

Impact case study (REF3)

Institution: University of Leicester		
Unit of Assessment: 7		
Title of case study: Improved science-based management of tropical and temperate peatlands to mitigate carbon losses and greenhouse gas emissions		
Period when the underpinning research was undertaken: 1 January 2000 to 31 December 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Professor Susan Page	Role(s) (e.g. job title): Professor of Physical Geography	Period(s) employed by submitting HEI: 1985 – Present
Period when the claimed impact occurred: 1 August 2014 – 31 October 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>Professor Page's peatland carbon and greenhouse gas (GHG) emissions research drove global government and NGO policies to protect carbon rich peatlands and rainforests, better understand the environmental impacts of peatland agriculture and palm oil production, enhance the sustainability of pulpwood production, and develop methodologies to limit climate change. Government and policy/advisory bodies—including the Indonesian and UK governments, and the United Nations—have adopted Page's data on peatland GHG emissions and recommendations on emissions mitigation, which has transformed worldwide peatland management policies. Page's research contributed to renewable energy directives, including the EU Parliament's and Norway Government's bans of palm oil-based biofuels.</p>		
2. Underpinning research		
<p>Peatlands are globally important carbon stores but when drained (e.g. for agriculture or plantations), the peat degrades, and stored carbon is released to the atmosphere as greenhouse gases (GHGs). Drainage also increases the risks of peatland fires, which in Southeast Asia cause significant deteriorations in public health and associated premature mortalities, and of peat subsidence, resulting in flooding which may ultimately preclude agricultural land use.</p> <p>Page's research on the 1997 Indonesian peatland fires [R1, G1] determined the scale of peat carbon loss and GHG emissions arising from this source and was the initial research to draw attention to this issue. Page's continuing research brought public and policy-makers' attention—again, for the first time—to the scale of land use changes on SE Asian peatlands and the carbon losses arising from drainage-driven peat degradation [R2], showing that emissions from peatland drainage in Southeast Asia were contributing the equivalent of 1.3% to 3.1% of global CO₂ emissions from the combustion of fossil fuels.</p> <p>Page's 2011 research established the extent and magnitude of the tropical peatland carbon store [R3, G2], demonstrating that Southeast Asian peatlands contain 77% of tropical peat carbon stocks. In 2011, Page also published two studies, funded by the International Council on Clean Transportation (ICCT) identifying the scale of GHG emissions arising from large-scale oil palm plantations on peatland [R4] along with their current and modelled future spatial extent in Southeast Asia.</p> <p>Page undertook consultancy-funded research through Deltares (2008-2010) to establish the consequences of drainage on peatland subsidence and flood risk in Southeast Asian plantation landscapes (2012) [R5] and demonstrated that rapid initial subsidence over the first five years accounted for surface lowering of around 1 metre, with longer term lowering of 5 cm</p>		

per year. Whilst peat subsidence was already a recognised feature of drained peatlands in the temperate zone, this was the first large-scale study to quantify subsidence in tropical peatlands. The results demonstrated that within only a few decades, subsidence would bring the peat surface down to levels at which drainability and flooding would become increasingly problematic, eventually resulting in extensive loss of productive land.

In 2018, Page and team **discovered vast, previously undocumented peatlands in the Republic of Congo** driven by their research (2018-2023 NERC-funded) in Central Africa [R6, G3]. A combination of fieldwork and remote sensing analysis revealed the world's largest extent of tropical peatland, covering 145,500 km² and storing 30.6 billion tonnes of carbon. This increased Page's previous best estimate of total tropical peatland carbon stocks [R3] by 36%.

Page's Defra and NERC-funded research on lowland peatlands in the Fens of eastern England established the **GHG emissions factors for UK lowland peat under agricultural management** [G4]. This research confirmed that lowland peats in England and Wales under crops and grassland are amongst the largest sources of GHG emissions from the UK land-use sector. The study formed the basis of further NERC- and Defra-funded studies on opportunities for GHG mitigation through agricultural management and restoration measures [G5, G6].

