Institution: The Open University

Unit of Assessment: B7 Earth Systems and Environment Sciences

Title of case study: Carbon and Methane exchanges in wetlands

1. Summary of the impact

Vincent Gauci and The Open University (OU) Ecosystems Research Group have demonstrated human influences over exchanges of carbon within vulnerable, temperate and tropical wetland ecosystems, which are the largest source of the powerful greenhouse gas methane to the atmosphere. The group's work showing that acid rain pollution suppresses methane emissions from wetlands has influenced policy in the UK, particularly peatland restoration, where the group has had direct interaction with users. The group's work on carbon balance resulting from deforestation, drainage and fires in the carbon-rich Bornean peat swamp has also informed IPCC methodologies for carbon balance calculations in its 2013 Wetlands Supplement.

2. Underpinning research

Wetlands, and peatlands in particular, are among the largest surface reservoirs of carbon and the single largest source of methane to the atmosphere. Research by Dr Gauci and the Ecosystems Research Group has focused on human influences over the stability of carbon within temperate and tropical peatlands that have been subject to human interference (principally through drainage) and on the influence of human activity such as pollution, climate warming and CO_2 enrichment on wetland methane emissions. The group has been influential in identifying that the deposition of pollution-derived sulfate in acid rain dramatically reduces emission of the powerful greenhouse gas methane (Gauci et al*.,* 2002) and that this 'sulfate suppression' of methane emissions may have been sufficient to offset climate-driven growth in the global wetland methane emission source into the middle of this century (Gauci et al., 2004). Critically, and given the reduction of sulfur pollution in industrialised nations, the group has identified the long-lived duration of the sulfate-suppression effect, i.e. that recovery from methane suppression by sulfate deposition may take several decades (Gauci et al., 2005). This is supported by research into the responses of wetland methane emissions to individual high sulfur emission events in history, such as the Icelandic Laki eruption of 1783–84 (Gauci et al., 2008).

The work of Gauci and the Ecosystems Group has also extended to understanding other forms of carbon exchange within wetland ecosystems. Their recent work has focused on variations in carbon losses of peatlands into rivers, caused by deforestation, drainage and fires in Bornean peat swamps. These deposits are a particularly large reserve of carbon, and the Open University research demonstrated that these ecosystems are undergoing instability and collapse as a consequence of deforestation and land use change (Moore et al., 2013). This was the first such study to report fluvial carbon losses from forested as well as deforested catchments, and was the first to identify the age of the carbon that was lost. The group found that the carbon lost from forested ecosystems is modern and as such is tightly coupled to current net primary productivity. In contrast, the carbon lost from deforested and drained peats was often thousands of years old, in other words derived from the deep and ancient peat reserves. Notably, the oldest carbon lost originated in peatlands that had been converted to oil palm agriculture. The work was led by Gauci, who was senior and corresponding author on the paper.

3. References to the research

Gauci, V., Matthews, E., Dise, N., Walter, B., Koch, D., Granberg, G. and Vile, M. (2004) 'Sulfate suppression of the wetland methane source in the 20th and 21st centuries', *Proceedings of the National Academy of Sciences of the USA*, vol. 101, no. 34, pp. 12583–7.

Gauci, V., Dise, N. and Blake, S. (2005). Long-term suppression of wetland methane flux following

a pulse of simulated acid rain', *Geophysical Research Letters*, vol. 32(L12804).

Gauci, V., Blake, S., Stevenson, D.S. and Highwood, E.J. (2008) 'Halving of the northern wetland CH_4 source by a large Icelandic volcanic eruption', *Journal of Geophysical Research: Biogeosciences*, vol. 113, G00A11.

Moore, S., Gauci, V., Evans, C.D. and Page, S.E. (2011) 'Fluvial organic carbon losses from a Bornean blackwater river', *Biogeosciences*, vol. 8, pp. 901–9.

Boardman, C.P., Gauci, V., Watson, J.S., Blake, S. and Beerling, D.J. (2011) 'Contrasting wetland CH_4 emission responses to simulated glacial atmospheric CO_2 in temperate bogs and fens', *New Phytologist*, vol. 192, no. 4, pp. 898–911.

Moore, S., Evans, C.D., Page, SE., Garnett, M.H., Jones, T.G., Freeman, C., Hooijer, A., Wiltshire, A.J., Limin, S.H. and Gauci, V. (2013) 'Deep instability of deforested tropical peatlands revealed by fluvial organic carbon fluxes', *Nature*, vol. 493, pp. 660–3.

Relevant grants:

2012–15	£597,425 awarded by NERC to Gauci for a project entitled 'The contribution of trees to tropical wetland methane emissions' (total ~£750k to all partners – Universities of Bristol, Leicester and Nottingham).
2011–15	£157,170 awarded by Defra to Gauci for a project entitled 'Lowland peatland systems in England and Wales – evaluating greenhouse gas fluxes and carbon balances', competition code CTE1103 (total grant value: £1,750,783).
2010–14	£184,543 awarded by Defra to Gauci for a project entitled 'Investigation of peatland restoration (grip blocking) techniques to achieve best outcomes for methane and greenhouse gas emissions / balance', competition code: CTE0945 (total grant value: £1,065,519).
2010–14	£306,512 awarded by NERC Network to Gauci for a project entitled 'MethaneNet'.
2009	£69,624 awarded by NERC to Gauci for a project entitled 'Urgency: Quantifying fluvial carbon losses following the catastrophic 2009 peat swamp forest fires of Kalimantan, Borneo'.
2007–09	£23,347 awarded by The Wildlife Trusts and EEDA to Gauci as PI and consultant for a project entitled 'Carbon balance and C offset potential of the Great Fen Project'.
2007–10	£21,008 awarded by NERC to Gauci for a project entitled 'Dissolved organic carbon losses from natural and degraded tropical peatlands'.

