Denial of long-term issues with agriculture on tropical peatlands will have devastating consequences

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LETTER TO THE EDITOR

Denial of long-term issues with agriculture on tropical peatlands will have devastating consequences

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The first International Peat Congress (IPC) held in the tropics – in Kuching (Malaysia) – brought together over 1000 international peatland scientists and industrial partners from across the world ('International Peat Congress with over 1000 participants!', 2016). The congress covered all aspects of peatland ecosystems and their management, with a strong focus on the environmental, societal and economic challenges associated with contemporary large-scale agricultural conversion of tropical peat.

However, recent encouraging developments towards better management of tropical peatlands have been undermined by misleading newspaper headlines and statements first published during the conference. Articles in leading regional newspapers ('Oil palm planting on peat soil handled well, says Uggah, 2016b; Cheng & Sibon, 2016; Nurbianto, 2016a,b; Wong, 2016) widely read across the region portrayed a general consensus, in summary of the conference, that current agricultural practices in peatland areas, such as oil palm plantations, do not have a negative impact on the environment. This view is not shared by many scientists or supported by the weight of evidence that business-as-usual management is not sustainable for tropical peatland agriculture.

Peer-reviewed scientific studies published over the last 19 years, as reflected in the Intergovernmental Panel on Climate Change (IPCC) Wetland Supplement on greenhouse gas inventories, affirm that drained tropical peatlands lose considerable amounts of carbon at high rates (Drösler *et al*., 2014). Tropical peat swamp forests have sequestered carbon for millennia, storing a globally significant reservoir below ground in the peat (Page *et al*., 2011; Dommain *et al*., 2014). However, contemporary agriculture techniques on peatlands heavily impact this system through land clearance, drainage and fertilization, a process that too often involves fire. Along with biodiversity losses driven by deforestation (Koh *et al*., 2011; Posa *et al*., 2011; Giam *et al*., 2012), the carbon stored in drained peatlands is rapidly lost through oxidation, dissolution and fire (Couwenberg *et al*., 2009; Hirano *et al*., 2012; Ramdani & Hino, 2013; Schrier-Uijl *et al*., 2013; Carlson *et al*., 2015; Warren *et al*., 2016). Tropical peat fires are a major contributor to global greenhouse gas emissions and produce transboundary haze causing significant impacts on human health, regional economies and ecosystems (Page *et al*., 2002; Marlier *et al*., 2012; Jaafar & Loh, 2014; Chisholm *et al*., 2016; Huijnen *et al*., 2016; Stockwell *et al*., 2016). With future El-Niño events predicted to increase in frequency and severity (Cai *et al*., 2014) and with fire prevalence now decoupled from drought years (Gaveau *et al*., 2014), future large-scale fire and haze events are imminent given the extensive areas of now-drained fire-prone drained peatlands (Kettridge *et al*., 2015; Turetsky *et al*., 2015; Page & Hooijer, 2016).

In reality, just how much of the estimated 69 gigatonnes of carbon (Page *et al*., 2011) stored in South-East Asian tropical peatlands is being lost due to agricultural operations under the current management regime is still uncertain. Of great concern is that none of the agricultural management methods applied to date have been shown to prevent the loss of peat and the associated subsidence of the peatland surface following drainage (Wösten *et al*., 1997; Melling *et al*., 2008; Hooijer *et al*., 2012; Evers *et al*., 2016). Recent projections suggest that large areas of currently drained coastal peatlands will become undrainable and progressively be subjected to longer periods of inundation by river and ultimately sea water (Hooijer *et al*., 2015a,b; Sumarga *et al*., 2016). With growing risk of saltwater intrusion, agriculture in these coastal lands will become increasingly untenable, calling into question the very notion of 'long-term sustainability of tropical peatland agriculture'.

