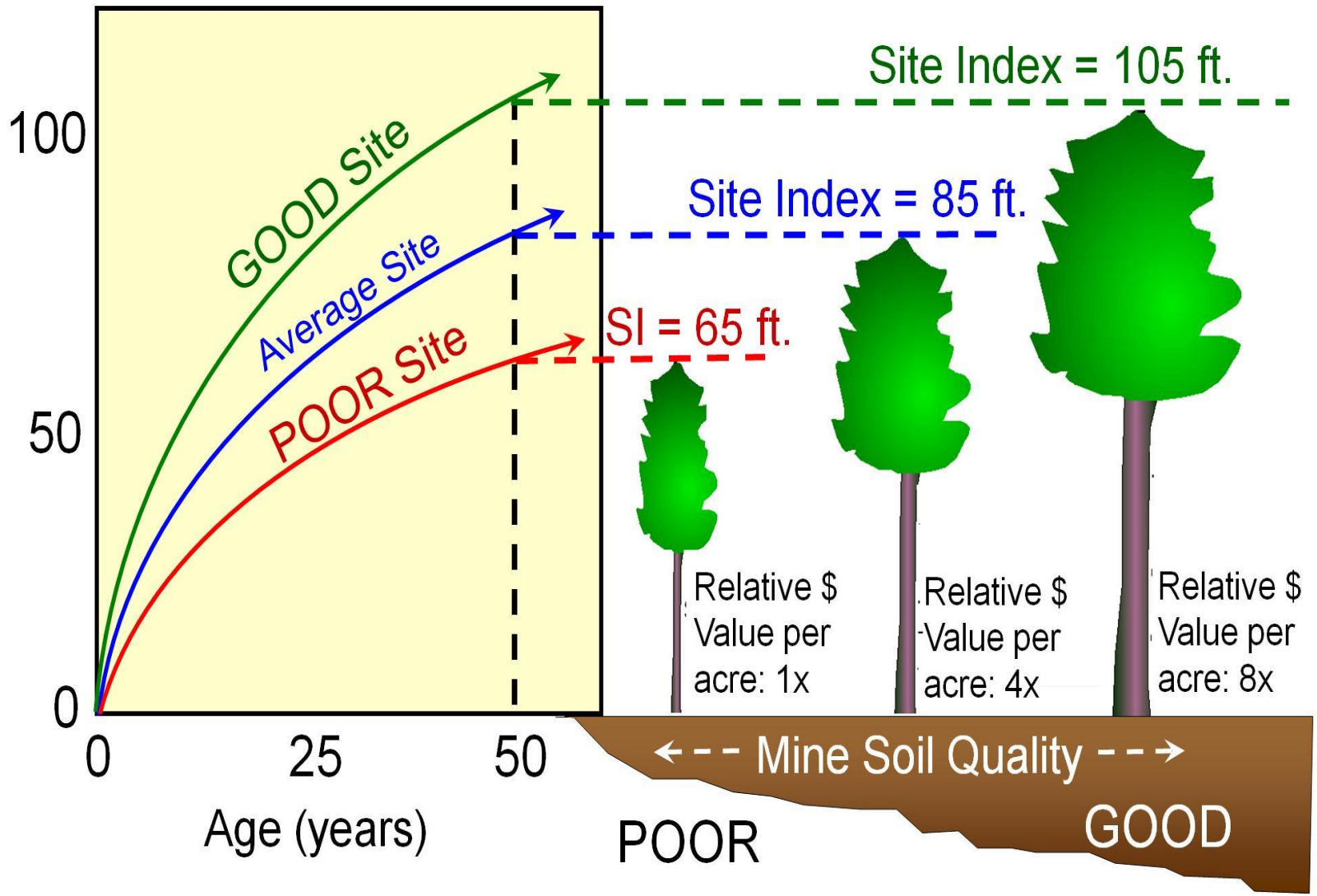
Brown = ☺

- Lower pH
- Lower EC
- > Fines

Sources: Angel et al, 2006; Burger et al., 2005; Conrad et al., 2008; Haering et al., 2004; Skousen et al., 2011; Daniels and Amos, 1984; Rodrigue and Burger, 2004

Amendments Improve Growth!

Sources: Angel et al., 2008; Emerson et al., 2009; Sena et al., 2014; Showalter et al., 2009; Thomas and Skousen, 2011; Wilson-Kokes, 20013a and 2013b



Source: Burger et al.

