

Carbon Sequestration on Surface Mine Lands

Quarterly Report

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ABSTRACT

The April-June 2004 quarter was dedicated to the establishment of monitoring systems for all the new research areas. Hydrology and water quality monitoring continues to be conducted on all areas as does weather data pertinent to the research. Studies assessing specific questions pertaining to carbon flux has been established and the invasion of the vegetation by small mammals is being quantified. The approval of two experimental practices associated with this research by the United States Office of Surface Mining was a major accomplishment during this period of time. These experimental practices will eventually allow for tree planting on long steep slopes with loose grading systems and for the use of loose dumped spoil on mountain top removal areas with no grading in the final layer of rooting material for tree establishment.

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INTRODUCTION

EXECUTIVE SUMMARY

During the last quarter, preparation for planting, and the initiation of sampling and locating the necessary monitoring systems were the primary activities. This quarter the primary activities are associated with the actual monitoring and sampling of new and past year establishments. The locations of 2004 tree planting areas, acreage, species and numbers are summarized in tables 1-3 below.

Table 1. Peabody DOE Plantings Year 2004 Western Kentucky 38,760 seedlings 57 acres 21.5 ha		
Species	Total	Per Acre
Green Ash	6,213	109
Bald Cypress	1,539	27
Silky Dogwood	1,140	20
Black Locust	3,762	66
Bur Oak	1,140	20
Chestnut Oak	1,083	19
N Red Oak	6,612	116
Shumard Oak	3,306	58
White Oak	5,073	89
Pecan	1,083	19
Wild Plum	912	16
Pitch/Lob Pine	2,508	44
Redbud Yellow	1,083	19
Poplar	3,306	58

Table 2. Pittston DOE Plantings Year 2004 Eastern Kentucky 81,600 seedlings 120 acres 45.3 ha		
Species	Total	Per Acre
Green Ash	15,480	129
White Oak	17,880	149
N Red Oak	11,640	97
Sugar Maple	2,400	20
White Pine	7,680	64
Black Locust	8,520	71
Redbud Yellow	2,400	20
Poplar	6,240	52
Dogwood	2,400	20
Sycamore	6,960	58

Table 3. Bent Mountain DOE Plantings Year 2004 Pike County, Kentucky 17,000 seedlings 25 acres 9.4 ha		
Species	Total	Per Acre
Green Ash	3,000	120
White Oak	2,800	112
N Red Oak	4,000	160
Sugar Maple	1,000	40
White Pine	800	32
Black Locust	1,500	60
Red Bud Yellow	500	20
Poplar	1,500	60
Dogwood	500	20
Sycamore	1,400	56

A monitoring program to measure treatment effects on above ground and below ground carbon (C) and nitrogen (N) pools for the planting areas is currently underway. Sample plots that were established in 2003 are currently being assessed to determine change from previous year (biomass, carbon and nutrients). The plots were designed in a manner to both adequately sample each species planted and to account for differences with respect to site preparation activities and micro-topographic variability amongst planting units.

Additional plots were developed this spring/summer to be used to assess the 2004 plantings, and will be monitored in fashion similar to those plots established in 2003 (Graves et al., 2003). Soil and tissue analyses from samples collected in the field have been and/or are currently being processed in the laboratory. Results from these activities will be presented in the 2004 Annual Report.

The Department of Mining Engineering collected penetration resistance, penetration depth and bulk density from the reclamation test cells. These samples were collected on all sited and on both the old and new tree planting areas.

The Biosystems and Agricultural Engineering Department acquired the necessary monitoring equipment for additional site installations and inspected and thoroughly tested all the new equipment to ensure that it was functioning properly, prior to installing in the field. They completed a second inventory of all monitoring equipment, five additional monitoring sites were identified and equipment installed. Previously installed sites were re-examined and serviced and miscellaneous damaged equipment was replaced. Laboratory data analysis for all 2003 samples (turbidity, settleable solids and suspended sediment concentrations) and analyses were begun on 2004 samples.

EXPERIMENTAL

Mineland Reforestation Mycorrhizae Study

Detailed studies to address specific questions pertaining to carbon cycling have been initiated with the development of additional manipulative plots to examine the influence of mycorrhizae, spoil chemical and mineralogical properties, and use of amendments on forest establishment and carbon sequestration. A factorial experiment using inoculated vs. non-inoculated species in non-fertilized, fertilized only, amended (organic mulch) only, and fertilized + amended plots was established in 2004 and described in the 6th Quarter Report (Graves et al., 2004).

