Recovery of Reclaimed Mine Sites in Southeastern Kentucky Based on Soil Organic Carbon and Carbon Isotopes

Belinda Leung, Department of Civil and Environmental Engineering, Syracuse University
Faculty Mentors: James F. Fox (University of Kentucky), Alice L. Jones (Eastern Kentucky University)
NSF-Research Experience for Undergraduates, Appalachian Headwaters Program 2010

Overview

Mountaintop coal mining in southeastern Kentucky alters soil carbon values as a result of geogenic organic carbon (GOC) compacted onsite during the process of reclamation. With nearly all carbon originating from GOC, soil organic carbon (SOC) slowly develops over time.

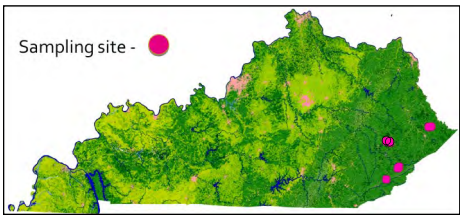
An undisturbed forest was used to compare reclaimed grasslands created from compaction, reclaimed forest created from strikeoff, and a site adhering to the recently developed Appalachian Regional Reforestation Initiative (ARRI) reclamation method (http://arri.osmre.gov/About/AboutARRI.shtm). Soil development was used as an indicator of recovery. By using the δ13C isotopic signatures of soil samples, the amount of carbon from SOC can be found and compared.

Sampling site at Bent Mountain—A 2-year old reclamation site employing the Appalachian Regional Reforestation Initiative (ARRI) method.

Methods and Sites of Interest

Samples were taken from sites throughout eastern Kentucky varying in age from 2 to 14 years since reclamation. Soil pits were dug and samples taken at five depth intervals to 50cm.

For litter and lower depth interval samples, an unmixing model was created to calculate the amount of SOC at multiple depths. SOC development over sampling sites was compared with SOC profiles and soil turnover rates using the slope values of δ13C vs. log(SOC) plots.



Results and Discussion

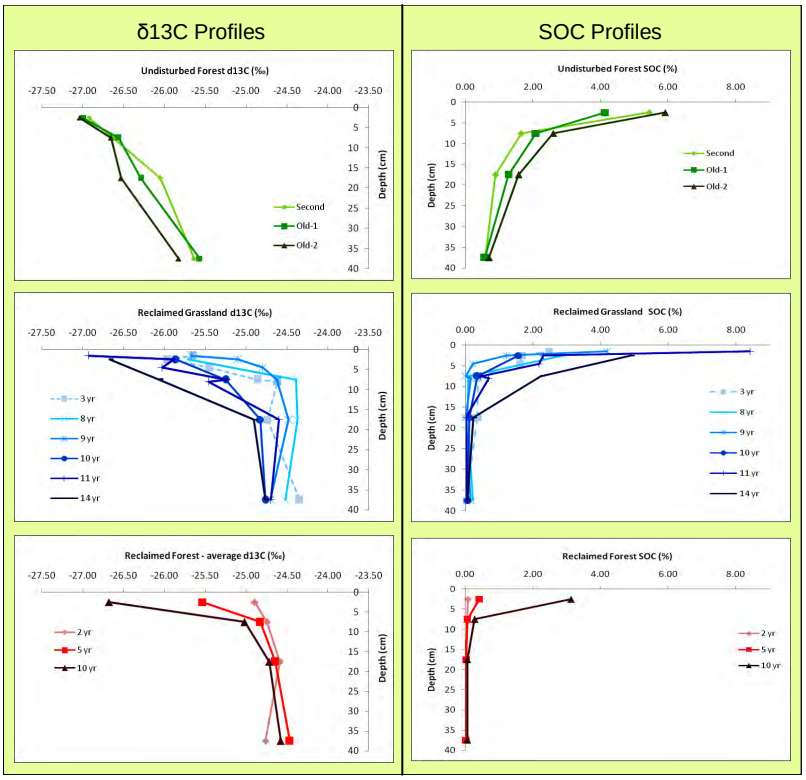
A lower average δ13C was found in undisturbed forest sites, with values ranging between -26.92‰ and -27.04‰. This is because of the more negative values of SOC versus GOC. In grassland reclaimed mining sites, δ13C values range from -25.71‰ to -26.93‰ over 11 years. In forest reclaimed mining sites, δ13C values were between -24.90‰ and -26.68 ‰ over 8 years. Undisturbed forests exhibited a well developed SOC profile down to 40cm. Reclaimed sites were only developed to 20cm after a maximum of 14 years, but SOC was found to be developing deeper with time.

