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NATURAL ENVIRONMENT RESEARCH COUNCIL

Forests, rain and runoff: particulate organic carbon in the Pacific North-West and its impact on the Earth's thermostat

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AGU Biogeosciences Student Presenter

1. Introduction

Export and burial of carbon recently fixed from the atmosphere by plants and soils (as opposed to fossil carbon eroded from bedrock) transfers carbon dioxide from the atmosphere into geological storage. Recent studies[1,2] suggest that storm-driven erosion of terrestrial biomass can effectively sequester carbon in tectonically and climatically extreme regimes. However, while the contribution of more typical continental terrain remains poorly constrained, it is difficult to evaluate the global importance of biomass erosion. Moreover, there is insufficient understanding of the processes which mobilise particulate organic carbon (POC), its sources and initial pathways and their variation under different hydrologic conditions. We address these issues in the temperate montane forests of Oregon's Coast and Cascade Ranges, and compare the results to a similar catchment in the Swiss Prealps.

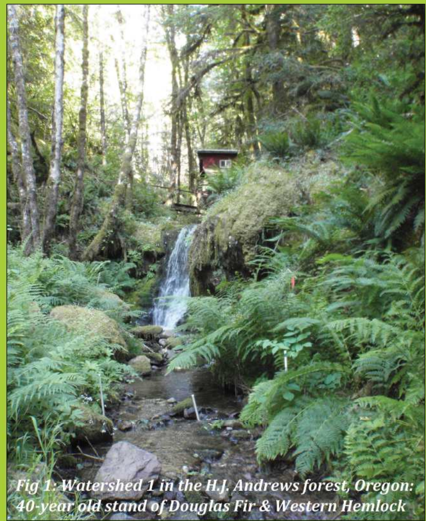


Fig 1: Watershed 1 in the H.J. Andrews forest, Oregon: 40-year old stand of Douglas Fir & Western Hemlock

2. Sites & methods

Study sites: We obtained suspended sediment samples from four Oregon watersheds: H.J. Andrews Forest and Hinkle in the Cascades; Alsea and Trask in the Coast Range. H.J. Andrews is underlain by entirely volcanic substrate; Alsea sits on marine sediments on the accretionary prism; and Hinkle and Trask are largely volcanic with intercalated sediments.

Sampling took place between 2004 and 2009. Collection was by turbidity threshold sampling except for those from H.J. Andrews, which are discharge-proportional compound samples collected every three weeks.

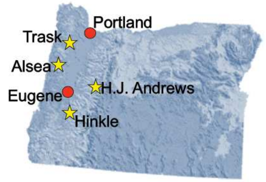


Fig. 2: Location of watersheds within Oregon

Preparation: Samples were carefully removed from the filters and homogenized using a pestle and mortar. They were then heated (≤80°C) with 1M hydrochloric acid to remove inorganic carbonate, and rinsed.

Analysis: N_2 and CO_2 abundances and $^{13}C/^{12}C$ ratios were obtained using a flash Elemental Analyser coupled to a continuous flow Nier-type mass spectrometer via a gas bench for gas separation. Analytical error bars are smaller than the point size in the following graphs.

3. Streams carry high % organic carbon, sourced directly from standing biomass

- POC concentration in the Oregon catchments (mean = 9.5%, σ= 7.1, n=198) is much higher than in the Swiss one (mean = 1.5%, σ = 0.3, n=120) (fig. 3).

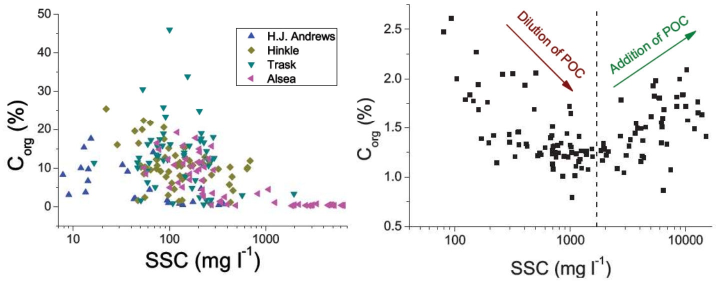
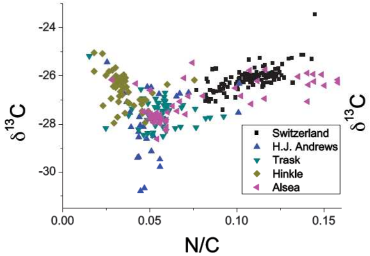


