Carbon Sequestration and Mineland Reforestation

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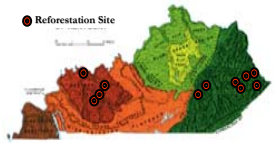
Introduction

Research to address mechanisms by which atmospheric concentrations of CO^2 may be reduced is of global significance. Enhanced sequestration of carbon in terrestrial systems is a proposed mechanism to offset CO^2 emissions. Reforestation of abandoned and previously reclaimed mine lands has been identified as one such method for increasing terrestrial C sequestration. Given that these areas are essentially devoid of C after mining, the planting of forests is expected to dramatically affect carbon processes via C accumulation in soils and in forest biomass. As such, a mine land reforestation project has been initiated in Kentucky.



Reforestation study areas in Kentucky, 2002-present

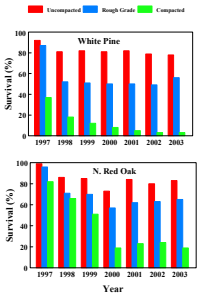
Objectives

To demonstrate the potential for terrestrial C sequestration on mined lands, a reforestation project has been initiated by the University of Kentucky at several locations within the State that differ with respect to site specific geology and reclamation practice. In this study, various methods are being employed to lessen both physical and chemical limitations on the site so that the establishment of forested species (hardwood and conifers) is possible. A research program to evaluate the effectiveness of these methods and to quantify carbon flux within this system has been initiated. Our specific objectives are:

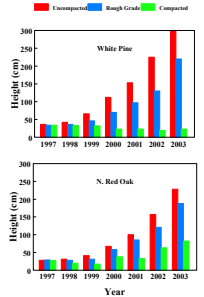
- *Development of concepts that combine capture and storage of CO^2 with concomitant reduction of criteria-pollutant emissions;*
- *Demonstrate and verify large scale carbon sequestration by reforestation of post-mining lands using high value trees species.*

Pilot Study

In order to evaluate the carbon sequestration potential of minelands, one must first establish whether or not the sites can support a forest after the mining activities are complete. Productivity varies greatly across minelands and reclamation activities can either facilitate or hinder their utility for forest growth or C sequestration. The Surface Mine Reclamation Act requires that mined lands be returned to their approximate origin contour. The extensive spoil compaction needed to recontour these sites, however, has severely hindered tree growth on mines. The physical impediments on compacted minesoils truncate the volume of soil available for root expansion and limit forest growth. The reduced volume of fine materials also directly alters both water and nutrient availability and may ultimately result in seedling mortality. A study to evaluate the role of compaction on seedling survival and growth was initiated by our group in 1997. Results have shown that compaction not only limits seedling growth and increases mortality, but potential off-site environmental impacts (decreased water infiltration, increased runoff, and export of C and sediment) may occur.



Seedling survival by treatment.



Seedling height by treatment.

Seedling plots on compacted site (control) after seven years of growth.

Seedling plots on uncompacted site (loose dump) after seven years of growth.

Methods

A research program to evaluate the effectiveness of reforestation and to quantify carbon flux within this system has been initiated. Metrics designated for the monitoring include: weather variables and site hydrology; vegetative biomass and growth parameters; plant tissue, litter and soil/spoil analysis (physical and chemical); decomposition; CO^2 efflux at the soil surface; and chemical analysis of water from bulk precipitation collectors, runoff and lysimeters. Initial planting of tree seedlings began in the winter of 2002/3. Over 400 ha (>1,000,000 seedlings) have been planted thus far with an additional 200 ha remaining for years two through five of the proposed project period. Monitoring of basic growth and survival metrics will proceed in accordance with the planting progress. More detailed studies to address specific questions pertaining to carbon flux are being initiated with the establishment of manipulative plots to examine climate effects, the influence of spoil depth, mycorrhizae, chemical and mineralogical properties, management practices, and use of amendments on forest establishment

Ripper

Application of spoil

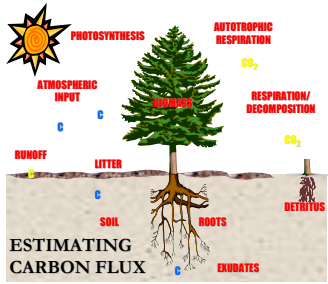
Ripping previously reclaimed site

Traditional (control)

Loose dumped

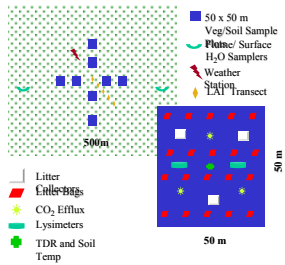
Ripped

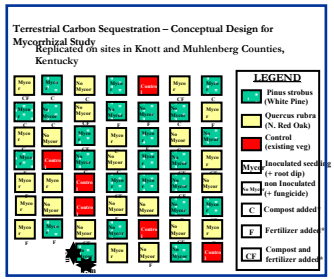
Excavated



Oak seedling

Compost amendment





Outlook

- In the Appalachian region, where the majority of the 2.4 million hectares disturbed by US coal mining resides, carbon sequestration complements traditional reclamation objectives.
- Globally, C accumulation rates on degraded lands have been estimated at 0.3 Mg C ha-1 yr-1 (Nabuurs et al. 1999; IPCC, 2000).
- Rates ranging from 0.2 to 2 Mg C ha-1 yr-1 are used to predict the affect of reclaiming mine land in Europe and the United States (Nabuurs et al. 1999;IPCC, 2000).
- Information gained from this study will help to define and quantify the potential for carbon sequestration on these degraded sites particularly as it pertains to the Appalachian region.
- However, time for plant growth and for the development of a litter layer are needed before an accurate assessment for terrestrial sequestration may be ascertained.