3. References to the research

[R1]. Page, S.E., Siegert, F., Rieley, J.O., et al. (2002). The amount of carbon released from peat and forest fires in Indonesia during 1997. *Nature* 420, 61-65.

[R2]. Hooijer, A., Page, S.E., et al. (2010) Current and future CO₂ emissions from drained peatlands in Southeast Asia. *Biogeosciences* 7, 1505-1514.

[R3]. Page, S.E., Rieley, J.O. & Banks, C.J. (2011) Global and regional importance of the tropical peatland carbon pool. *Global Change Biology* 17, 798-818.

[R4]. Page, S.E., Morrison, R. & Malins, C. (2011) Review of peat surface greenhouse gas emissions from oil palm plantations in Southeast Asia. *Indirect Effects of Biofuel Production* 15, 1-77. (ICCT White Paper. Washington: International Council on Clean Transportation).

[R5]. Hooijer, A., Page, S.E. & Jauhiainen, J. (2012) Subsidence and carbon loss in drained tropical peatlands. *Biogeosciences* 9, 1053-1071.

[R6]. Dargie, G., Lewis, S., Lawson, IT, Page, S.E., et al. (2017) Age, extent, and carbon storage of the central Congo Basin peatland complex. *Nature* 542, 86-90.

Relevant grants

[G1]. Prof. Susan Page (Co-I) (PI, University of Nottingham), via EUTROP: Natural resource functions and biodiversity of tropical peatlands in SE Asia. Funder: European Commission. Dates: 1/10/1998 – 30/9/2002. Value : GBP41,439. UoL grant number: RM48GPE.

[G2]. Prof. Susan Page (PI), via CARBOPEAT: Carbon-climate-human interactions in tropical peatlands. Funder: European Commission. Dates: 1/1/2007 – 31/10/2009. Value : GBP102,750. UoL grant number: RP13G0020.

[G3]. Prof. Susan Page (Co-I), Dr Arnoud Boom (Co-I) (PI, University of Leeds), via CongoPeat: Past, present and future of the peatland of the central Congo basin. Funder: NERC. Dates: 01/09/2018 – 31/08/2023. Value: GBP148,996. UoL grant number: RP13G0359.

[G4]. Prof. Susan Page (Co-I), Dr Joerg Kaduk (Co-I) (PI, CEH). Lowland peatland systems in England and Wales: evaluating GHG fluxes and carbon balances. Funder: Defra (SP1210). Dates: 1/4/2012 – 31/3/2016; Value: GBP158,565. UoL grant number: RP13G0199.

Final report on project SP1210 (2017): Lowland peatland systems in England and Wales – evaluation of greenhouse gas fluxes and carbon balances. Defra.
<http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17584>

[G5]. Prof. Susan Page (Co-I), Dr Joerg Kaduk (Co-I) (PI, CEH). Managing agricultural systems on lowland peat for reduced GHG emissions. Funder: Defra (SP1218). Dates : 1/2/2019 – 31/3/2022; Value: GBP55,312. UoL grant number: RP13GO425. **Initial reports:** i) An assessment of the potential for paludiculture in England and Wales; ii) An assessment of the societal impacts of water level management on lowland peatlands in England and Wales. Both available at: <https://lowlandpeat.ceh.ac.uk/outputs>

[G6]. Prof. Susan Page (Co-I), Dr Joerg Kaduk (Co-I) (PI, University of Bangor). Supporting long-term ecosystem function in lowland organic soils (SEFLOS). Funder: NERC. Dates : 1/3/2017 – 31/1/19; Value: GBP40,024. UoL grant number: RP13G0327.

4. Details of the impact

Policies on greenhouse gas (GHG) emissions

Since 2014, Page's research [R1, R2, R5] led to the first methodologies for calculating specific GHG emissions factors for peat oxidation and fire for degraded tropical peatlands [E1a-d]. The Indonesian Ministry of Environment and Forestry report (2015) [E1a] extensively implemented Page's methodologies to support the Government of Indonesia and United Nations Framework Convention on Climate Change (UNFCCC) initiative to reduce GHG emissions under REDD+ [E1c]. The Indonesian government incorporated Page's methodologies into two schemes for international emissions projection estimates (2015): INCAS [E1a] and UNFCCC [E1b] – now the standard methodology for assessment of GHG emissions from forests and peatlands in Indonesia. Page's peatland emissions research was used in the 2017 UNEP Emissions Gap Report, providing estimates to reduce global GHG emissions by 2030 [E1d].

