REFORESTATION OF MINED LAND FOR BOND RELEASE, PRODUCTIVE LAND USES, AND ENVIRONMENTAL QUALITY

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PROGRESS REPORT (2008-2009)

This report is presented in four parts:

1. An overview of the Powell River Project forestry research program;
2. A technical paper on the growth and productivity of native hardwoods planted in 1992 on mined land on the Powell River Project site (Burger and Fannon, starts on page 7);
3. A technical paper on tree establishment and response (hybrid poplar, white pine, and native hardwoods) to forest practices applied to post-SMCRA mined sites (Fields-Johnson and others, starts on page 20);
4. A description of a new study established in 2007 on the Powell River Project testing the feasibility of growing tree plantations as bio-energy crops for fuel production (Evans and others, starts on page 35).

Dr. Burger in one of the Powell River Project reforestation studies; these trees are now 28 years old.

Powell River Project Forestry Reclamation Research Overview

Forestry is a logical post-mining land use because of its traditional economic importance to the region, and because of the many services it provides the public, such as flood control, water quality, wildlife habitat, carbon sequestration, and aesthetic environments. After the implementation of the SMCRA in 1978, highly-graded mined landscapes covered with agricultural grasses and legumes were common. However, landowners and coal operators throughout the Appalachian coalfields are now commonly reclaiming with trees for forestry using a technique developed by Powell River Project (PRP) researchers. This technique, commonly called the Forestry Reclamation Approach (FRA), is summarized in several new or revised Virginia Cooperative Extension bulletins located at: http://www.cses.vt.edu/PRP/VCE_Pubs.html

The foundation for mined land reforestation practices is based on many Powell River Project forestry research sites in Virginia and adjacent states. The results from these research sites allow us to develop new and revised reforestation guidelines for reclaiming mined land, and they allow us to demonstrate the value of reclaimed forests. Because forestry is a long-term enterprise, we maintain and monitor these field sites over time. The older the research sites become, the more valuable they are, because they show how reclamation treatments will ultimately affect the success and value of the restored forest. In addition to maintaining older experimental sites, we install new experiments each year to fill gaps in our knowledge and address new issues confronting the mining community.

Research Reports

During the year 2008-09 we did research on several existing study sites. Herbaceous ground covers used for erosion control can be very competitive and detrimental to tree survival and growth. This was demonstrated in a six-year study that showed that native hardwoods can grow at three times the rate when ground cover is reduced to 60 to 80% while still controlling erosion. The Virginia Department of Mines, Minerals, and Energy has since changed the ground cover standard for forestry post-mining land uses from 90% to a level needed to control erosion. We summarized the results of this and other long-term studies in Powell River Project Virginia Cooperative Extension publications that are currently available from the Powell River Project website: http://www.ext.vt.edu/pubs/mines/460-124/460-124.html

Part 2 (J. Burger and A. Fannon, starts on page 7) of this report contains the results of a species trial showing that, with time (15 years), valuable native hardwoods such as the oaks and tulip poplar do as well as or better than less valuable species such as commonly-planted sycamore and ash. However, the rates of growth of all species were slower than expected compared to non-mined sites, which means pre-mining capability was not restored on these sites using practices using techniques common in the early 1990s. New FRA procedures should improve post-mining forest productivity.

Part 3 (Fields-Johnson and others, starts on page 20) contains early results from a new and ongoing study designed to demonstrate the benefits of reduced grading and tree-compatible ground covers for native hardwoods and American chestnut hybrids. Reduced grading of topsoil substitutes increases water infiltration, reduces runoff, and improves tree survival and growth.

Tree-compatible ground covers are better for hardwood establishment, and they allow greater recruitment of native plants.

Part 4 (Evans and others, starts on page 35) describes a new study that tests the suitability of reclaimed mined land for growing short rotation (15 years) tree plantations for biomass energy feedstocks. Several fast-growing species planted at two densities are being tested at three locations in Wise County, Virginia.

Ongoing Research Activities

Our ongoing Powell River Project reforestation research program is dedicated to: (1) helping coal operators meet their reclamation requirements; (2) helping landowners maximize the value of their reclaimed mined land; and (3) helping mining communities meet their socio-economic needs. The following ongoing studies are being conducted to meet these goals:

1. Ground cover control to improve native hardwood establishment

- This PRP project is in its eighth growing season. The results after five years are featured in a PRP Virginia Cooperative Extension bulletin, "Establishing Ground Cover for Forestry Post-mining Land Uses," VCE No. 460-124. This project is maintained as part of the PRP forestry field tour.