Methods

Two mine sites in WV

- Birch River
- Catenary

Yearly tree growth and soil samples collected

Data from Fernow Experimental Forest

- Two studies

Web Soil Survey

- Calculate pre-mine SI

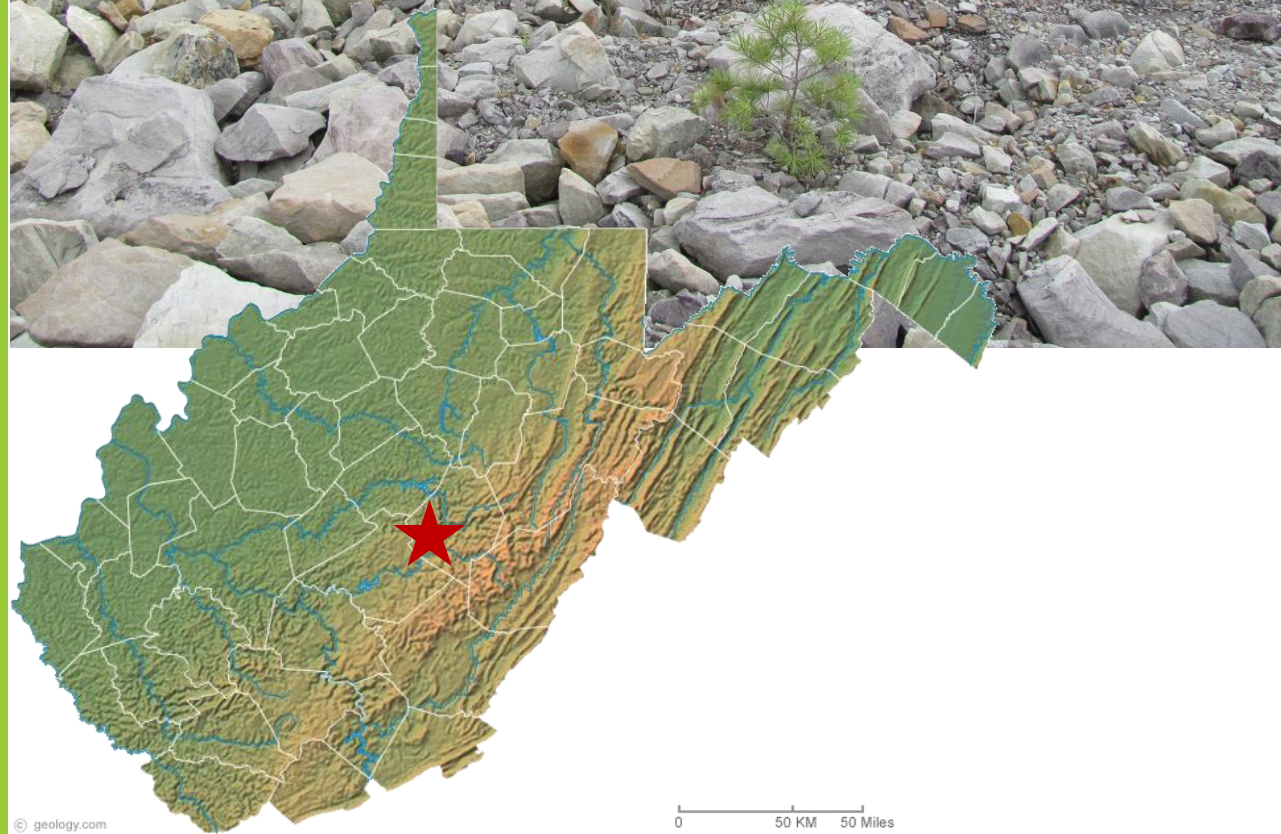
