Carbon Flux in First-Order Headwater Streams in Coalmine Watersheds: A Preliminary Study

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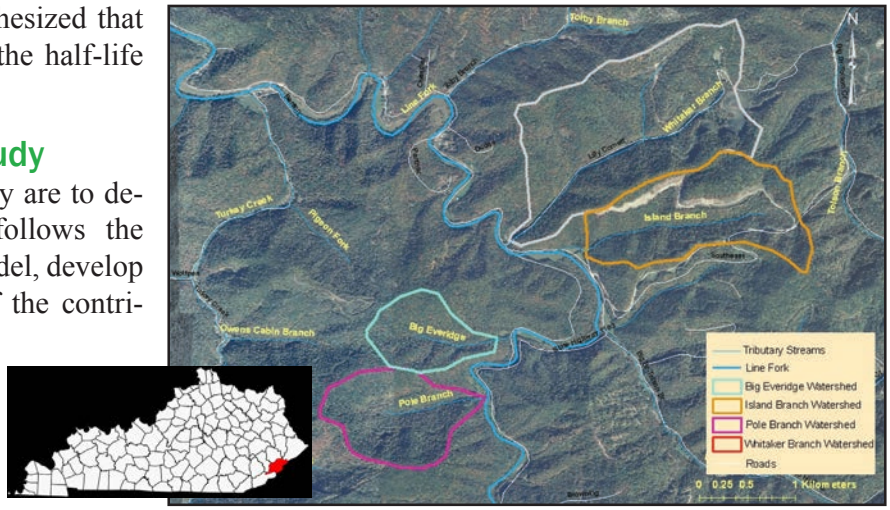
Abstract

A four-month long study was performed on first-order headwater streams in southeastern Kentucky to estimate the carbon flux leaving the first-order watersheds. Carbon flux was calculated using carbon-13 (δ13C) isotopes to determine the contributions of geogenic organic carbon (GOC), or "crushed coal", compared to soil organic carbon (SOC). Contributions of bank vs. surface erosion in mine sites were established using stable nitrogen-15 (δ15N) isotopes. Using a standard half-life model for sediment flux, it is hypothesized that carbon flux also follows the half-life model.

Primary Goals of Study

The goals of this study are to determine if carbon-flux follows the sediment flux half-life model, develop a better understanding of the contributions of GOC versus SOC in reclaimed mine sites of varying ages, and estimate daily sediment and carbon flux levels for each watershed.



General Site Information

Southeastern Kentucky sits on the Cumberland Plateau, which can be characterized as a hilly to mountainous region. Including its dense forest and sparse population, coal is the most important economic resource.

Specific Site Information

Sites were selected to represent the many levels of land affected by mining.

- Big Everidge (Control): Undisturbed mixed-mesophytic forest
- Whitaker Branch: Mined between 1998-2003, includes surface area and underground mining reclaimed in the last 5 years
- Pole Branch: Pre-Surface Mining and Reclamation Control Act (SMCRA) site, mined between 1975-1994, includes surface (auger) and underground mining, reclaimed more than 10 years ago
- Island Branch: Reclaimed in 2007 (mined from 1998), includes surface (auger) and underground mining.

Methodology

An ISCO sampler was used to collect water samples and determine how much sediment is contained in a known volume of water in mg/l. To take a time-integrated sample of sediments, a sand trap was placed near the mouth of the stream. An isotope ration mass spectrometer (IRMS) was used to analyze δ13C (%), δ15N (%), and total organic carbon (TOC), where (%) was per mil. Sediment and carbon flux can be calculated using precipitation data. Maximum retention of precipitation can be expressed as:

$$S = (1000/CN)-10 \quad (1)$$

Where CN (value from 1-100) is the curve number which is determined by land use. The value for S can then be used to calculate runoff for a given event and can be expressed as:

$$P_e = (P-.25)^2/P+.85 \quad (2)$$

Where P_e is runoff and P is the precipitation during the event. Flow (Q) can be calculated using runoff (P_e). Knowing the concentrations (C) of sediments in water (mg/l) during the event, the sediment can be calculated:

$$Q_e = C*Q \quad (3)$$

Where Q_e is sediment flux for a given time period; usually expressed as mg/s or kg/day.