A more accurate view of drained peatland agriculture is that of an extractive industry, in which a finite resource (the peat) is 'mined' to produce food, fibre and fuel, driven by global demand. In developing countries with growing populations, there are strong socio-economic arguments for exploiting this resource to support local livelihoods and broader economic development (Mizuno *et al*., 2016). However, we must accept that ongoing peat loss is inevitable under this scenario. Science-based measures towards improved management, including limitations on the extent of plantation development, can be used to minimize the rate of this peat loss (President of Indonesia, 2011). Such an evidence-based position, supported with data and necessary legal instruments, is needed for sustainable futures. The scientifically unfounded belief that drained peatland agriculture can be made 'sustainable', and peat loss can be halted, via unproven methods such as peat compaction debilitates the effort to find sustainable possibilities. To a large extent, the issues surrounding unsustainable peatland management have now been recognized by sections of industry (Wilmar, 2013; APP, 2014; Cargill Inc., 2014; Mondelēz International, 2014; Sime Darby Plantation, 2014; APRIL, 2015; Olam International, 2015), government (President of Indonesia, 2014, 2016, Mongabay, 2015; Mongabay Haze Beat, 2015; Hermansyah, 2016) and consumers (Wijedasa *et al*., 2015). In recognition of the constraints and risks of peatland development, many large and experienced oil palm and pulpwood companies have halted further development on peat and introduced rigorous management requirements for existing peatland plantations (Lim *et al*., 2012). However, the denial of the empirical basis calling for improved peatland management

remains persistent in influential policy spaces, as illustrated by the articles reporting on the conference ('Oil palm planting on peat soil handled well, says Uggah, 2016b; Cheng & Sibon, 2016; Nurbianto, 2016a,b).

The search for more responsible tropical peatland agriculture techniques includes promising recent initiatives to develop methods to cultivate crops on peat under wet conditions (Giesen, 2015; Dommain *et al.*, 2016; Mizuno *et al.*, 2016). While a truly sustainable peatland agriculture method does not yet exist, the scientific community and industry are collaborating in the search for solutions (International Peat Society, 2016), and for interim measures to mitigate ongoing rates of peat loss under existing plantations. Failing to recognize the devastating consequences of the current land use practices on peat soils and failing to work together to address them could mean that the next generation will have to deal with an irreversibly altered, dysfunctional landscape where neither environment nor society, globally or locally, will be winners.

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References

APP (2014) APP Forest Conservation Policy Update 2014.

APRIL (2015) APRIL Group's Sustainable Forest Management Policy 2.0. 1–4.

Cai W, Borlace S, Lengaigne M *et al.* (2014) Increasing frequency of extreme El Niño events due to greenhouse warming. *Nature Climate Change*, **5**, 1–6.

Cargill Inc. (2014) Cargill Policy on Sustainable Palm Oil.

Carlson KM, Goodman LK, May-Tobin CC (2015) Modeling relationships between water table depth and peat soil carbon loss in Southeast Asian plantations. *Environmental Research Letters*, **10**, 74006.

Cheng L, Sibon P (2016) Sarawak opening up coastal lowland areas for agriculture, plantation devt — Adenan. *BorneoPost*, Available at: http://www.theborneopost.com/2016/08/17/sarawak-opening-up-coastal-lowland-areas-for-agriculture-plantation-devt-adenan/ (accessed 17 August 206).

Chisholm RA, Wijedasa LS, Swinfield T (2016) The need for long-term remedies for Indonesia's forest fires. *Conservation Biology*, **30**, 5–6.

Couwenberg J, Dommain R, Joosten H (2009) Greenhouse gas fluxes from tropical peatlands in south-east Asia. *Global Change Biology*, **16**, 1715–1732.

Dommain R, Couwenberg J, Glaser PH, Joosten H, Suryadiputra I, Nyoman N (2014) Carbon storage and release in Indonesian peatlands since the last deglaciation. *Quaternary Science Reviews*, **97**, 1–32.

Dommain R, Dittrich I, Giesen W, Joosten H, Rais DS, Silvius M, Wibisono ITC (2016) Ecosystem services, degradation and restoration of peat swamps in the Southeast Asian tropics. In: *Peatland Restoration and Ecosystem Services: Science, Policy and Practice* (eds Bonn A, Allott T, Evans M, Stoneman R, Joosten H). Cambridge University Press, Cambridge.

Drösler M, Verchot LV, Freibauer A *et al.* (2014) Chapter 2: Drained inland organic soils. In: *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (eds Hiraishi T, Krug T, Tanabe K, Srivastava N, Jamsranjav B, Fukuda M, Troxler T), pp. 1–79. IPCC, Switzerland.

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*, 1–16, doi: 10.1111/gcb.13422/abstract

Gaveau DLA, Salim M, Hergoualc'h K *et al.* (2014) Major atmospheric emissions from peat fires in Southeast Asia during non-drought years: evidence from the 2013 Sumatran fires. *Scientific reports*, **4**, 1–7.