Birch River

Established in 2007

Brown

Gray

Mulch



Catenary

Established in 2005

Brown

Gray

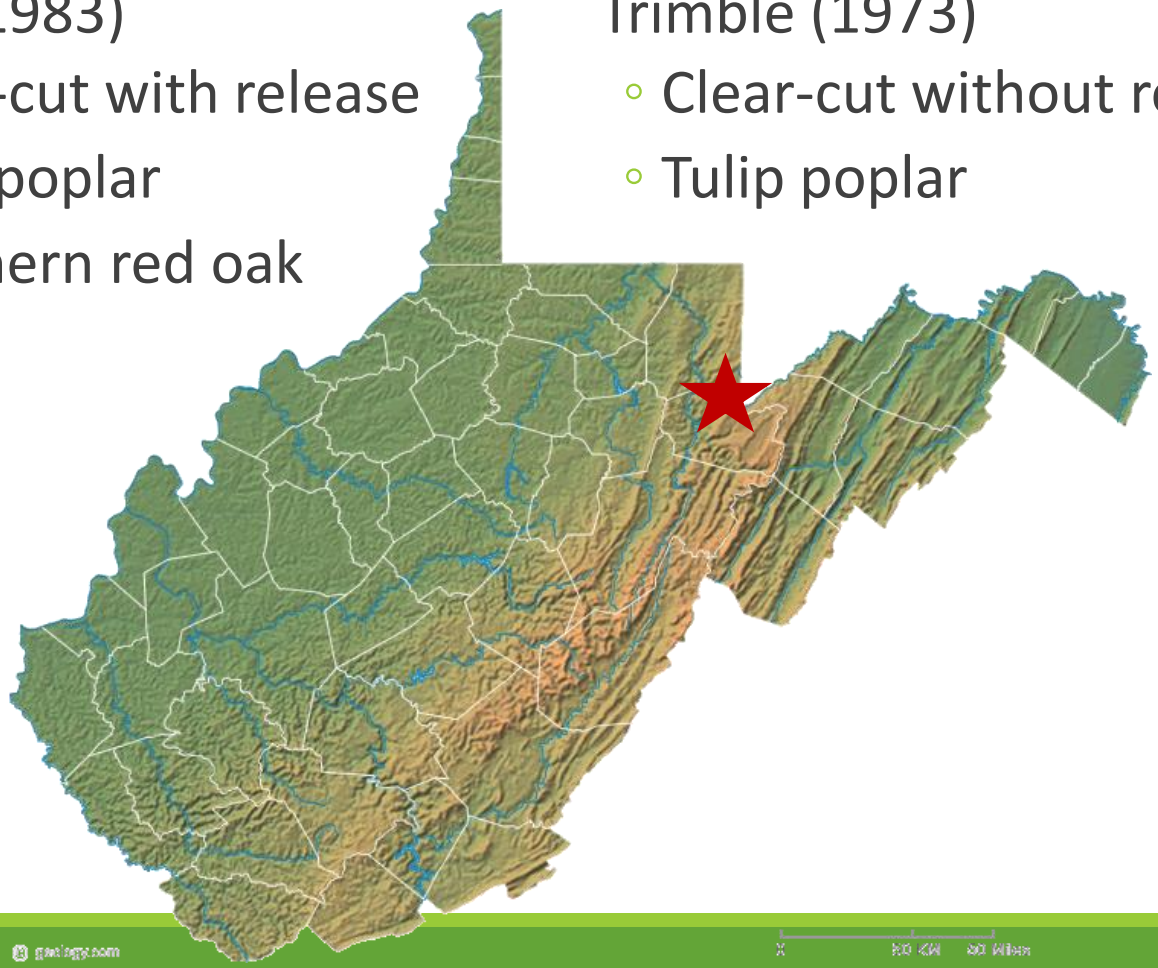
Fernow Experimental Forest

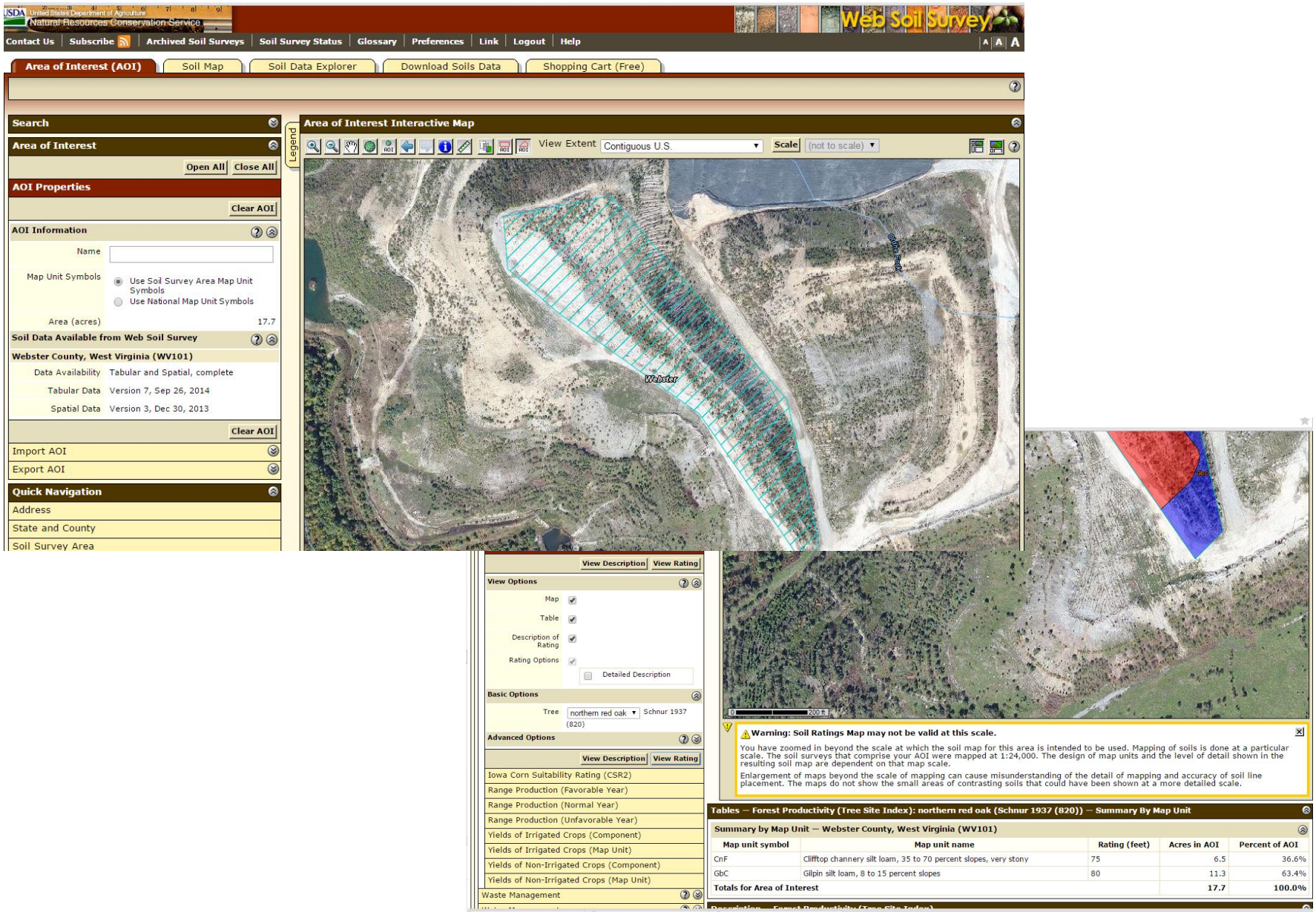
Smith (1983)