2. Hardwood establishment field trials

- This is a large ongoing study with 10 3-acre sites located in three states. The study tests hardwood establishment on a variety of operationally-prepared mined sites in a three-state region. We completed tree, ground cover, and site measurements for 10 continuous years. A preliminary analysis of this project was presented and published at the Annual Meeting of the American Society of Mining and Reclamation in Breckenridge, Colorado, in June, 2005.

  Auch, W. T., J. A. Burger, and D. O. Mitchem. 2005. Hardwood stocking after five years on reclaimed mined land in the Central Appalachians. In: R. I. Barnhisel (ed.). Proc., 22nd Mtg., Amer. Soc. for Mining and Reclamation. June 18-24, 2005, Breckenridge, CO. ASMR, 3234 Montavesta Rd., Lexington, KY.

3. Growth and productivity of several native hardwoods on reclaimed mined land

- This species trial was established on three sites at the PRP demonstration area in Wise County, Virginia. The sites had been surfaced-mined for coal in 1990 and reclaimed in 1991 using standard reclamation practices. The purpose of this study was to contrast after 15 years the growth, survival, and overall performance of seven hardwood species. The species groups represented included non-native fuelwood species, upland hardwoods, riparian species, and a valuable but off-site hardwood species. Trees were planted in March, 1992. Northern red oak, white oak, and yellow poplar, all upland native hardwood species, proved to be good choices for general reforestation; however, better reclamation procedures than those used when this study was established (compacted mix of overburden materials with heavy herbaceous ground cover) are needed to restore forest land capability to pre-mining conditions.

- Ms. Amy Gail Fannon, PRP Cooperative Extension Agent, conducted this recent analysis as part of a Virginia Tech undergraduate research course. She presented the work in a national student competition at the Soil Science Society of America Annual Meeting in Houston, Texas. The results of this study were also presented at the annual meeting of the American Society of Mining and Reclamation in June, 2009, in Billings, Montana, and published in the meeting proceedings. This study is featured below as Part 2 of this PRP Progress Report.

  Burger, J. A., and A. G. Fannon. 2009. Forest land capability of reclaimed mined land for seven Appalachian hardwood species. Natl. Mtg., Amer. Soc. for Mining and Reclamation, Billings, MT. *Revitalizing the Environment: Proven Solutions and Innovative Approaches*, May 30-June 5, 2009. R.I. Barnhisel (ed.). ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

4. White oak response to different mine soil types

- We continue to monitor an 80-acre native hardwood planting on Rapoca Coal Company land. This cooperative effort among Rapoca, Virginia Tech, and the Virginia Department of Mines, Minerals, and Energy (DMME) serves as a model for the application of Powell River Project reforestation guidelines. Our last report on this study was published in the spring of 2007. We will visit and remeasure the experimental plots on this study site when the trees are 10 years old.

  Showalter, J. M., J. A. Burger, C. E. Zipper, J. M. Galbraith, and P. F. Donovan. 2007. Influence of mine soil properties on white oak seedling growth: A proposed mine soil classification model. *Southern Journal of Applied Forestry* 31(2):99-107.

5. Reforestation and carbon sequestration by forests and soils on mined land

- This project was funded by the Appalachian Regional Commission, the Virginia Department of Mines, Minerals and Energy, The Nature Conservancy, the U.S. Department of Energy, and the Powell River Project. The project is directed toward reforestation of compacted mined land reclaimed prior to the implementation of the Forestry Reclamation Approach. It compares survival and growth of three forest types (hybrid poplar plantations, white pine plantations, and mixed native hardwoods) growing on mined land subjected to forest practices (weed control, tillage, and fertilization). This 3x3 factorial experiment is replicated three times in each of three states (Virginia, West Virginia, and Ohio). Results after five years were reported by Chris Fields-Johnson and others at the annual meeting of the American Society for Mining and Reclamation in Richmond, VA, in June, 2008.

  Fields-Johnson, C., C. E. Zipper, and J. A. Burger. 2008. Fourth-year tree response to three levels of silvicultural input on mined lands. Proc., Amer. Soc. of Mining and Reclamation Ann. Mtg., Richmond, VA, June 2008.

- The second objective of this study is to measure the potential of restored forests to sequester large amounts of atmospheric carbon, which is associated with the greenhouse effect and climate change. Much of the elevated level of CO_2 in the atmosphere is attributed to land use change and the burning of coal and other fossil fuels. This project will help determine the benefits of reforesting mined land for sequestering carbon from

the atmosphere. Information on this study objective is contained in the following publications:

Amichev, B. Y. 2007. Biogeochemistry of carbon on disturbed forest landscapes. Ph.D. Dissertation. Virginia Polytechnic Institute and State University. 371 p.

