Ecosystem Structural and Functional Development on Reforested Mined Lands

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Introduction

Surface mining for coal has drastically disturbed 600,000 ha of land in the Appalachian region since the 1800's. At least 10,000 additional ha are disturbed each year. The primary native ecosystem prior to mining is mixed hardwood forest. Research within the last few decades has focused on improving tree establishment and survival on the rocky, compact mine soils common in the post-mining landscape (Figs. 1 and 2). However, *it is unclear whether the established forest vegetation provide the same ecological functions as the native forest ecosystems.*

Figure 1: Topsoil substitutes common in the region


Figure 2: Reestablishing approximate original contour

Study Objectives

1. Quantify the rate at which key forest ecosystem functions return to the landscape.
2. Relate ecosystem structural development to ecosystem functional development.

Experimental Design

Powell River Project (PRP)

Located in southwest VA (Fig. 3), the PRP is a public-private, cooperative land-grant project. Research from the PRP focuses on creating practical and cost-effective solutions for natural resource and reclamation challenges related to surface coal-mining.

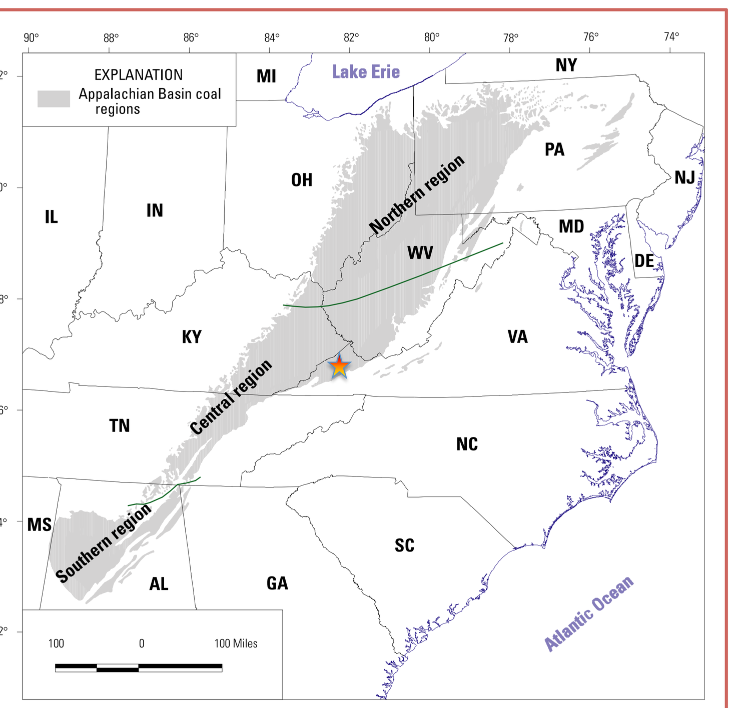

Figure 3: Extent of the Appalachian Basin coal region. Powell River Project location indicated with star.

Chronosequence of four forest stands following reclamation and reforestation (ages 5, 11, 21 and 30 years) and an unmined reference stand representative of the pre-mining forest condition (Fig. 4). Within each age cohort, three 5 m radius plots were established for sample collection and stand characterization.