Fig 3: Organic carbon concentration in suspended sediment from Oregon (left) and Switzerland (right), plotted against suspended sediment concentration



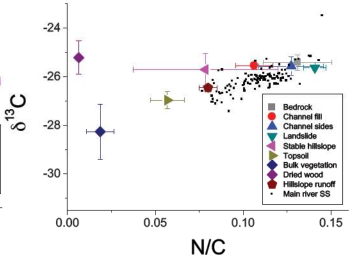


Fig 4 (left): Chemical composition of suspended POC in Oregon and Switzerland

Fig 5 (right): Chemical composition of POC in the suspended load and carbon stores across the Swiss catchment. SS = suspended sediment. Error bars are twice the standard error on the mean.

- Oregon suspended POC shows much wider compositional spread (fig. 4) than Swiss POC, covering almost exactly the spread seen across all POC stores in the Swiss catchment (fig. 5).
- In Oregon, only Alsea samples show the influence of fossil carbon; the others consist only of standing biomass. Many Oregon samples have a pure non-fossil (vegetation?) signal (low N/C).
- In Switzerland, fossil carbon strongly influences suspended POC chemical composition, and soil may play a role in homogenising the input from standing biomass. In Oregon, vegetation and soil pools with different chemical signatures appear to be sourced directly by the stream.

Fig 6: the Erlenbach catchment in the Swiss Prealps

Why do these differences exist?

1) Oregon is tectonically and geomorphologically more stable than Switzerland, where creep landslides on the stream banks are constantly active (fig. 6). Hence, there is less clastic sediment to dilute the POC input.
2) Discharge in the Swiss catchment is much more variable than in the Oregon watersheds (σ is an order of magnitude greater), with the result that the channel is usually much wider than the stream flowing in it.
3) 1) and 2) combined allow vegetation to grow right up to and overhang the stream edges in Oregon, but not in Switzerland (figs. 1 & 6).

4. Outstanding questions

- Sampling at H.J. Andrews has so far been limited to discharges of Q <75 l s^{-1}. Such rates accounted for only about a third of the total volume of water discharged over the past 10 years. It is therefore important to find out how POC concentration and composition behaves at higher Q.
- If, as in Switzerland, POC concentration increases again at higher Q (fig. 3), then ~6 t km^{-2} yr^{-1} could be exported from Oregon headwaters. The rate of POC export from the Swiss catchment is ~21 t km^{-2} yr^{-1}, of which about half is non-fossil (and hence part of the potential carbon sink)
- If POC concentration stays low (for example, if material already sampled includes input from surface runoff as well as in-channel clearing, and there are no further sources to be activated), export rate would be ~0.8 t km^{-2} yr^{-1}.
- Reality may be in between: POC export from the Alsea in water year 2008 (including several flood events) was 2.7 t km^{-2} yr^{-1}[3]
- Further fieldwork at H.J. Andrews is planned for this winter to collect suspended sediment at higher Q. With this additional material, we hope to assess the global significance of riverine POC export from the Pacific North-West and investigate potential climate feedbacks in the system.

[1]Hilton, R.G., A. Galy, N. Hovius, M-C. Chen, M. J. Horng & H. Chen (2008). Tropical cyclone-driven erosion of the terrestrial biosphere from mountains. *Nature Geoscience* **1** 759-762

[2]Hilton, R.G., P. Meunier, N. Hovius, P.J. Bellingham & A. Galy (2011). Landslide impact on organic carbon cycling in a temperate montane forest. *Earth Surface Processes and Landforms* **36**(12) 1670-1679

[3]Hatten, J.A., M.A. Goñi & R.A. Wheatcroft (2010). Chemical characteristics of particulate organic matter from a small mountainous river in the Oregon Coast Range, USA. *Biogeochemistry*, DOI:10.1007/s10533-010-9529-z

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