- Clear-cut with release
- Tulip poplar
- Northern red oak
- SI 75
- SI 62

Trimble (1973)

- Clear-cut without release
- Tulip poplar




USDA United States Department of Agriculture
Natural Resources Conservation Service
Web Soil Survey
Contact Us | Subscribe | Archived Soil Surveys | Soil Survey Status | Glossary | Preferences | Link | Logout | Help
Area of Interest (AOI)
Soil Map
Soil Data Explorer
Download Soils Data
Shopping Cart (Free)
Search
Area of Interest
Open All
Close All
AOI Properties
Clear AOI
AOI Information
Name
Map Unit Symbols
Use Soil Survey Area Map Unit Symbols
Use National Map Unit Symbols
Area (acres) 17.7
Soil Data Available from Web Soil Survey
Webster County, West Virginia (WV101)
Data Availability Tabular and Spatial, complete
Tabular Data Version 7, Sep 26, 2014
Spatial Data Version 3, Dec 30, 2013
Clear AOI
Import AOI
Export AOI
Quick Navigation
Address
State and County
Soil Survey Area
Legend
Area of Interest Interactive Map
View Extent
Contiguous U.S.
Scale
(not to scale)
Webster
View Description
View Rating
View Options
Map
Table
Description of Rating
Rating Options
Detailed Description
Basic Options
Tree
northern red oak
Schnur 1937 (820)
Advanced Options
View Description
View Rating
Iowa Corn Suitability Rating (CSR2)
Range Production (Favorable Year)
Range Production (Normal Year)
Range Production (Unfavorable Year)
Yields of Irrigated Crops (Component)
Yields of Irrigated Crops (Map Unit)
Yields of Non-Irrigated Crops (Component)
Yields of Non-Irrigated Crops (Map Unit)
Waste Management
Warning: Soil Ratings Map may not be valid at this scale.
You have zoomed in beyond the scale at which the soil map for this area is intended to be used. Mapping of soils is done at a particular scale. The soil surveys that comprise your AOI were mapped at 1:24,000. The design of map units and the level of detail shown in the resulting soil map are dependent on that map scale.
Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.
Tables — Forest Productivity (Tree Site Index): northern red oak (Schnur 1937 (820)) — Summary By Map Unit
Summary by Map Unit — Webster County, West Virginia (WV101)
Map unit symbol | Map unit name | Rating (feet) | Acres in AOI | Percent of AOI
CnF | Clifftop channery silt loam, 35 to 70 percent slopes, very stony | 75 | 6.5 | 36.6%
GbC | Gilpin silt loam, 8 to 15 percent slopes | 80 | 11.3 | 63.4%
Totals for Area of Interest | | | 17.7 | 100.0%

Site Index on Mine Sites

Site	Northern red oak SI	White oak SI	Tulip poplar SI
Birch River	78	78	92
Catenary	78	85	95