Age 5 | Age 11 | Age 21 | Age 30 | Unmined

Figure 4: Reforested chronosequence and unmined reference stand

Soil Temperature and Moisture

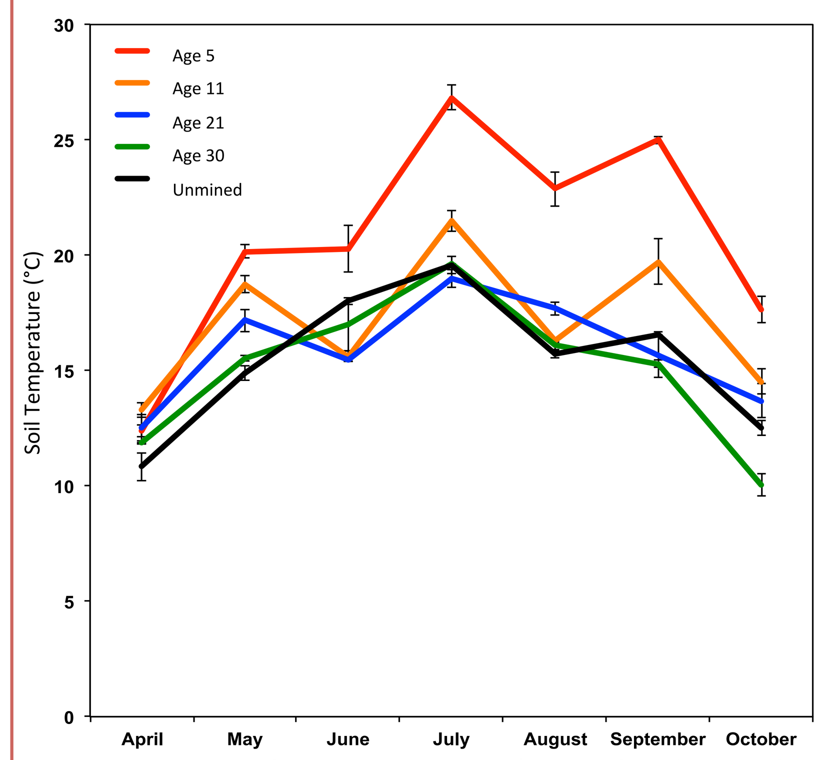

Figure 5: Soil temperature at each age cohort by month

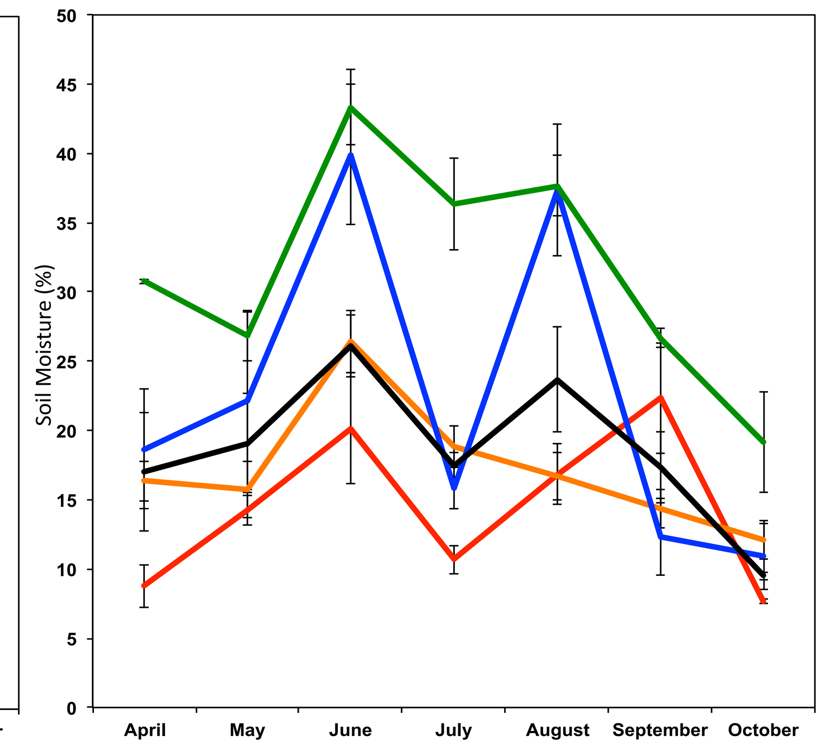

Figure 6: Soil moisture at each age cohort by month

Microbial Biomass

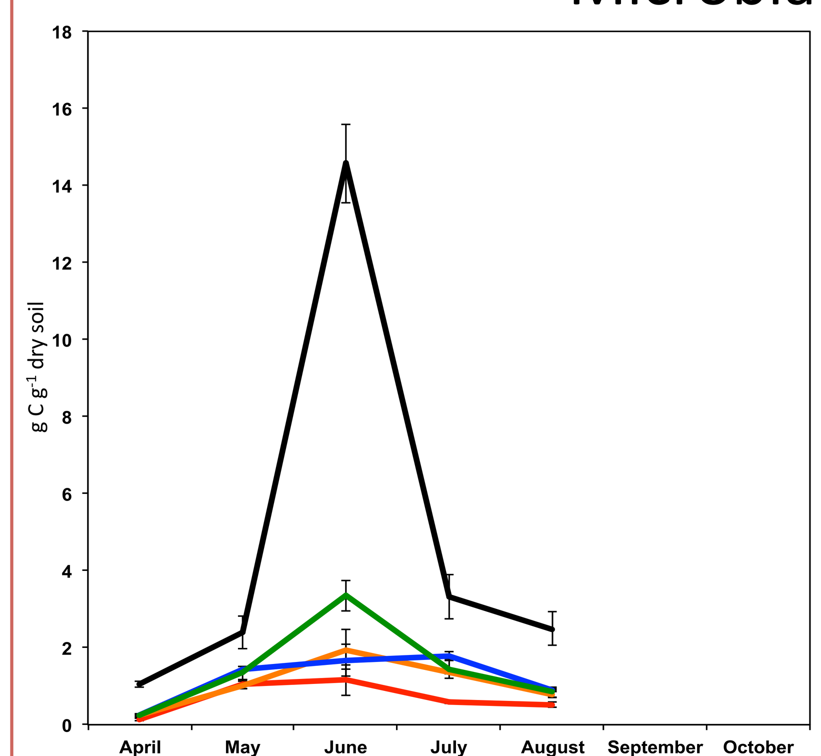

Figure 7: Total microbial biomass carbon

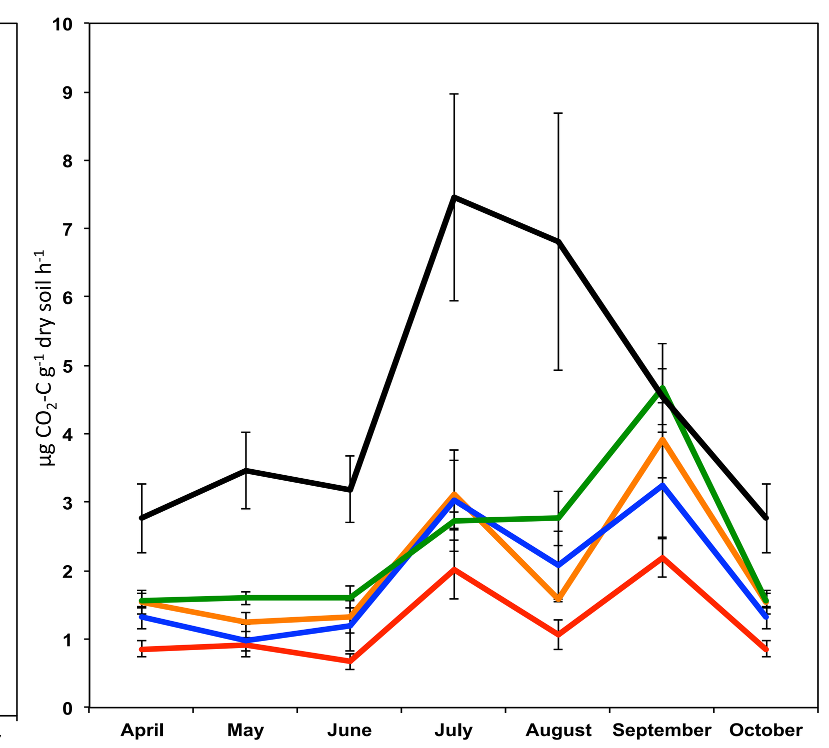

Figure 8: Active microbial biomass carbon

Nitrogen Availability

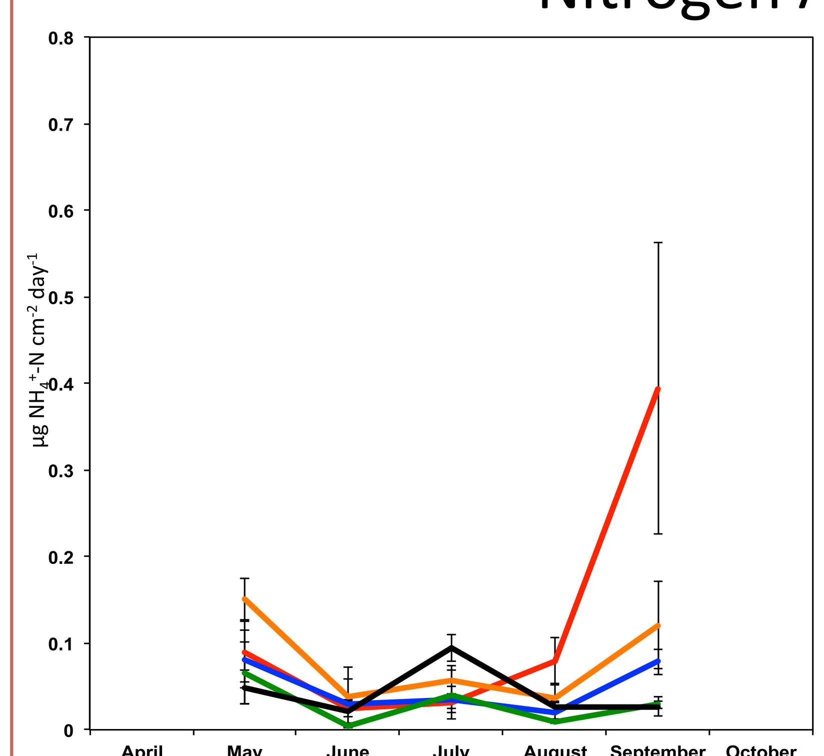