Appalachian Headwaters Research Program
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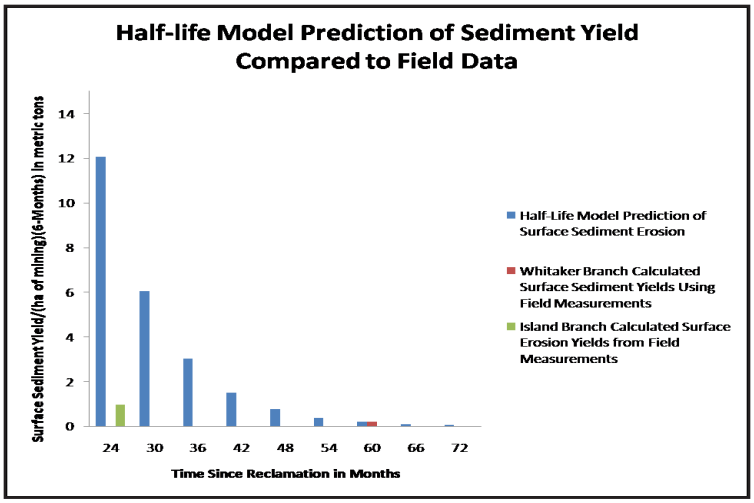

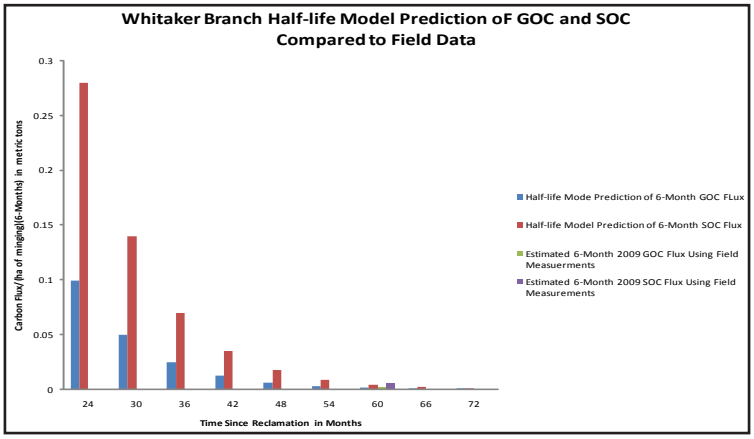

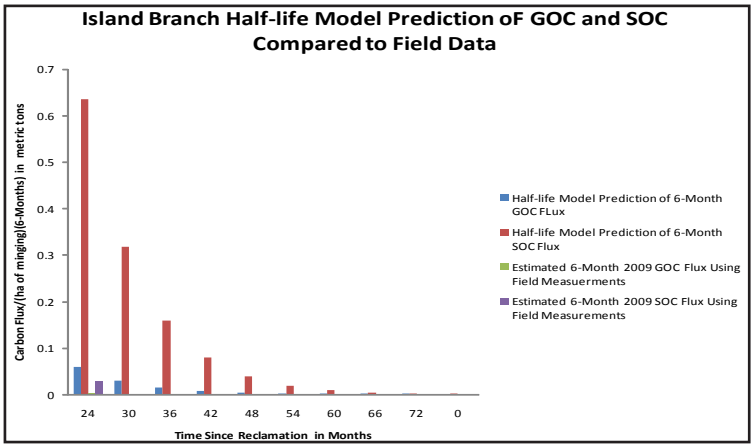

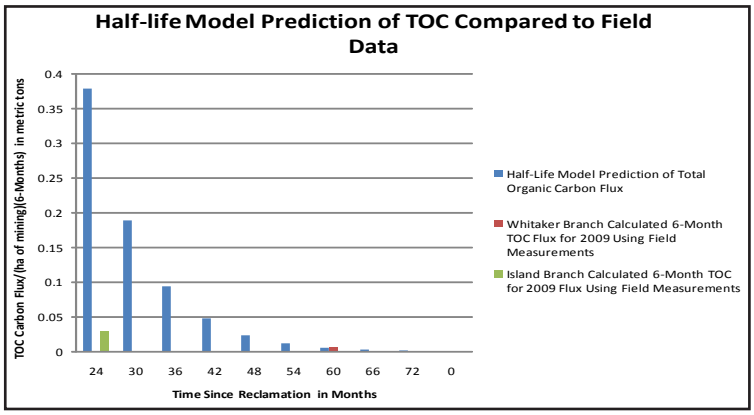

Carbon flux is calculated by the results of the IRMS for TOC. To find contributions of GOC compared to SOC for carbon flux, an un-mixing model is used where two equations are necessary:

$$M_{mix}c_{mix} = X_A c_A + X_B + c_B \quad (4)$$
$$(2)\ X_A + X_B = 1 \quad (5)$$

Where M_{mix} is the total mass of the mixed sediment sample, c_{mix} is the tracer concentration of the mixed sample, $X_{A,B}$ are the mass fraction of sediment sources of A and B, and $c_{A,B}$ are the tracer concentration of sources A and B. Equation (4) can be solved by using equation (5).

Conclusions

The half-life model proposed by Curtis (1978) was found to be a good predictor of surface-sediment yield. However, the half-life model was not accurate in predicting GOC and SOC flux in mined watersheds. This may be because of the change over time of GOC and SOC contribution to TOC. For Island Branch, the reduction in the calculated sediment yield may be explained by the large berm in the watershed, blocking the flow of sediment into the mined areas.

Reference

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