Institution: Liverpool John Moores University (LJMU)		
Unit of Assessment: UOA7		
Title of case study: Protecting tropical peatlands and their ecosystem services		
Period when the underpinning research was undertaken: 2016-present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Dr Stephanie Evers	**Role(s) (e.g. job title):** Reader in Aquatic Ecology and Biogeochemistry	**Period(s) employed by submitting HEI:** 12 September 2016-present
Period when the claimed impact occurred: 2016-present		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Peatlands are globally important carbon (C) stores, covering just 3% of Earth's land surface, but storing 1/3rd of soil C. Of that, tropical peat hold c. 20% (*c.*105 Gt C). However, the role of tropical peat as C stores is currently under serious threat from large-scale expansion of drainage-based agriculture. In the REF impact period, Evers' research, via the development of the research consortia: TROCARI (Tropical Catchment Research Initiative), on tropical peat swamp forests (TPSF) in Malaysia and Indonesia has been used to:

- Contribute improved IPCC, NCAR and GFED emission factors for drained and burning tropical peatlands.
- Provide input into core RSPO sustainable oil palm certification guidelines on oil palm on peatlands and peatland rehabilitation.
- Provide evidence to inform the Indonesian peatland restoration agency guidelines.
- Provide data for the Malaysian Forestry department and NGO, Global Environment Centre, to help conserve and rehabilitate one of Malaysia's largest (>80,000ha) remaining peat swamp forest reserves.
- Provide scientific data on emissions to Malaysian policy makers, directly resulting in a rescinded permit for peat swamp forest (PSF) clearance and development, resulting in conservation of c. 1000ha of PSF and conservation of over 5 million tons of C.
- Contribute to widespread dissemination of current issues to local, national and international stakeholders including involvement in British High Commission (BHC) Malaysia and BHC Singapore collaborative outputs towards COP26.

2. Underpinning research

In 2012, Evers founded the research consortium TROCARI, with a MoU between the core founding members (University of Nottingham (UoNott) Malaysia Campus –Evers led, Universiti Teknologi Malaysia, Universiti Sarawak and Global Environment Centre). Since 2016, the membership of this group has expanded significantly and the central members of the team, led by Evers published an article in Global Change Biology which questioned the fundamental unsustainability of drainage-based agriculture on tropical peatlands ([1], cited in BGPP, 2018 and RSPO 2019a). It argued that the concept that peat sustainability and plantation development could be achieved in parallel, was fundamentally unachievable, and that the ongoing narrative of sustainability has seriously undermined effective environmental policy development[1]. This research set the scene the development and expansion of a range of biophysical and socioeconomic projects which aid in evidencing the impact of peat degradation for improved GHG accounting and informed management decisions.

From this, Evers recognised a key conflict between EPA (Environmental Protection Agency, US) and IPCC (International Panel for Climate Change) emissions factors for global oil palm production, and the knock-on effect for effective policy development, especially in relation to use of palm oil (PO) for biofuel in the US and EU. Evers' MRes student, Cooper, (Co-supervised with Stojersten, Aplin and others at UoNott) under a RGS grant (Co-I Evers) undertook the first in-situ

assessment of the emissions associated with the process of conversion (the disputed gap in knowledge). This data published in Nature Communications[2] identifies a previously unseen pulse in N_2O emissions, alongside CO^2, evidencing that conversion of Southeast Asian peat swamp forest is contributing between 16.6 and 27.9% of combined total national GHG emissions from Malaysia and Indonesia or 0.44 and 0.74% of annual global emissions[2]. This emissions pulse is a doubling of the current UN IPCC emission factor. In combination, our research has also shown that oil palm plantations halve the C stocks on peat swamp forest over 5-10 years during the same process of conversion[3] and that losses are enhanced during the increasing number and duration of dry periods[4] which would be associated with the climate projections for SE Asia.

Evers has also developed collaborations with LSE (Dr T. Smith) which drove the development of novel research into quantifying and characterising emission factors (EF) from peat fires in Malaysia. Current EFs for peatland fires used in IPCC accounting have relied on a very small number of in-situ fire emissions studies, resulting in up to 91% variability in proposed EFs from fires and massive uncertainty on global emissions estimates. Fires in tropical peatlands account for 25% or more of the estimated total greenhouse gas (GHG) emissions from global deforestation and forest degradation, amounting to approximately 3% of total global anthropogenic GHG emissions. In research funded by RGS and Monash University large grant awards (Evers Co-I), our data provided the first in-situ derived EFs and emissions chemistry data for Malaysian peat fires([5], cited in GFED, 2018 & NCAR, 2018), and supported by Evers' PhD student, Samuel (Funded by Malaysian Agriculture and Research Development Institute, MARDI) have been able to show how EFs are influenced by soil bulk density and fertilisation (both increased under plantation conditions), critical for informing on links between plantation management, fire emissions accounting and fire impacts ([5], cited in RSPO, 2019a).