Policies on biofuels derived from palm oil

Page's research on carbon emissions from Indonesian peat fires [R1] contributed to the European Parliament's 2017 vote to ban biofuels made from vegetable oils, including palm oil, by 2020 [E2a]. The Rainforest Foundation, Norway, drew upon Page's findings on GHG emissions from peat oxidation and fire [R3, R4], leading to a total ban on the public procurement and use of palm oil-based biofuel in Norway (June 2017)—the first country ban by a public entity on palm oil biofuel use [E2b,c,d]. Page's data [R4] drove the European Parliament Environment Committee (ENVI) to phase out biodiesel from vegetable oils by 2030, with accelerated phasing-out of palm oil biofuel use in Europe by 2021 [E2e].

Global, sustainable peatland and forest management policies

Transforming paper production practice in Indonesia

Page co-developed the **Independent Peatland Expert Working Group (IPEWG)** to inform sustainable forest and peatland management by APRIL, one of Indonesia's largest pulpwood plantation industries [E3a-h]. Page is an IPEWG member, and further co-developed APRIL's Peatland Roadmap (2017) [E3a]. Page's research [R1 – R5] provided strategic evidence for responsible peatland operations, including supporting **APRIL's appointment of a peatland Science Team**.

With inputs from Page and IPEWG, the Science Team undertook research that developed APRIL's knowledge in three critical peatland science areas: the net flux of greenhouse gases, water-table management and subsidence. This included establishing four eddy covariance flux towers (2017–2020), **which measure the land-atmosphere exchange of carbon dioxide and methane, and provide critical data on their exchange in natural, plantation and mixed-use peatland** (2019) [E3b]. In 2019, IPEWG and the Science Team evaluated the effect of APRIL's plantation management on peat subsidence, which provided guidance to APRIL on best peatland management and water table regulation practices [E3c].

Policies to manage peatland drainage

Page et al's research connecting peatland drainage to subsidence, flooding, GHG emissions, and fire risk [R1, R2, R4, R5] provided substantial evidence for three *Wetlands International* (WI) peatland management recommendations, supporting the Indonesian government's 2016 commitment to restore 2 million ha of degraded peatland [E4a]. Page's findings on peatland subsidence rates [R5] and SE Asia's peat forest losses [R2] informed WI 2015 (Malaysia) flooding projections and recommendations for sustainable peatland development [E4a]. Page's subsidence data [R5] informed WI 2015 (Indonesia) projections that "within 25, 50 and 100 years, 71%, 83% and 98% of the existing plantation area [will] experience . . . flooding" without immediate action [E4b]. WI 2016 also used these data [R5] to identify Indonesia's existing peatland management system as "unsustainable and irresponsible", and to **demand the phasing out of drainage in most of Indonesia's peatlands**. [E4c].

Sustainable palm oil

Page's research [R2, R4, R5] and advisory role with the Roundtable on Sustainable Palm Oil (RSPO) contributed to its **Best Management Practice** (2016) [E5a] and **Drainability Assessment Guidance** (2019) [E5b], to reduce GHG emissions from oil palm plantations on peatland and mitigate risks of flooding from subsidence.

Congo Basin and global peatland protection

As Co-I of a GBP3.1M NERC-funded research project [R6, G3], Page and team **discovered a vast area of tropical peatland in the Congo Basin** (2018). This peatland occupies 145,500 km²—an area slightly larger than England—and stores 30 billion tonnes of carbon: equivalent to three years' worth of global GHG emissions. **These findings spurred the Brazzaville Agreement (2018) [E6a] to conserve Congolese peatlands**, signed by the governments of Republic of Congo, Democratic Republic of Congo, Peru, and Indonesia, under the auspices of the UN Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN) [E6a]. It further motivated **the 2018 establishment of the UNEP Global Peatlands Initiative**, a cooperation of 28 organisations, including Page/University of Leicester, to promote best practices in peatland management [E6b-c].