Source: USDA, 2014b

Average Site Index

Forest productivity (SI) from Web Soil Survey

Weighted average of soil types on sites

Formulation equation

$$H = b_1 S^{b_2}(1-e^{b_3 A}) \text{ ^} b_4 S^{b_5}$$

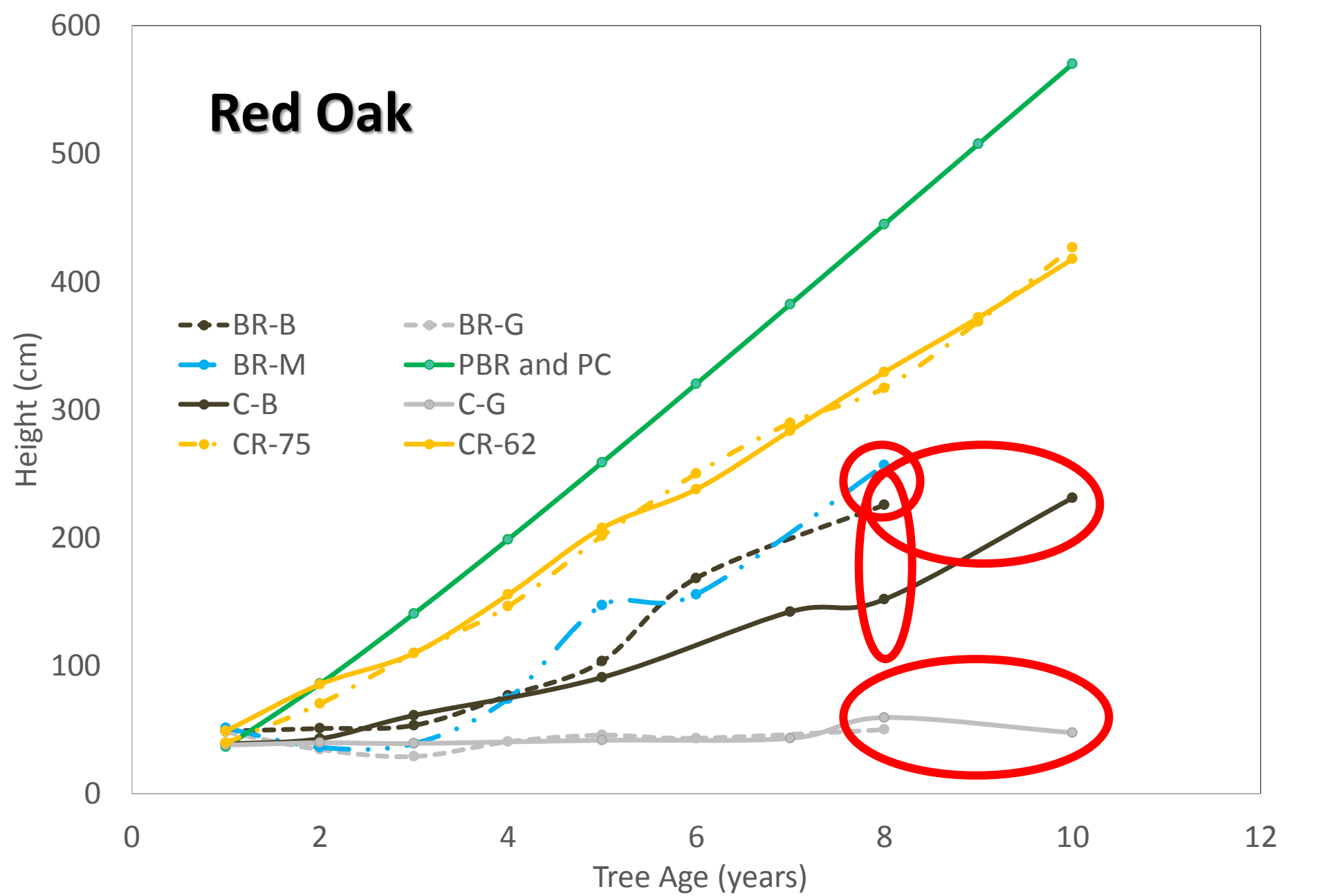
H = Height
bi = Regression Parameters
S = Site Index
A = Age