Figure 9: NH_4^+-N available on a daily basis

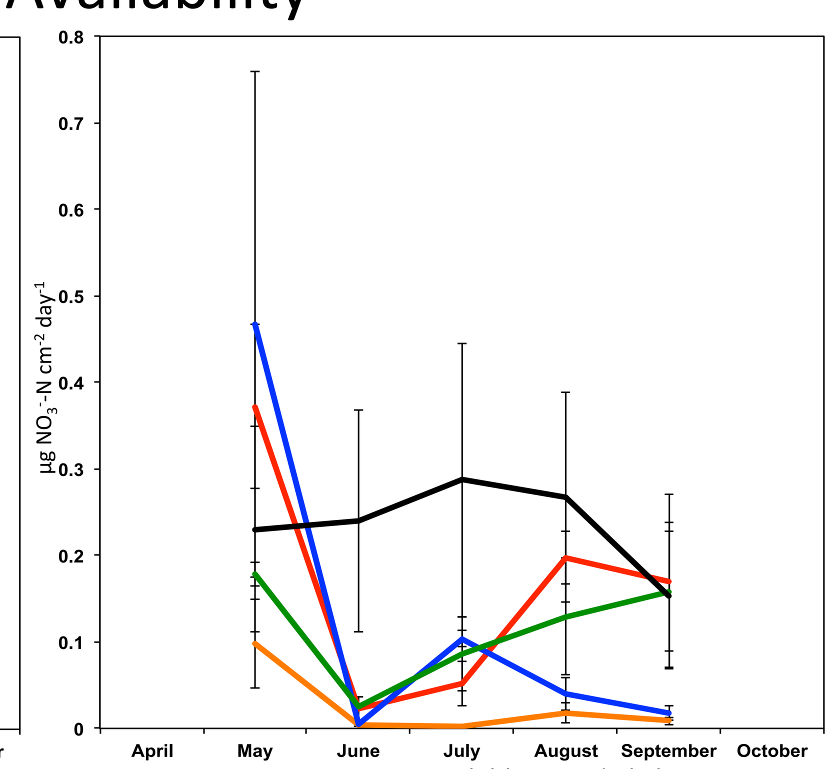

Figure 10: NO_3^--N available on a daily basis

Greenhouse Gas Fluxes

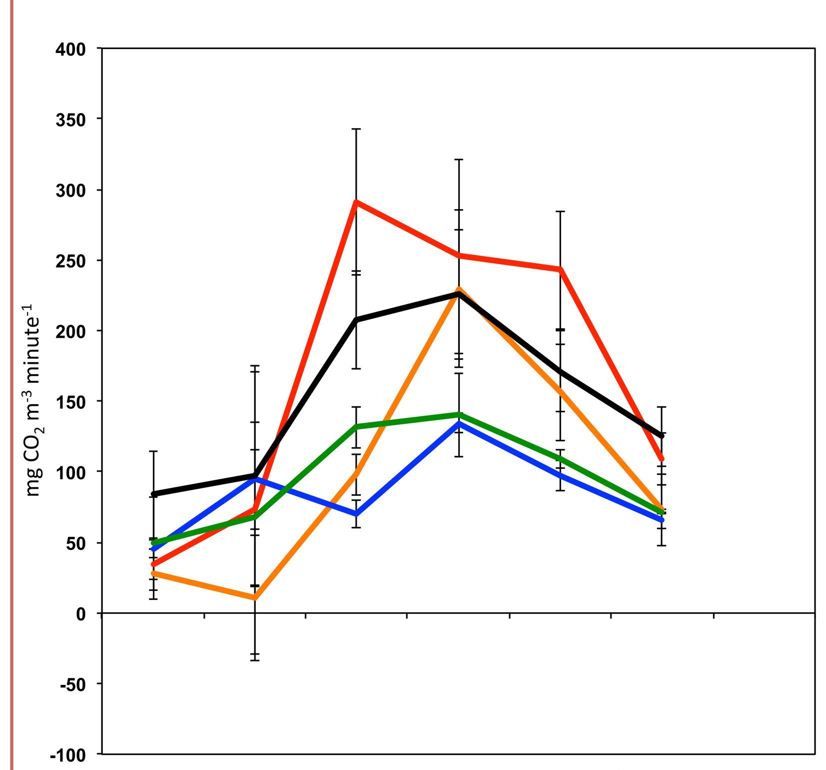

Figure 11: CO_2 Flux

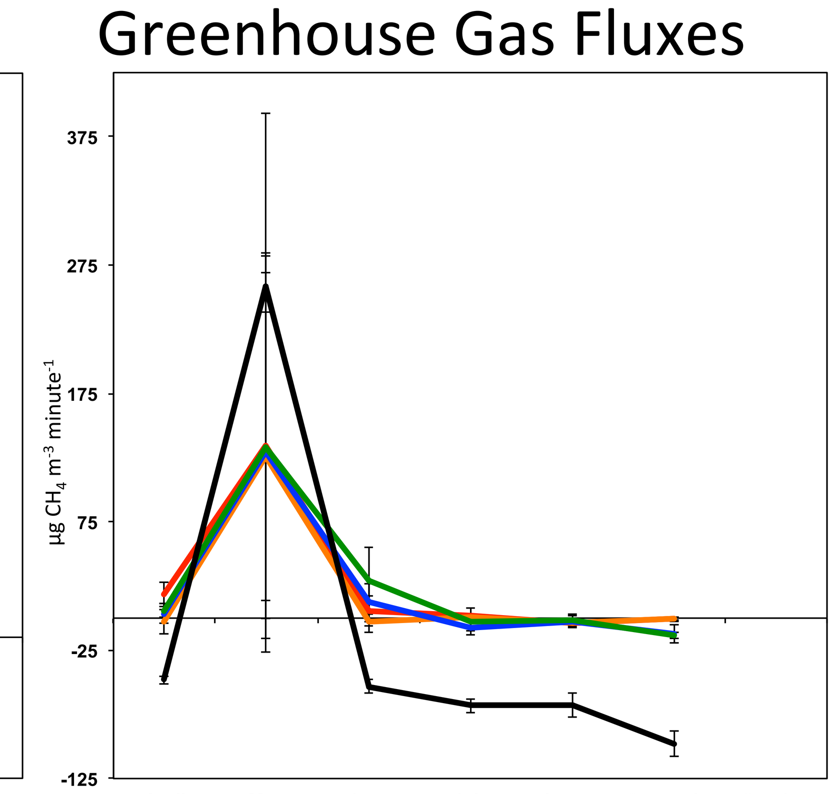

Figure 12: CH_4 Flux

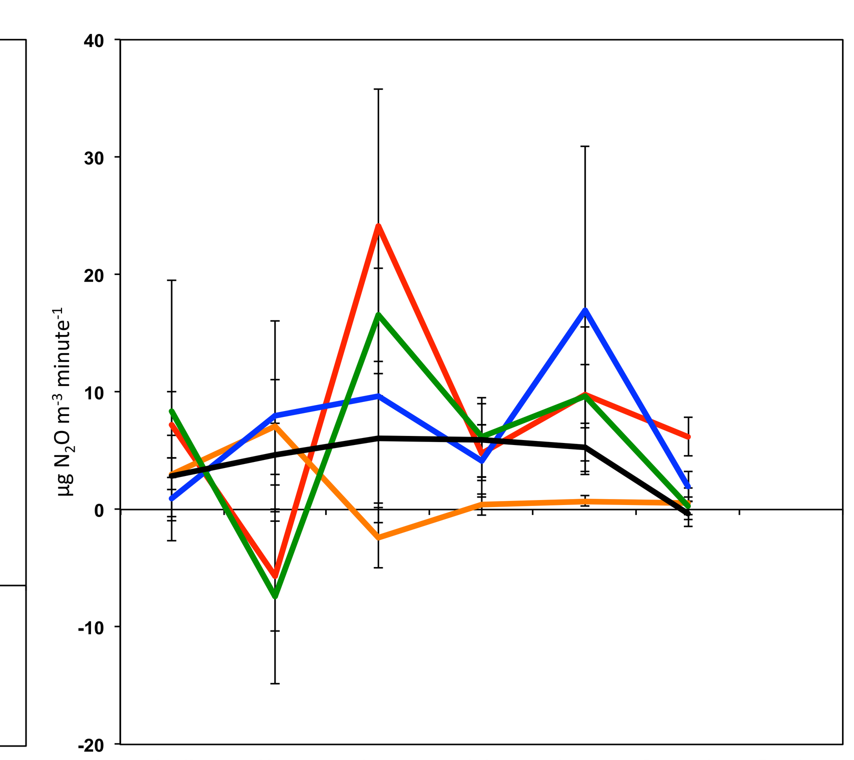

Figure 13: N_2O Flux

Methods

C and N fluxes were measured monthly throughout the 2013 growing season by:

- Vented static chambers for soil carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) fluxes
- Ion exchange membranes for available ammonium (NH_4^+) and nitrate (NO_3^-),
