Carbon quality, characteristics and decomposition in peatland soils and streams

Supervisors: Sheila Palmer, Lee Brown & Joseph Holden

Project overview

Peatlands cover more than 400Mha of the globe (Holden, 2005), and some estimates place their combined carbon mass in the range of 390-455Pg (Pg = 1015g), representing somewhere between one-third to one-half of the global total soil carbon stock (Freeman *et al*., 2001b; Holden, 2005). Peat soils currently act as a net sink in many areas but evidence is emerging that the sink function may vary considerably between successive years depending on patterns of rainfall (Billett *et al.*, 2004). Consequently, many peatlands may become net sources within the next ten to twenty years due to changes in climate (Worrall *et al*., 2005). Additionally, there is growing concern that peatland management practices such as vegetation burning may be contributing to rises in C export from peatlands (Holden *et al.*, 2007).


Hyporheic wells in a small peatland stream

Peat-derived dissolved organic carbon (DOC) is the main form of carbon exported in upland catchments (Hope *et al*., 1997; Palmer *et al.*, 2001). Carbon in both its dissolved and particulate organic forms is a major energy source within stream ecosystems and contributes significantly to stream ecosystem metabolism (Jones and Mulholland, 2000; Dawson *et al*., 2001; Sobczak & Findlay, 2002). Processes controlling dissolved organic carbon concentrations in upland streams are of concern to water companies due to the potential for the generation of unwanted by-products in water treatment systems (Worrall *et al.*, 2004). Despite the importance of carbon in UK upland river systems, DOC and POC metabolism and transformation in peatland river systems remains poorly understood. Yet studies in the UK and elsewhere have shown that peat-derived DOC does contain a biodegradable component (Fellman et al., 2008), that significant DOC removal can occur in upland streams (Dawson et al., 2001), and that DOC characteristics vary seasonally (Sharp *et al.*, 2006). One area in particular that has received little attention with reference to understanding the mechanisms affecting carbon export from peatlands is the hyporheic zone (sedimentary interface between stream water and ground water; Brunke and Gonser, 1997). Some authors suggest removal of up to 50% DOC as water moves through the hyporheic zone of forested streams in the USA (Sobczak & Findlay, 2002) but it remains unclear whether this magnitude of removal occurs in UK moorland streams.

Project Goals

This PhD will address these research gaps through detailed studies of carbon quality, characteristics and decomposition in peatland systems across the north of England. Studies will focus on: (1) the solubility and biodegradability of C in soils; (2) processes by which C is

transformed in peat soils and streams; (3) C dynamics in streams and the hyporheic zone, including an assessment of the role of stream physical and chemical properties in C cycling; and (4) the influence of moorland burning on the above. A combined approach of descriptive and experimental approaches will be utilised throughout the study. The project will run alongside a NERC funded project (EMBER) which is examining the effects of moorland burning on soil physical, hydrological and chemical properties, stream hydrology and sediment transport, and aquatic ecosystems. The successful candidate will have the opportunity to work closely with the EMBER project team in fully instrumented research catchments.

Benefits

The successful candidate will benefit from inter-disciplinary training in hydrology, biogeochemistry and stream ecology as part of the River Basin Processes and Management research cluster in the School of Geography, recently rated in the top six research departments in the 'Geography and Environmental Studies' category (RAE 2008). Training at Leeds deals fully with the elements described in the Joint Research Centre statement on skills training for research students. PhD students take modules provided by the staff development unit (e.g. starting your PhD, small group teaching) and a 15-week faculty-training course (covering elements such as planning, critical reading and writing, oral presentations, writing research papers). Students present results and receive constructive feedback from peers in a Research Support Group, from colleagues in the River Basins research group, and at a university postgraduate research day.

The nature of the project means that the student will be trained in project specific research methods including soil and water chemical analysis, and soil and stream hydrology. There will be opportunities to develop applied statistical for skills, both internally and at external workshops. An additional important part of the training will be to attend national and international conferences (e.g. EGU, AGU) to present results and gain feedback. The student will be encouraged to submit papers for publication during the project.

Applications

The prospective student should have (or expect to receive) a minimum of a first class or high 2i BSc degree in an appropriate discipline, and have interests and experience in most, if not all, of the following topics: soils, environmental management, hydrology and the UK uplands. Successful applicants will be considered for full-time funding for 3.5 years duration from a range of sources including NERC, departmental and university sources. Self funded students are also welcome to apply for the project. Informal enquiries should be directed to Sheila Palmer at s.m.palmer@leeds.ac.uk. Further details about postgraduate research degrees at the School of Geography, University of Leeds can be found here.

References

Billett, M.F., Palmer, S.M., Hope, D., Deacon, C., Storeton-West, R., Hargreaves, K.J., Flechard, C. & Fowler, D. (2004) Linking land-atmosphere-stream carbon fluxes in a lowland peatland system. Global Biogeochemical Cycles 18, GB1024, doi: 10.1029/2003GB002058

Brunke M. and Gonser T. 1997. The ecological significance of exchange processes between rivers and groundwater. Freshwater Biology **37 (1)**: 1-33

Dawson, J.J.C., Bakewell, C. & Billett, M.F. (2001) Is in-stream processing an important control on spatial changes in carbon fluxes in headwater catchments? Science of the Total Environment 265(1-3): 153-167

Fellman, J.B., D'Amore, D.V., Hood, E. & Boone, R. D. (2008) Fluorescence characteristics and biodegradability of dissolved organic matter in forest and wetland soils from coastal temperate watersheds in south-east Alaska. Biogeochemistry 88: 169-184

Holden, J., Shotbolt, L., Bonn, A., Burt, T.P., Chapman, P.J., Dougill, A.J., Fraser, E.D.G., Hubacek, K., Irvine, B., Kirby, M.J., Reed, M.S., Prell, C., Stagl, S., Stringer, L.C., Turner, A., Worrall, F. (2007) Enviornmental change in moorland landscapes. Earth Science Reviews 82: 75-100

Hope, D., Billett, M.F., Milne, R. & Brown, T.A.W. (1997) Exports of carbon in British rivers. Hydrological Processes 11: 325-344

Jones JB. and Mulholland PJ. 2000. Streams and Groundwaters. Academic Press, San Diego, California, USA

Palmer, S.M., Hope, D. , Billett, M.F., Dawson, J.J.C. & Bryant, C.L.. (2001) Sources of organic and inorganic carbon in a headwater stream: Evidence from carbon isotope studies. Biogeochemistry 52: 321-338

Sharp, E.L., Parsons, S.A. & Jefferson, B. (2006) The impact of seasonal variations in DOC arising from a moorland peat catchment on coagulation with iron and aluminium salts. Environmental Pollution 140(3): 436-443

Sobczak, W.V. & Findlay, S. (2002) Variation in bioavailability of dissolved organic carbon among stream hyporheic flowpaths. Ecology 83: 3194-3209

Worrall, F. & Burt, T. (2005) Predicting the future DOC flux from upland peat catchments. Journal of Hydrologt 300: 126-139

Worrall, F., Harriman, R., Evans, C.D., Watts C.D., Adamson, J., Neal, C. Tipping, E., Burt, T., Grieve, I., Monteith, D.,Naden, P.S., Nisbet, T., Reynolds, B. & Stevens, P. (2004) Trends in dissolved organic carbon in UK rivers and lakes. Biogeochemistry 70: 369-402