UK environment and emission policies

Page's Defra-funded research (2012-2016) on GHG emissions from peatland under **intensive agricultural management** in eastern England [G4] informed the recommendation of the UK Parliament Environmental Audit Committee's report on Soil Health (2016) that the Government should take tougher action to tackle land use practices that degrade peat [E7a]. The UK government's reporting to UNFCCC (published by BEIS) used Page's data [G4] as evidence for Tier 2 reporting on GHG emissions from agricultural lowland peatlands [E7b].

5. Sources to corroborate the impact (indicative maximum of 10 references)**Policies on Greenhouse Gas emissions**

[E1a]. Indonesian National Carbon Accounting Scheme INCAS

[E1b]. INCASReport-1501E- AnnualGHG <https://tinyurl.com/y6loasvg>

[E1c]. Indonesian Government submission to United Nations 'National forest reference emissions level for REDD+' (2015): <https://tinyurl.com/y3jx2bne>

[E1d]. United Nations Environment Programme report 'Sectoral greenhouse gas emission reduction potentials in 2030' (2017): <https://tinyurl.com/ya2yudgv>

EU and European Government policies on biofuels derived from palm oil

[E2a]. ENVI MEPs vote biodiesel ban palm oil 2017 <https://tinyurl.com/y3ys4gh3>

[E2b]. Norway government ban on palm-oil derived biofuels:

[E2c]. Norway Parliament palm oil ban For-peats-sake <https://tinyurl.com/y4b57xdx>

[E2d]. Norway Parliament palm oil-biodiesel ban-news2017 <https://tinyurl.com/y4pam4sb>

[E2e]. European Parliament ban on palm-oil derived biofuels: <https://tinyurl.com/mprc8g4>

Sustainable Land and Forest Management Policies

- [E3a]. IPEWG road map and working plans: <https://tinyurl.com/yyvuz76b>
- [E3b]. APRIL reports. Methane: <https://www.rekoforest.org/carbon-measurement>.
- [E3c]. APRIL reports. Subsidence: <https://tinyurl.com/y274wu8l>
- [E3d]. APRIL 2019 Sustainability news
- [E3e]. APRIL 2019 Sustainability Report
- [E3f]. APRIL-IPEWG Phase1 Update 2018
- [E3g]. APRIL Peatland Management 2015
- [E3h]. APRIL-SustForestMan Policy 2015

Global policies to manage peatland drainage

- [E4a]. Wetlands International report 2015: *Flooding projections from elevation and subsidence models for oil palm plantations in the Rajang Delta peatlands, Sarawak, Malaysia*, 2015. <https://tinyurl.com/y4lmsglo>
- [E4b]. Wetlands International report 2015: *Assessment of impacts of plantation drainage on the Kampar Peninsula peatland, Riau*. <https://tinyurl.com/yxhzhgjh>
- [E4c]. Wetlands International report 2016: *Can Peatland Landscapes in Indonesia be Drained Sustainably? An Assessment of the 'eko-hidro' Water Management Approach*. <https://tinyurl.com/yxpy77xw>

RSPO

- [E5a]. RSPO Manual on Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat: <https://tinyurl.com/y28f3blc>
- [E5b]. RSPO Drainability Assessment Procedure: <https://tinyurl.com/y5t7dpur>

Congo Basin and global peatland protection

- [E6a]. The Brazzaville Agreement, 28 March 2018: <https://tinyurl.com/y5mcskb6>
- [E6b]. The Global Peatlands Initiative: <https://www.globalpeatlands.org/>
- [E6c]. UNEP feature on the Global Peatlands Initiative: <https://tinyurl.com/y5xppds8>

UK land management policies

- [E7a]. UK Parliament Environmental Audit Committee's report on Soil Health: <https://tinyurl.com/yyhmf9br>
- [E7b]. Emission factors for UK peatlands (BEIS): <https://tinyurl.com/sz3m42y>