The slopes of undisturbed forest curves are the most steep (-1.26 to -1.64), indicating higher microbial activity and higher soil turnover rates. Grassland reclaimed curve slopes ranged from -.758 to -1.001. Forest reclaimed curve slopes ranged from -.764 to -1.191. These data show forest reclaimed lands have a 2.5 times faster rate of slope steepening per year for δ13C vs. log (SOC) compared to grasslands, indicating higher rates of microbial activity and soil turnover.

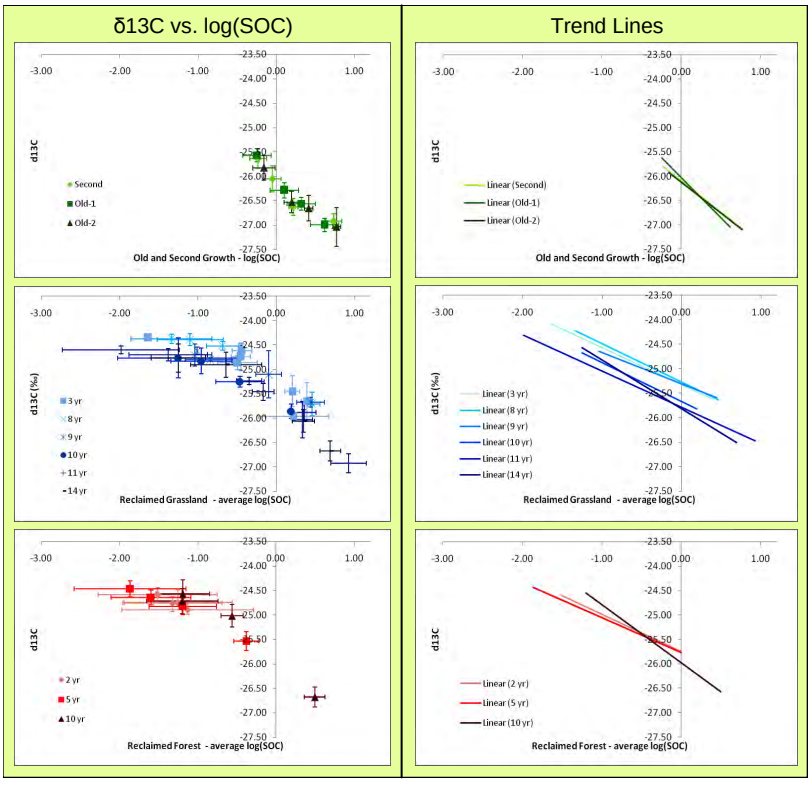
Appalachian Headwaters Research Program

Eastern Kentucky Environmental Research Institute
Eastern Kentucky University
521 Lancaster Avenue • Moore B-18
Richmond, Kentucky 40475
(859) 622-6914 • www.eri.eku.edu

August 2010
RS10.023



δ13C profiles are compared to SOC profiles. The darker the curve, the longer the reclamation period.



δ13C vs. log(SOC) and Trend Lines. The darker the curve, the longer the reclamation period.

Findings

It is found that δ13C in the soil decreases with depth and time in reclaimed sites, while δ13C in undisturbed sites exhibit constant, higher values. Undisturbed sites also exhibit a well developed SOC profile. Reclaimed sites reflect developing SOC levels that will increase over time, but levels are not parallel the constant, higher values of undisturbed soil.

When considering slope and soil turnover rates, reclaimed sites do show gradual improvement in SOC development. This turnover is even faster in ARRI sites, resulting in more efficient recovery rates. However, undisturbed forests again exhibit more ideal soil profiles. These forests exhibited the most steep slope, indicating higher microbial activity and higher soil turnover rates.

Overall, the undisturbed forest sites presented more desirable conditions than their reclaimed and ARRI counterparts.

Further Studies

Continued sampling over time, as well as collecting more samples from each site would help establish long term trends. Collection of coal samples at each reclaimed mine site for end member use would also be helpful. It is suggested that δ13C enrichment values be used in the SOC profile instead of constant end member values.

BELINDA LEUNG is a senior environmental engineering undergraduate at Syracuse University who plans to continue environmental studies in graduate school.

JAMES F. FOX is an assistant professor of water resources in the Department of Civil Engineering at the University of Kentucky and co-director of the Appalachian Headwaters Summer Research Program.

ALICE JONES is a professor of environmental planning in the Department of Geography & Geology at Eastern Kentucky University and co-director of the Appalachian Headwaters Summer Research Program.

The study was conducted as part of NSF Research Experience for Undergraduates and Research Experience for Teachers program: *Coal Mining's Impacts on Soil Carbon Storage and Erosion in Appalachian Headwater Stream Health* — a ten-week summer research program co-hosted by Eastern Kentucky University and the University of Kentucky.

Funded by the National Science Foundation, Division of Earth Sciences, Award No EAR-0754888, with co-funding from the NSF Experimental Program in Competitive Research (EPSCoR), and the Innovations in Environmental Education (EdEn) venture fund.