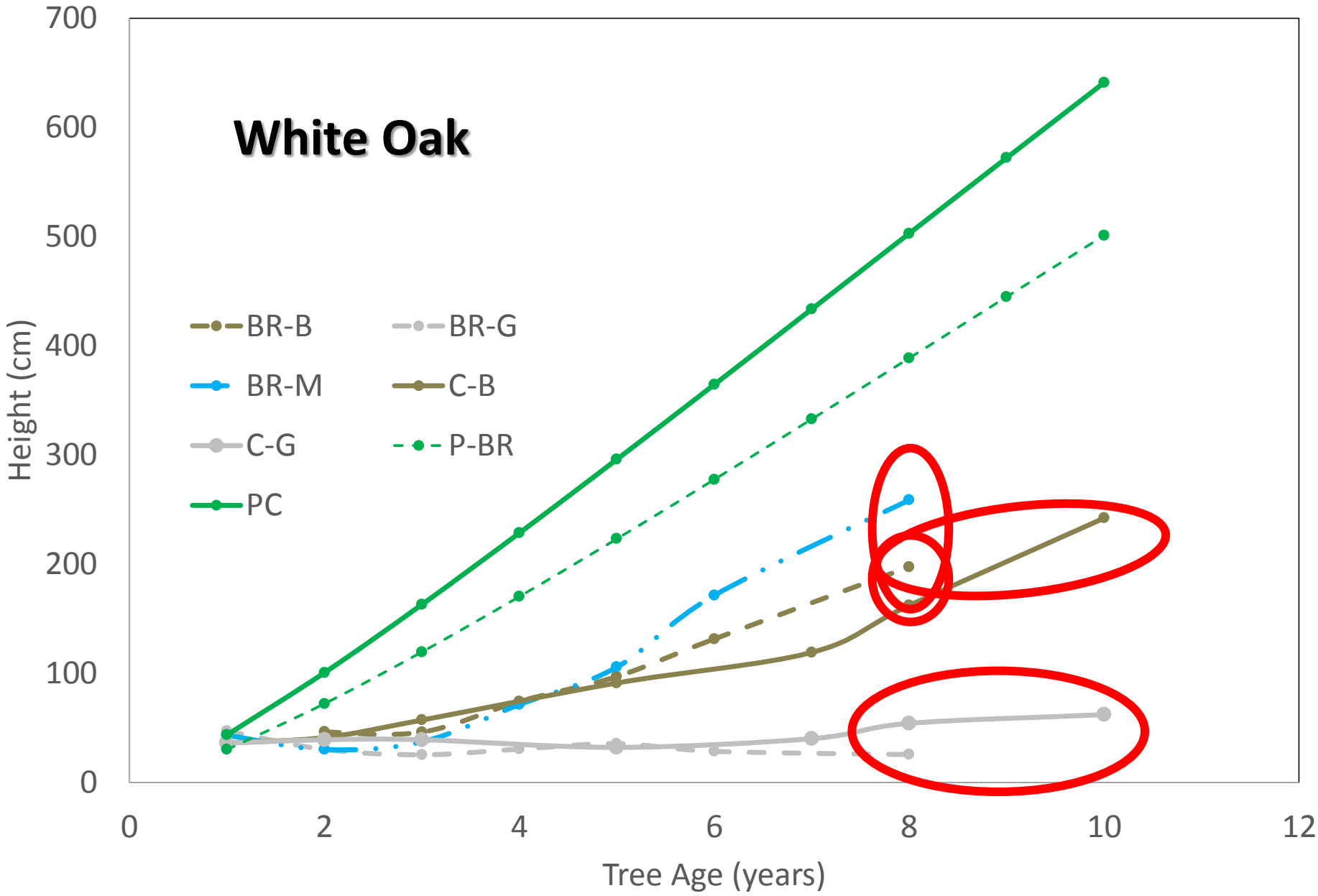
Sources: Carmean et al., 1989; USDA, 2014b

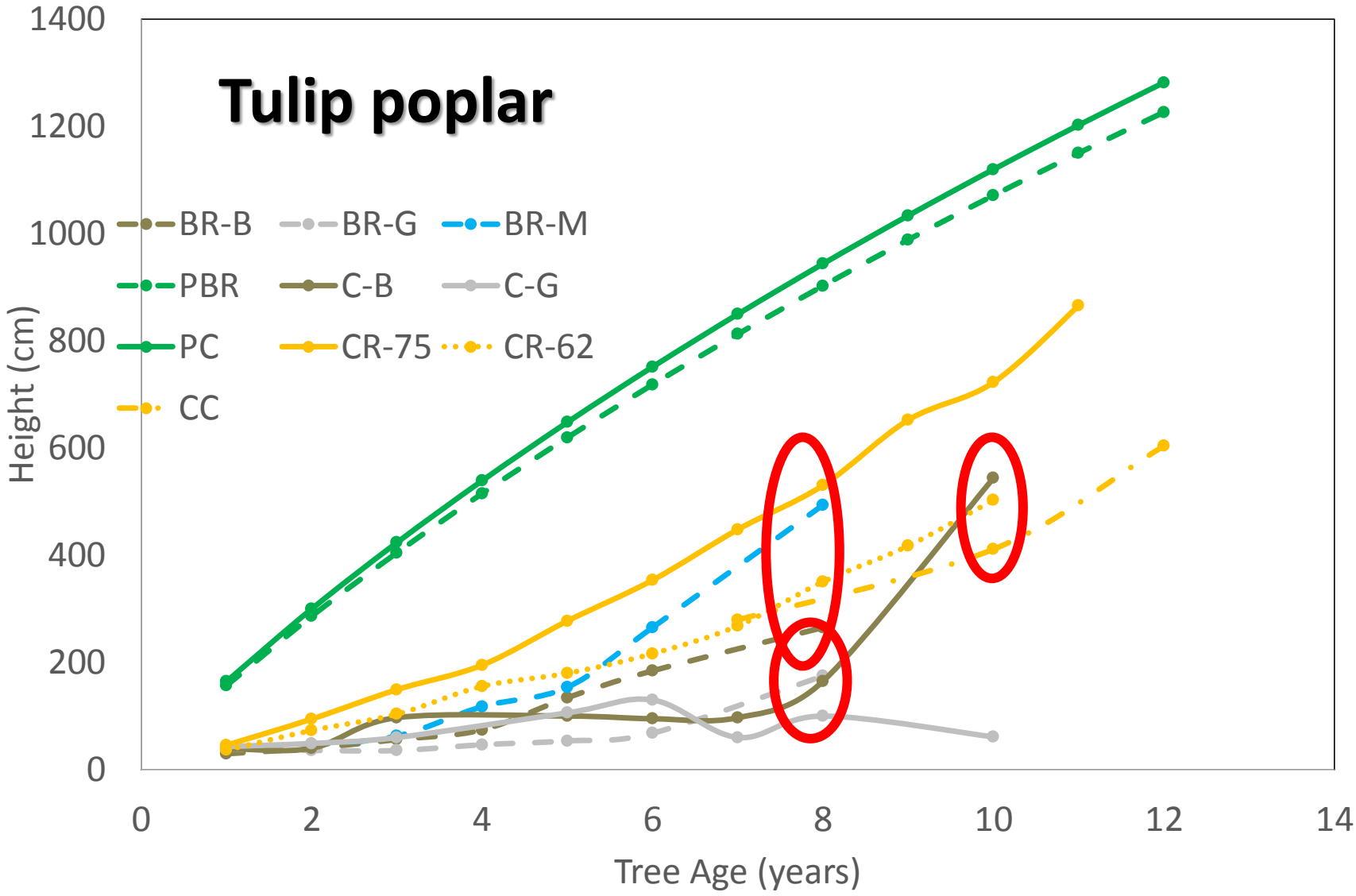
Birch River – brown sandstone	**BR-B**
Catenary – brown sandstone	**C-B**
Birch River – gray sandstone	**BR-G**
Catenary – gray sandstone	**C-G**
Birch River – mulch	**BR-M**
Clear-cut with release – SI 62	**CR-62**
Clear-cut with release – SI 75	**CR-75**
Clear-cut without release	**CC**
Pre-mining – Birch River	**PBR**
Pre-mining – Catenary	**PC**