During a 2014 field campaign, in collaboration with UoNott, we received support from the NERC Airborne Research & Survey Facility (Evers Co-I). Since 2016, this ongoing research combined *in situ* vegetation, soil and gas flux data with airborne hyperspectral, LiDAR (*Light detection and ranging*) and InSAR (*Interferometric synthetic aperture radar*) remotely sensed imagery to investigate the environmental effects of the land use change (linked to ongoing NERC Envision & STARS PhDs; Evers Co-Supervisor) (cited in RSPO,2019b). However, from 2017 we also developed methods which combine ISBAS (*Intermittent small baseline subset*) and Sentinel 1 data to measure short and long-term tropical peat motion in the North Selangor Forest Reserve, Peninsular Malaysia ([6], cited in RSPO 2019ab). This work has been expanded as part of the £2.2M UKSpace Agency funded project 'PASSES' of which Evers is Co-I. Outputs provide directional movement of surface level change and are being linked to GHG emissions, water table change and land use and provide models of large scale impacts of peat degradation, estimates of regional GHG fluxes and subsidence-linked flood predictive modelling (presented BHC – Malaysia, 2020).

3. References to the research

All publications have been published in high quality journals **(impact factors in bold)** and have undergone rigorous peer review:

- Evers S., Yule C., Padfield R., O'Reilly, P. & Varkkey, H. (2016) Keep Wetlands Wet: The Myth of Sustainable Development of Tropical Peatlands – Implications for Policies and Management, Global Change Biology 23: 534–549. doi:10.1111/gcb.13422 **(IF: 8.55)**
- Cooper H.V., Evers S., Aplin P., Crout N., Dahalan M.P. & Sjogersten S. Greenhouse gas emissions resulting from conversion of peat swamp forest to oil palm plantation (2020), Nature Communications, 11,1 (407) **(IF: 12.12)**
- Tonks, A.J., Aplin, P., Beriro, D.J., Cooper, H., Evers, S., Vane, C.H. & Sjögersten, S. Impacts of conversion of tropical peat swamp forest to oil palm plantation on peat organic chemistry, physical properties and carbon stocks (2017) Geoderma 289, pp. 36-45. DOI: 10.1016/j.geoderma.2016.11.018 **(IF 4.84)**

- Matysek M, Evers SL, Samuel MK, Sjogersten S. 2017. High heterotrophic CO2 emissions from a Malaysian oil palm plantations during dry-season Wetlands Ecology and Management, 26 :415-424 **(IF 1.8)**
- Smith, T. E. L., Evers, S., Yule, C. M., & Gan, J. Y. (2018). In situ tropical peatland fire emission factors and their variability, as determined by field measurements in Peninsula Malaysia. Global Biogeochemical Cycles, 32, 18– 31. **(IF 4.61)**
- Marshall C, Large DJ, Athab A, Evers SL, Sowter A, Marsh S, Sjogersten S. 2018. Monitoring tropical peat related settlement using ISBAS InSAR, Kuala Lumpur International Airport (KLIA) ENGINEERING GEOLOGY, 244 :57-65 **(IF: 4.77)**

Relevant Grants

- RGS Post Fire emissions in tropical peatlands 2019-2021, £15,000 (Co-I)
- UK Space Agency (2018-2021) Peatland Assessment in SE Asia with Satellite (PASSES) £2,157,800 (Co-I)
- BBSRC (2017-2020) 'SUSTAINPEAT: Overcoming barriers to sustainable livelihoods and environments in smallholder agricultural systems on tropical peatland' £570,000 (Co-I)
- Monash Large Research Grant (2016-2018): Characterizing impacts of degradation and burning on microbial biodiversity and greenhouse gas emissions for sustainable management of Selangor Peatswamp forests, c. £70,000 (Co-I)
- MARDI (2015-2019) 'Land use alteration and impacts to physical chemical properties of peat and GHG emissions' c.£60,000 (MYR300,000) (PI)
- NERC DTP Envision PhD funding 'An investigation into how oil palm cultivation is degrading North Selangor tropical peatland ecosystem services' (2015) (Co-I)
- NERC- Airborne Research & Survey Facility 'An investigation into how oil palm cultivation is degrading North Selangor tropical peatland ecosystem services' (2014) economic value >£100,000 (Project partner)
- Ralph Brown Expedition Award (2014) 'A spatial assessment of how oil palm cultivation is degrading the North Selangor peat swamp, Malaysia, £15,000 (Co-I)