4. Details of the impact

The impact of work by Dr Gauci and the Ecosystems Group has influenced several groups of policymakers and users, often by direct interaction and targeted research.

The research of Gauci and the Ecosystems Group demonstrated that acid rain pollution suppresses methane emissions from wetlands, and was featured in a US Environmental Protection Agency Report to Congress (Methane and Nitrous Oxide Emissions From Natural Sources. United States Environmental Protection Agency Report: Office of Atmospheric Programs (6207J) EPA 430-R-10-001, Washington, DC 20460 April 2010). This led Defra to investigate the potential role of sulfur pollution in mitigating emissions from restored UK peatlands. The economic potential of understanding peatland carbon dynamics and the role of sulfate in mitigating emissions has been recognised by the Great Fen Project, which is taking the carbon balance and offsetting of a great swathe of the Cambridgeshire Fens into account in its future plans

(http://www.greatfen.org.uk/about/studies). The work helped the Great Fen Project to recognise that while its 're-wetting' conservation restoration strategy arrests carbon loss by reducing carbon oxidation, the high sulfate concentrations that exist within the fen peats means that there are likely to be lower methane emissions than could normally be expected to occur as a consequence of elevating the water-table. The work was influential in planning the purchase of much of the area for conservation, in part through marketing the scheme's carbon offsetting potential and avoid carbon losses.

Gauci and the Ecosystems Group's work on the fluvial carbon losses of pristine and degraded tropical forested peatlands in Borneo feeds directly into the IPCC (Intergovernmental Panel on Climate Change) and REDD (UN Reducing Emissions from Deforestation and Forest Degradation programme) processes, since they have provided the only currently available data on dissolved organic carbon (DOC) exchanges for such ecosystems. This understanding of the carbon dynamics of the ecosystems is essential in subjects covered by protocols such as REDD, including carbon offsetting, avoided carbon losses and mitigation of carbon losses, because dissolved organic carbon is the single largest carbon fraction lost from these ecosystems via river drainage.

The Open University-led study was discussed in detail at three IPCC workshops in Brazil, Tanzania and Japan and is central for establishing the baseline for natural DOC losses within the IPCC Wetlands Supplement and for identifying a scaling factor for DOC losses from drained tropical peatlands. Annette Freibauer (one of the Coordinating Lead Authors of Chapter 2 'Drained Inland Organic Soils' of the 2013 Supplement to 2006 IPCC Guidelines for National Greenhouse Inventories: Wetlands), points out that the work:

> 'has been a very important scientific source in the development of methodologies and emission factors for DOC for drained and rewetted organic soils. The paper has been quoted in the scientific background text and has been used as one out of four tropical studies for DOC losses from natural ecosystems and as one out of two tropical studies on which the methodology for anthropogenic DOC losses was based. As these numbers show, the scientific literature on anthropogenic DOC losses in the tropics is very limited so that this paper has been of particularly high value for the 2013 IPCC Wetlands Supplement.'

Given the contribution of DOC to understanding carbon balance within these ecosystems, the findings reported by Moore et al. (2013) will directly feed into future REDD demonstration projects that will have both local development and positive climate benefits.

In the UK, findings of Gauci and The Open University group have helped shape a Defra-supported research programme to look at the carbon dynamics response to peatland restoration work that has been highlighted in a government Natural Environment White Paper 'Natural Choice: Securing the value of nature'. The OU component of the research was to work on intact and restored lowland fen sites at Wicken in Cambridgeshire to understand the exchanges of greenhouse gases including methane, N_2O and CO_2. The project has been identified in the White Paper as research that will demonstrate '…how best to manage our lowland peatlands in a way that supports efforts to tackle climate change'. The group's research into controls on methane emissions feeds directly into an Open University-led international research network on methane (www.methanenet.org), which has hosted a discussion meeting on methane mitigation (November 2011) and a session on the same subject at a major international meeting (Planet Under Pressure 2012) associated with the UN 'Rio+20' meeting. The meetings involved policymakers and Planet Under Pressure 2012 was specifically geared to communicating science to policymaking bodies and NGOs.

5. Sources to corroborate the impact

External sources corroborating impact:

1. Eastern Research Group inc. (2010) Methane and Nitrous Oxide Emissions. In: Natural Sources. United States Environmental Protection Agency Report: Office of Atmospheric

Programs (6207J) EPA 430-R-10-001, Washington, DC 20460 April 2010.
2. IPCC Wetlands Supplement. Ch. 2 Drained Inland Organic Soils. http://www.ipcc-nggip.iges.or.jp/home/wetlands.html
3. Open University report to the Great Fen is referred to prominently in the master plan for the area provided by LDA Design. http://www.greatfen.org.uk/great-fen-masterplan
4. The Open University work is central to providing evidence in support for the 2nd (climate change) of 7 strategic drivers of the Great Fen plan http://www.greatfen.org.uk/sites/default/files/Great%20Fen%20Masterplan_%20Section%203_Strategic%20Drivers%20444Kb_1.pdf

Beneficiaries who could be contacted to corroborate impact:

5. UK scientific representative, Intergovernmental Panel on Climate Change expert group
6. Lead coordinating author of IPCC Wetlands Supplement report
7. Director of Living Landscapes, The Wildlife Trusts for Bedfordshire, Cambridgeshire and Northamptonshire
8. Great Fen Project Manager (testimonial available on request)