Treatment	pH	EC (dS/m)	Fines (%)
BR-B	5.2	0.01	45
C-B	5.4	0.01	60
BR-G	6.5	0.01	49
C-G	6.8	0.01	42
BR-M	7.0	0.04	43
Fernow	4.1 to 5.2	0.0	Unknown
PB	4.6 to 4.7	0.0	Unknown
PC	4.7 to 4.9	0.0	Unknown

Treatment	Ca	K	Al	Fe
	----$cmol_c$/kg-----		----mg/kg---	
BR-B	6	0.6	402	219
C-B	7	0.6	431	154
BR-G	6	0.3	113	126
C-G	10	0.4	150	149
BR-M	197	12	115	51


Red Oak
Height (cm)
600
500
400
300
200
100
0
0
2
4
6
8
10
12
Tree Age (years)
BR-B
BR-G
BR-M
PBR and PC
C-B
C-G
CR-75
CR-62


White Oak
BR-B
BR-G
BR-M
C-B
C-G
P-BR
PC
Height (cm)
0
100
200
300
400
500
600
700
0
2
4
6
8
10
12
Tree Age (years)


Tulip poplar
BR-B
BR-G
BR-M
PBR
C-B
C-G
PC
CR-75
CR-62
CC
Height (cm)
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
Tree Age (years)

Tree Growth

Trees growing on mines

Not original productivity

Limitations to height estimates

Weeds, animal and insect damage, stock quality, planting techniques

Sources: Beck and Trousdell, 1973; Carmean, 1975 ; Carmean et al., 1989

Conclusions

Birch River > Catenary

Brown sandstone > gray

Mulch increases growth

Tulip poplar:

- Brown and mulch > clearcut

Acknowledgements

Paul Ziemkiewicz (WVU)

Scott Eggerud (US OSM)

John McHale, Mitch Kalos, Jonathon Sanchez, Jeff Andrews (Patriot Coal)

Keith O'Dell, Bill Young, Mike Duvall (Arch Coal)

Paul Emerson, Curtis Delong, Calene Thomas, Lindsey Wilson-Kokes (former WVU grad students)

Steffany Scagline (WVU)

Angel, P., C. Barton, R. Warner, C. Agouridis, T. Taylor, and S. Hall. 2008. Forest establishment and water quality characteristics as influenced by spoil type on a loose-graded surface mine in eastern Kentucky. p. 28-65. *In:* Barnhisel, R. (ed), Proceedings, 2008 American Society of Mining and Reclamation. June 4-8, 2008. Richmond, VA.

Angel, P.N., D.H. Graves, C. Barton, R.C. Warner, P.W. Conrad, R.J. Sweigard, and C. Agouridis. 2006. Surface mine reforestation research: evaluation of tree response to low compaction reclamation techniques. p. 45-58. *In:* Barnhisel, R. (ed.), Proceedings, 2006 American Society of Mining and Reclamation. March 26-30, 2006, St. Louis, MO.