4. Details of the impact

Evers' long-term commitment to bring together scientists and stakeholders to provide evidence-based recommendations on peatland management in Malaysia (S5) was central to Evers being asked to provide an **expert contribution to the RSPO guidelines (RSPO, 2019ab, S1, S2 and highlighted in S5)** as well as being asked to present at a high level BHC Malaysia seminar series (S7). Evers has been developing close collaborations with local stakeholders in the region over the last 10 years (5 of which she was residential in Malaysia), knowing that local buy-in, collaboration and engagement is central to delivering positive impact. Evers' involvement in the RSPO guidelines took the form of a **focused case study on TROCARI research findings (S1 - pg18)** and number of **citations throughout S1 and S2** as well as **Evers' contribution on recommendation text in S1 and S2**. The data provided highlight decomposition-based and fire-based emissions linked to PSF conversion and the resulting changes to soil surface height, soil chemistry and C storage. The case study (S1) also highlights a potential method for (via the ISBAS and Sentinel 1 remote sensing method development) wide-scale monitoring of subsidence across the region[6]. RSPO (S1) decree that all certified plantations must firstly monitor subsidence rates and then ensure they do not allow soil levels to drop below a 40-year buffer of drainability. As all oil palm on peat is drained, and therefore subsides, **this new ruling means that eventually, all certified companies will have to exit from peat-based oil palm**. As such, via advising on the content of these guidelines (see S1 and S2 acknowledgements pages) as well as contributing key evidence to justify the need to reconsider agricultural conversion, **Evers and collaborators have contributed to the long-term intention to remove oil palm of peat and the rehabilitation of wetlands and their C storage capacity from RSPO certified areas**. Currently, 17% of oil palm in the Southeast Asia Region is on peatlands representing well over 3.1M Ha of land and millions

of tonnes of stored carbon. While data is still outstanding on what proportion of that is RSPO certified, in total, **RSPO certification represents c.17% of the global total oil palm area**. **Sustainable certified palm oil is used by a number of large UK located** brands and retailers including Co-Op, Waitrose, Sainsbury's, IKEA and Tesco's. As such, our involvement in contributing data and Evers contribution to recommendations means that via RSPO, our work impacts both globally and nationally on the overall drive towards removal of drainage-based oil palm agriculture on peatlands and thus reduction of the globally significant contribution oil palm on peat makes to GHG emissions.

Our data is also **informing international emissions inventories**, Currently GHG emissions from tropical peatlands that have been drained and converted for plantation agriculture (e.g. oil palm) are not considered in GHG emissions budgets as considered by the UN Framework Convention on Climate Change (UNFCCC). However, the overall sustainability of biofuel derived from palm oil, especially for companies actively engaged in peatland conversion is still under consideration by bodies such as the EU Transport Agency and the US Environmental Protection Agency. Cooper et al., 2019, represents the first direct in-situ assessment of emissions in association with the first 5 years of conversion. This data was presented at the 13th Expert (Agriculture, Forestry and Other Land Use Sector) Meeting on Data for the Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database (EFDB) (Bali, Indonesia, Dec 2016). **The data presented are now included in the EFDB database, used for country specific GHG reporting under United Nations Framework Convention on Climate Change (UNFCCC) Paris agreement (2015)** which will support Malaysia in quantifying and developing strategies for mitigating emissions. Additionally, data from Smith et al (2018)[5] now feeds into **NCAR's (National Center for Atmospheric Research, US) fire inventory (S4) and Global Fire Emissions Database (GFED; S6) which are used by IPCC for global emissions accounting**.

The data produced has been paramount to protecting C reserves in Malaysian peatlands. With continued pressure to develop areas of PSF, Evers led a letter to senior Malaysian ministers and industry CEOs quantifying the expected GHG emissions linked to conversion of PSF to oil palm. This action directly resulted in the revoking of permits for agricultural conversion for an area of PSF in Selangor (S5). In doing so, **this research helped conserve c. 1000ha of PSF and an estimated 5 million tonnes of carbon**. Assuming a recommended carbon value of US$60 (RM 240) per tonne (Stern & Stiglitz, 2017). This means that this area of peatland had a C value of £250 million. **Our data has also helped to influence management decisions within North Selangor Peat Swamp Forest Reserve via contribution to the ICMP (Integrated catchment management plan) 2014-2023 (S5)**, an 81,000Ha protected area. Data on C emissions from encroaching oil palm[2] undertaken in collaboration with the Selangor state forestry department, as well as drained forest[2,3] and burnt[5] areas has contributed to the decisions to install of over 120 drain blocks along the southern border of the reserve. NSPSF stores approximately 80 megatonnes of carbon which is substantial in the context of Malaysia's carbon emissions (fossil fuel emissions are 60,000 tonnes per year). These drain blocks mean that fire occurrences have reduced (only one fire since 2017) and aerobic conditions will be minimised and thereby reducing decomposition-based C emissions across the area[2,3,4]. Our experience in this has also been integrated into the RSPO Guidelines 2019b (BMPs for management and rehabilitation of peatlands, S2) to enable wider impact. **Data has also been cited in the Giesen et al., (S3) report to BRG (Indonesian peat restoration agency, responsible for rehabilitating 2MHa of peatlands)**. While they quote Evers et al., 2016[1] in relation to questioning the whole premise of sustainability of drainage-based agriculture and the need for 100% rewetting, they also cite data on the impacts to C losses[3]. This data is also feeding into development of current national and regional policy documents (S5).