The research plots were established on mined sites in Knott and Muhlenberg Counties, KY. Fifty-four 15 x 15 meter plots were delineated on each site. Prior to planting, each site was ripped to a depth of approximately 2-meters using a dozer. Half of the area received an application of 40 tonnes per acre of a wood chip/manure compost mixture (Figures 1-3). The composted areas were subsequently ripped again to incorporate the material into the spoil. Two tree species; *Pinus taeda* (Loblolly Pine) and *Quercus rubra* (Northern Red Oak), were planted in the plots. Each plot received 100 seedlings spaced at 1.5 meter centers. Each treatment will be examined in triplicate for each species. At 100 trees per plot x 3 plots per treatment x 8 treatments x 2 species, 4,800 seedlings were planted per site. Additional plots with no trees planted were established as controls and to evaluate potential for carbon sequestration on sites planted with grass species. Half of the seedlings from each plot were tagged and measured (height, diameter and leaf area) during this reporting period. These trees will be evaluated each year for growth and survival statistics. Soil samples were also collected from the sites during this reporting

period and are currently being analyzed. Whole tree harvesting and tissue samples will be collected from non-tagged seedlings of each treatment in 2005.



Figure 1. Compost amended site, Knott Co. KY

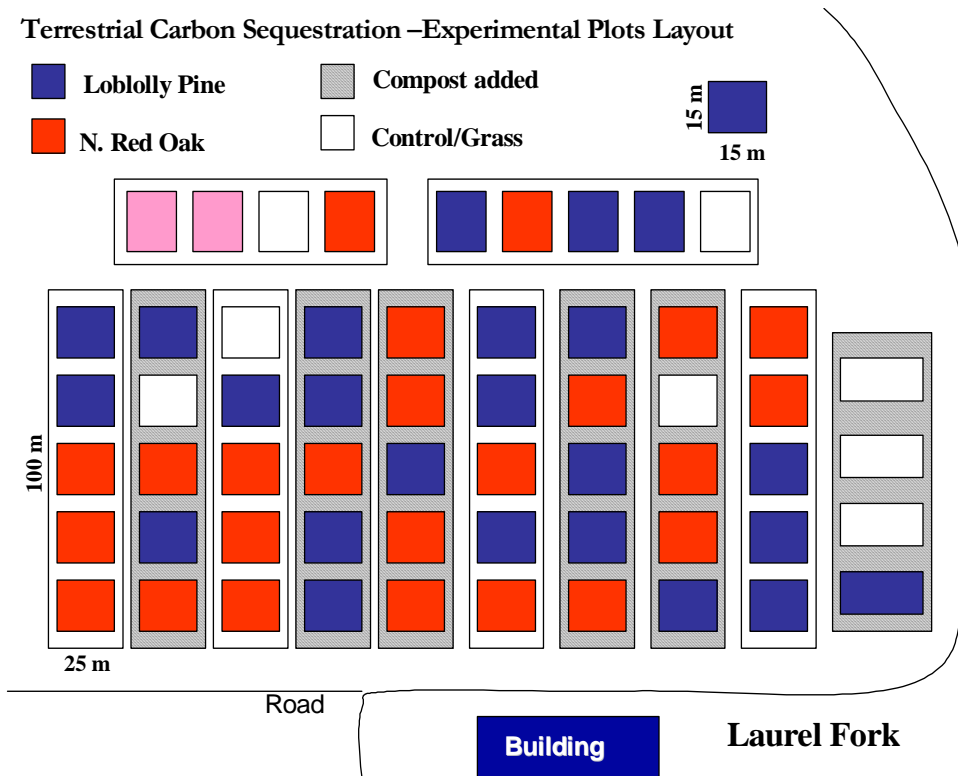


Figure 2. Actual plot layout on site in Knott Co. KY.