- Total and active microbial biomass by chloroform fumigation extraction and substrate induced respiration, respectively.

Results

- The 5-year-old stand had the least amount of canopy cover and had the warmest soil temperatures over most of the growing season (Fig. 5).
- Soil moisture was highly variable, and generally increased with canopy cover in the reforested plots (Fig. 6).
- The unmined reference plots had higher total microbial biomass C relative to the reforested plots throughout the study (Fig. 7).
- Active microbial biomass C was highest in unmined reference and lowest in the 5-year-old cohort for nearly every month (Fig. 8).
- Available NH_4^+-N and NO_3^--N were highly variable (Figs. 9 and 10).
- CO_2 and fluxes appear to follow trends in temperature (Fig. 11).
- Reforested plots had much smaller CH_4 fluxes than unmined plots (Fig. 12).
- No clear trends in N_2O fluxes were found (Fig. 13).

Future Directions

Analyze Structural Development

- Calculate aboveground biomass from recorded tree measurements
- Soil textural analysis by the particle-size analysis method
- DNA identification of microbes present (through collaboration)

Quantify Soil Nutrient Pool Development

- Total C, N, macro-, and micro-nutrients using soil samples collected at three subsamples of each of four depth increments (forest floor, 0-5 cm, 5-10 cm, and 10-25 cm) from each plot
- Use stable isotope techniques to separate geogenic and pedogenic sources of C and N

Evaluate Linkages Between Ecosystem Structure and Function

- Correlate tree, microbial, and soil structural development with measured ecosystem functions.

Acknowledgements

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Learn More:

The Powell River Project

Forest Soils and Biogeochemistry Lab

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