Bise, J.B. 2013. Coal industry statistics. p. 1-23. *In* C.J. Bise (ed.) Modern American coal mining methods and applications. Society for Mining, Metallurgy, and Exploration, Inc. Englewood, CO.

Burger, J.A. 1999. Academic research perspective on experiences, trends, constraints and needs related to reforestation of mined lands. p. 63-74. In: Proceedings, Enhancements of Reforestation at Surface Coal Mines: Technical Interactive Forum, March 23-24, 1999. Fort Mitchell, KY.

Burger, J., D. Graves, P. Angel, V. Davis, and C. Zipper. 2005. The forestry reclamation approach. Forest Reclamation Advisory No. 2. p. 4. Available at http://arri.osmre.gov/Publications/Publications.shtm#FRAs. Accessed 8 January 2015.

Carmean, W.H. 1975. Forest quality evaluation in the United Sates. Advances in Agronomy. 27: 209-269.

Carmean, W.H. 1977. Site classification for northern forest species. p. 205-239. *In:* Intensive Culture of Northern Forest Types Symposium Proceedings. USDA Forest Service General Technical Report NE-29.

Carmean, W.H., J.T. Hahn, and R.D. Jacobs. 1989. Site index curves for forest species in the eastern United States. USDA Forest Service, North Central Forest Experiment Station. Gen. Tech. Rep. NC-128. St. Paul, MN.

Conrad, P.W., R.J. Sweigard, V. Badaker, D.H. Graves, and C.D. Barton. 2008. The impact of surface applied mulches on selected physical properties of reclaimed mountaintop removal sits. Inter. J. Mining, Reclamation and Environment. 22:222-236.

Daniels, W.L. and D.F. Amos. 1985. Generating productive topsoil substitutes from hard rock overburden in the southern Appalachians. Env. Geochem. & Health. 7:8-15.

Emerson, P., J. Skousen, P. Ziemkiewicz. 2009. Survival and growth of hardwoods in brown versus gray sandstone on a surface mine in West Virginia. J. Environ. Qual. 38:1821-1829.

Haering, K.C., W.L. Daniels, and J.M. Galbraith. 2004. Appalachian mine soil morphology and properties: effects of weathering and mining method. Soil Sci. Soc. Am. J. 68:1315-1325.

Rodrigue, J.A. and J.A. Burger. 2004. Forest Soil productivity of mined land in the Midwestern and Eastern coalfield regions. Soil Sci. Soc. Am. J. 68:833–844.

Sena, K., C. Barton, S. Hall, P. Angel, C. Agouridis. 2014. Influence of spoil type on afforestation success and natural vegetation recolonization on a surface coal mine in Appalachia, United States. Restoration Ecology. Available at http://onlinelibrary.wiley.com/doi/10.1111/rec.12164/pdf. Accessed 08 February 2015.

Skousen, J. Showalter, J.M., J.A. Burger, and C.E. Zipper. 2010. Hardwood seedling growth on different mine spoil types with and without amendment. J. Environ. Qual. 39: 483-491.

Skousen, J., , C. Zipper, J. Burger, C. Barton, and P. Angel. 2011. Selecting materials for mine soil construction when establishing forests on Appalachian mine sites. Forest Reclamation Advisory No. 8. p. 6. Available at http://arri.osmre.gov/FRA/Advisories/FRA_No.8%20Soil%20Materials.pdf. Accessed 08 February 2015.

Smith, H.C. 1983. Growth of Appalachian hardwoods kept free to grow from 2 to 12 years after clearcutting. USDA Forest Service, Northeastern Forest Experiment Station. Res. Paper. NE-528. Broomall, PA.

Thomas, C., and J. Skousen. 2011. Hardwood tree performance on amended brown and gray mine spoils after four years. p. 665-675. *In:* Barnhisel, R. (ed.), Proceedings, 2011 American Society of Mining and Reclamation, June 12-16, 2011. Bismark, ND.

Trimble, G.R. 1973. Response to crop-tree release by 7-year old stems of yellow-poplar and black cherry. USDA Forest Service, Northeastern Forest Experiment Station. Res. Paper. NE-253. Upper Darby, PA.

U.S. Energy Information Administration (EIA). 2013. Annual coal report 2012. Available at http://www.eia.gov/coal/annual/pdf/acr.pdf. Accessed 19 January 2015.

USDA. 2014b. Web Soil Survey. Available online at http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. Accessed 01 February 2015.

Wilson-Kokes, L., C. Delong, C. Thomas, P. Emerson, K. O'Dell, and J. Skousen. 2013a. Hardwood tree growth on amended mine soils in West Virginia. J. Environ. Qual. 42:1363-1371.

Wilson-Kokes, L., P. Emerson, C. Delong, C. Thomas, and J. Skousen. 2013b. Hardwood tree growth after eight years on brown and gray mine soils in West Virginia. J. Environ. Qual. 43:1353-1362.

Questions?