Amichev, B., J. A. Burger, and J. A. Rodrigue. 2008. Carbon sequestration by forests and soils on mined land in the Midwestern and Appalachian coalfields of the U.S.. *Forest Ecology and Management*. 256:1949-1959.

6. Establishing hardwood forests with American chestnut using the Forestry Reclamation Approach: Effects of grading practices and ground cover

- This project compares the relative success of reforestation established using three different types of ground covers on both compacted and uncompacted mined soils. In the winter of 2008, a native hardwood mix was planted across all sites along with five varieties of American chestnut hybrids. This project is demonstrating the benefits of using the Forestry Reclamation Approach, and it will test the viability of American chestnut hybrids as a species component in reclaimed native forests. This research trial was established with the cooperation of Red River Coal Co. (two study sites) and Paramont Coal Co. (one study site). It was funded by an OSM Applied Science Grant and the Powell River Project.
- An overview of the project and results from initial measurements are featured in Part 3 of this report.

Fields-Johnson, C., C. E. Zipper, J. A. Burger, and D. M. Evans. 2009. First-year response of mixed hardwoods and improved American chestnuts to compaction and hydroseed treatments on mined land. Natl. Mtg., Amer. Soc. of Mining and Reclamation, Billings, MT. *Revitalizing the Environment: Proven Solutions and Innovative Approaches.* May 30-June 5, 2009. R.I. Barnhisel (ed.) ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

7. Topsoil substitutes and amendments for reforestation

- The objective of this study is to determine how mine soils weather with time and how they may become more suitable for trees. Important unresolved questions for coal operators are what topsoil substitutes are needed for trees, and whether they are significantly different from those needed for grassland reclamation. The 25-year-old PRP overburden placement study containing plots with different mine soil mixes and organic matter amendments was planted with northern red oaks in spring 2002. Organic amendments included sawdust and four levels of sewage sludge. This project will test the long-term effects of these amendments on soil chemical properties and the growth of red oaks.
- During this proposed project year, we will measure total red oak biomass and nutrient content as affected by the different organic amendments. This study will show if the additional expense of adding organic matter to mine soils is justified based on tree response to these materials.

8. Bioenergy feedstock production potentials of reclaimed coal mines

- This project was funded by Alpha Natural Resources and installed with co-PI Carl Zipper in winter 2008 on three sites in Virginia. The purpose is to determine the feasibility of

using otherwise unproductive reclaimed mined land for feedstock production for raw materials for conversion to biobased fuels and biobased products. Five years ago, half-acre plots of three planted forest types (hybrid poplar, white pine, and mixed hardwoods) were each treated with three levels of management (weed control, weed control + tillage, and weed control + tillage + fertilizer). Three of the nine replications of this experiment are located on or near the PRP. The outcome of this project will be decision support information for landowners regarding the profitability of reforestation investments, and decision support information for policymakers regarding effects of financial incentives, such as carbon credits, needed to stimulate reforestation by landowners.

- This project is featured as Part 4 of this PRP Progress Report.

Outreach Activities

We conducted a tour of forestry research sites during the Powell River Project field day in September 2008 and supported Arbor Day events conducted by DMME.

We held a field tour for an environmental resource graduate class from Duke University in October 2008.

We participated and gave lectures at a Virginia Professional Engineers in Mining Seminar at the Southwest Virginia Higher Education Center in Abingdon, Virginia.

We co-authored an Appalachian Regional Reforestation Initiative Advisory:

> Burger, J., V. Davis, J. Franklin, C. Zipper, J. Skousen, C. Barton, and P. Angel. 2009. Tree-compatible ground covers for reforestation and erosion control. Appalachian Regional Reforestation Initiative, Forest Reclamation Advisory No. 6. 6 p.

We participated in the 3rd Annual Appalachian Regional Reforestation Conference in Prestonsburg, Kentucky, August 3-6, 2009.

What Are the Benefits of This Reforestation Research?

Our work has provided the foundation for the Forestry Reclamation Approach used by many coal operators in Virginia and adjacent states. It is currently being promoted by the Office of Surface Mining's Appalachian Regional Reforestation Initiative. Economic analyses have shown that the return on mined land reclaimed according to guidelines based on PRP research can be several times higher than on land currently reclaimed to unmanaged land uses. While improving the value of mined land for the landowner, coal operators benefit through more timely and successful recovery of performance bonds, and local communities benefit from land reclamation that improves water quality, reduces flooding potential, is more aesthetically pleasing, and is more valuable for a diversifying economy.