Sources of suspended sediment in an agricultural watershed in Atlantic Canada

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Sediments

- Erosion generates sediments in hydrological systems
- Human activities are resulting in changes in sediment fluxes which leads to:
 - Water quality issues
 - Source of contaminates and nutrients (eutrophication)
 - Degradation of aquatic environments (reduced light penetration, oxygen for spawning)
 - Degradation of terrestrial environments (erosion)

Sediments

Sources of sediments vary in type and quantity

- Surface runoff erosion
- Bank erosion
- Different land uses
- Sediments transported by streams frequently embody a mixture of sediment derived from different source areas



Questions to be answered

- Where are the sediments coming from
 - Is the majority of suspended sediment coming from bank or surface erosion?
 - If suspended sediment is coming from surface erosion can we distinguish between land use types to determine the contribution from each?









Sediment fingerprinting

It is based on the assumption that one or more properties of suspended sediment will reflect its origins and can be used as a tracer to track the sediment back to its source.



Study site

Black Brook Watershed (BBW)

- Northwest New Brunswick, Canada
- Potato production systems





65% agricultural



21% forest



14% residential or wetland area

Longitudinal Watershed



Longitudinal Watershed



Source Samples: Field

 Soil transects extend from the top of the stream bank, through the riparian zone and into the field

(3-7 samples/transect)

 Down-slope, mid-slope and upslope





Source Samples: Stream Bank



- Sampled actively eroding stream banks
- 3 profiles from each location
- 10 cm increments

Suspended Sediment

 Modified version of the Phillips designed in-situ time-integrated suspended sediment sampler



suspended sediment sampler

 Collected seasonally, from 2008-2014



Measurements/tracers

Distinct diagnostic signatures used to determine the proportion of each source contributing to suspended sediment (assortment of mixed signature sources)

- Tracers may include: Selection of tracers based
 - *Colour properties
 - *Radionuclide
 - Geochemical
 - Particle Size
 - Stable Isotopes
 - Organic constituents
 - Mineralogy and Magnetism

- on the following criteria:
 - 1. Conservative behaviour
 - 2. Ability to distinguish between sources
 - 3. Linearly additive behaviour

Tracer 1: Spectral-Reflectance/Color

- Spectral differences due to heterogeneous combination of:
 - Minerals
 - Water
 - Organic matter
- Quantified using diffuse reflectance spectrometry
 - 350-2500 nm wavelength spectroradiometer ASD FieldSpecPro
- Reflected light collected with a fiber optic cable





Tracer 2: Radionuclide Cs-137

- Man-made radionuclide
- Nuclear weapon testing
- Distributed back to Earth by precipitation
- Found only of surface soils
- Tracer used to distinguish between surface and subsurface soil



Un-mixing Model: MixSIAR

- Originally developed for ecological studies
 - Used to estimate the relative contribution of potential sediment sources at each sediment sampling site
- Bayesian isotopic mixing model
 - Uses the variance instead of means and standard deviations
- Monte Carlo methods
 - Producing simulations of possible values of sediment source proportions
- Statistical procedures
 - Canonical Discriminant Analysis
 - ANOVA
 - MixSIAR BIPLOT Analysis in R
- Kruskall-Wallis H-Test
 - Discriminate Function Analysis







Weir 4: > 60% Forested



D



Weir 8: > 90% Cultivated



Weir 3: ≈ 50% Cultivated



Weir 2: ≈ 60% Cultivated



Weir 1: ≈ 65% Cultivated



Summary

- Both bank erosion and field erosion can contribute significantly into the sediments in streams in BBW
- There are high spatial variations, depending on land use and topography
- There are strong local influences and may be some temporal dynamics adding onto the spatial variation
- Color and Cs-137 can be used as tracers to detect major sources.

Adding other tracers may help to explain the







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