Terrestrial Carbon Sequestration –Experimental Plots Layout

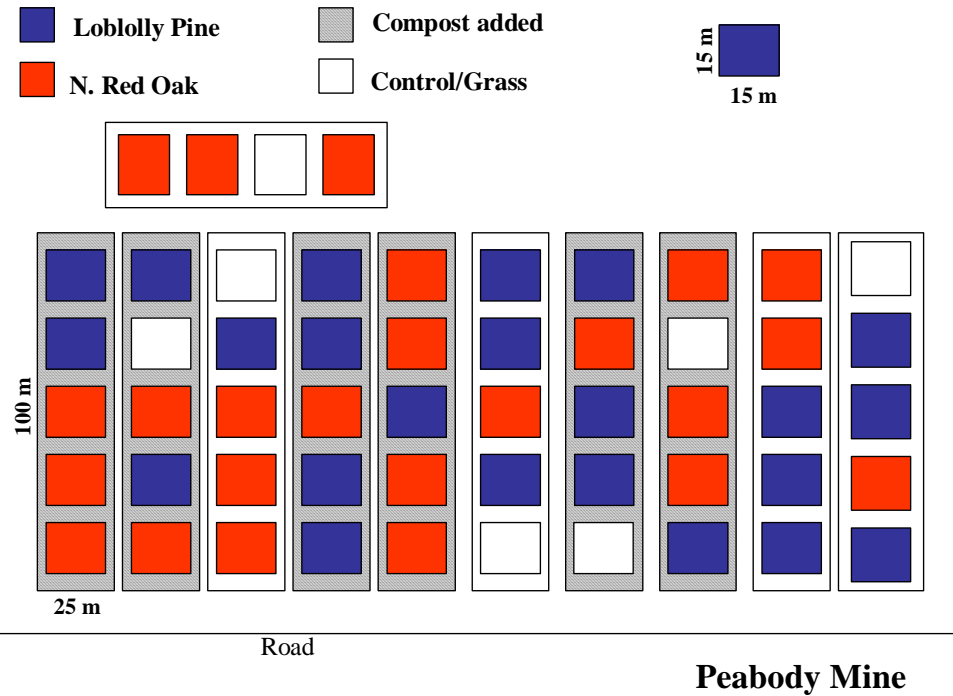


Figure 3. Actual plot layout on a site in Muhlenberg Co. KY.

Prior to planting, twenty-five seedlings of each species were collected for an assessment of growth characteristics and mycorrhizal inoculation index. Average height was 39.7 and 18.4 cm for the N. Red Oak and Loblolly Pine, respectively. The oak exhibited an average diameter of 5.1 mm, while the pine had an average diameter of 3.4 mm. The inoculation index for both species was low as exhibited in Table 1. The mycorrhizal plots will receive additional inoculation in the field to further enhance these numbers. Non-mycorrhizal plots will receive continued application of fungicide to suppress natural inoculation. Treatment effects were noticeable very soon after transplanting occurred (Figures 4 and 5), but an assessment of the extent of amendment influence is not quantifiable at this time.

Table 4. Mycorrhizal inoculation index of seedlings prior to planting.

Species	Inoculation Index (%) [†]		
	<i>Pt</i>	<i>Sc</i>	<i>Tt</i>
N. Red Oak	18	3	0
Loblolly Pine	26	9	1

[†]*Pt* = *Pisolithus tinctorius*; *Sc* = *Scleroderma cepa*; *Tt* = *Thelephora terrestris*



Figure 4. One-year old N. Red Oak on non- amended site, Muhlenberg Co. KY



Figure 5. One-year old N. Red Oak on compost amended site, Muhlenberg Co. KY

Decomposition and Soil CO₂Efflux

Efforts to examine decomposition and heterotrophic respiration on C cycling in the reforestation plots were enhanced during this reporting period. Litter bags (20 x 20 cm with 10 g of leaf material) were placed at random in selected plots within the reforestation area and on undisturbed forested sites. Each plot (6 total: 3 mined and 3 natural) received 24 bags which were stapled to the surface soil using steel rods. Three bags from each site will be collected every three months, weighed and analyzed for C and N concentrations. In addition, permeable columns were inserted into the soil at each site

(15 cm depth) in close proximity to the litter bags to evaluate carbon change over the same study period. The columns consisted of a homogenized spoil material with known C and N concentrations contained within a nylon bag. The spoil will be influenced by all climatic and biological activities subjected to original material located at the sites, and thus should be a good indicator of changes in soil carbon and nutrient levels. Columns will be removed at the same time and frequency as described for the litter bags. PVC collars have also been installed at these sites to evaluate soil CO₂ efflux using a LI-COR LI-8100 Automated Soil CO₂ Flux System. Carbon dioxide flux will be monitored monthly from the litter decomposition plots.

RESULTS AND DISCUSSIONS

Of particular importance for reporting is the approval of two experimental practices associated with this research by the United State Office of Surface Mining. They are the acceptance of reforestation on long steep slopes that have been lightly graded and the use of loose dumped spoil on mountain top removal areas with no grading of the final layer of rooting material for tree establishment. The present status of data analysis has been discussed in this and previous reports. Re-measurement of previously established tree seedlings and the initial measurement of the new plantings will yield new results and items for discussion as the year progresses. There will be new water quality and quantity data as well as spoil density measurements that will correlate to the growth responses that will be measured. As the regeneration continues to grow and develop additional areas will be included in the small mammal use of the areas.

CONCLUSIONS

There are no conclusions at this time. The project is scheduled to continue for this and one more growing seasons before terminating.