As PI of TROCARI, and having lived and worked in the region for several years prior to joining LJMU, Evers has been instrumental and the lead organiser of onsite logistics, experimental design

access and permits for all Malaysia-based fieldwork. She has also been the lead in terms of developing relationships with local, national and regional stakeholders; working with local industry, NGOs and government agencies to deliver impact from the research outputs (e.g. RSPO contributions and in an advisory role for the development of the Selangor peat swamp forest management activities) and current involvement in ongoing documents e.g. Malaysia's National Peatland Plan (S5). This approach has led to engagement with high level stakeholders, most recently the BHC Malaysia (invited speaker to high level presentation, and contribute to communications S7, S8) and BHC Singapore (to contribute to a joint COP26 policy document S9).

5. Sources (S) to corroborate the impact

1. RSPO BMP 2019 for Existing oil palm cultivation on peat volume 1 https://rspo.org/resources/peat/rspo-bmp-for-existing-oil-palm-cultivation-on-peat-volume-1-2018- Evers' contribution has been recognised in the acknowledgement section, and contains a case study of TROCARI findings (pg 19-20) as well as citations and seven papers referenced in section 8 (pages 102-107)
2. RSPO BMP 2019 Management and rehabilitation of peatlands volume 2 https://rspo.org/resources/peat/rspo-bmp-for-management-rehabilitation-of-peatlands-volume-2-2018- (Evers' has been recognised in the acknowledgment section (page 12), in section 2.3 the characteristics of tropical peatlands and four papers are referenced in section 8 (pages 151-157).
3. Giesen, Wim & Sari, Eli Nur. (2018). Tropical Peatland Restoration Report: the Indonesian case. 10.13140/RG.2.2.30049.40808 – Report to the Indonesian Peat Restoration Agency (Badan Restorasi Gambut or BRG) in its triple-R (RRR) program of Rewetting, Revegetation and Revitalisation. This report is an attempt to assist BRG by summarizing current (scientific) knowledge in these RRR fields). Two papers are cited[1,3] with Evers et al.,[1] being **quoted** on pg 23.
4. Smith et al., 2018 paper now feeds into **NCAR's fire inventory**: https://www.acom.ucar.edu/Data/fire/ - Our paper is cited in the September 2018 update: https://www.acom.ucar.edu/Data/fire/ListOfPapersWithNewEFDataUpdated9-12-2018.pdf
5. Supporting Letter from Mr Faizal Parish, Director, Global Environment Centre, Malaysia. Stating for Dr Evers that 'her work has been of strategic importance to:' …. '**Support for the management** of the 81,000ha North Selangor Peat Swamp Forest'… '**Enhancing sustainable practices of the Palm Oil Sector'…'Improving agriculture and practices of local communities'…'research input to policy making**' and that 'Dr Evers was key in influencing the then **Minister of Primary Industries to block approval for a proposed 1000ha oil palm plantation in the boundary of the forest.'**
6. Smith et al., 2018 also found in the latest EF Tables that will be used by the Global Fire Emissions Database (GFED). An accepted version can be found here: https://hes32-ctp.trendmicro.com:443/wis/clicktime/v1/query?url=https%3a%2f%2fwww.atmos%2dchem%2dphys%2ddiscuss.net%2facp%2d2019%2d303%2f&umid=db9bb1f5-d689-4cfb-a1b0-932def8a994a&auth=768f192bba830b801fed4f40fb360f4d1374fa7c-4fae0fa630c56ddd7f6c73c986ef98d7891b0194. The citation is in the supplement
7. Flyer for Evers **invited presentation** (Nov 2020) on her research. British High Commission (Malaysia) seminar series, alongside Prof, Tim Benton, Author of IPCC special report on Food, Land and Climate as well as Prof. Emeritus Tan Sri Zakri Abdul Hamid, Founding Chair of UN intergovernmental platform IPBES. This has led to:
8. **Future leadership (email evidence) a section of the BHC climate communications strategy in 2021**
9. Ongoing contribution to **the production of the UK-Singapore COP26 Policy Report project on Nature-based solutions to climate change**