Giam X, Koh LP, Tan HH, Miettinen J, Tan HTW, Ng PKL (2012) Global extinctions of freshwater fishes follow peatland conversion in Sundaland. *Frontiers in Ecology and the Environment*, **10**, 465–470.

Giesen W (2015) Utilising non-timber forest products to conserve Indonesia's peat swamp forests and reduce carbon emissions. *Journal of Indonesian Natural History*, **3**, 10–19.

Hermansyah A (2016) Soil compaction puts peatland at risk, agency says. *The Jakarta Post*, Available at: http://www.thejakartapost.com/news/2016/03/08/soil-compaction-puts-peatland-risk-agency-says.html (accessed 8 March 2016).

Hirano T, Segah H, Kusin K, Limin S, Takahashi H, Osaki M (2012) Effects of disturbances on the carbon balance of tropical peat swamp forests. *Global Change Biology*, **18**, 3410–3422.

Hooijer A, Page S, Jauhiainen J, Lee WA, Lu XX, Idris A, Anshari G (2012) Subsidence and carbon loss in drained tropical peatlands. *Biogeosciences*, **9**, 1053–1071.

Hooijer A, Vernimmen R, Visser M, Mawdsley N (2015a) Flooding projections from elevation and subsidence models for oil palm plantations in the Rajang Delta peatlands, Sarawak, Malaysia. Deltares report 1207384, 76 pp.

Hooijer A, Vernimmen R, Mawdsley N, Page S, Mulyadi D, Visser M (2015b) *Assessment of Impacts of Plantation Drainage on the Kampar Peninsula Peatland*. Deltares Report, Riau.. 1207384.

Huijnen V, Wooster MJ, Kaiser JW *et al.* (2016) Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997. *Scientific Reports*, **6**, 26886.

International Peat Congress with over 1000 participants! (2016a) PeatNews.

International Peat Society (2016) Statement regarding the Jakarta Post article of 18th August.

Jaafar Z, Loh TL (2014) Linking land, air and sea: Potential impacts of biomass burning and the resultant haze on marine ecosystems of Southeast Asia. *Global Change Biology*, **20**, 2701–2707.

Kettridge N, Turetsky MR, Sherwood JH *et al.* (2015) Moderate drop in water table increases peatland vulnerability to post-fire regime shift. *Scientific Reports*, **5**, 8063.

Koh LP, Miettinen J, Liew SC, Ghazoul J (2011) Remotely sensed evidence of tropical peatland conversion to oil palm. *Proceedings of the National Academy of Sciences of the United States of America*, **108**, 5127–5132.

Lim KH, Lim SS, Parish F, Suharto R (2012) *RSPO Manual on Best Management Practices (BMPs) for Existing Oil Palm Cultivation on Peat*. RSPO, Kuala Lumpur, Malaysia. 214 pp.

Marlier ME, DeFries RS, Voulgarakis A *et al.* (2012) El Niño and health risks from landscape fire emissions in southeast Asia. *Nature Climate Change*, **3**, 131–136.

Melling L, Goh KJ, Beauvais C, Hatano R (2008) Carbon Flow and Budget in Young Mature Oil Palm Agroecosystem on Deep Tropical Peat. *Planter*, **84**, 21.

Mizuno K, Fujita MS, Kawai S (2016) *Catastrophe & Regeneration in Indonesia's Peatlands: Ecology, Economy & Society* (eds Mizuno K, Fujita MS, Kawai S). NUS Press, Singapore, 466 pp.

Mondelēz International (2014) Mondelēz International Palm Oil Action Plan.

Mongabay (2015) Jokowi to oversee Indonesia peat restoration agency but details thin on the ground. Mongabay.

Mongabay Haze Beat (2015) Jokowi pledges Indonesia peatland "revitalization" to stop the burning. Mongabay.

Nurbianto B (2016a) Congress may change views on cultivation of peatland: IPS. *The Jakarta Post*, Available at: http://www.thejakartapost.com/news/2016/08/18/congress-may-change-views-on-cultivation-of-peatland-ips.html (accessed 18 August 2016).

Nurbianto B (2016b) Malaysia challenges the world over palm oil on peatland. *The Jakarta Post*, Available at: http://www.thejakartapost.com/news/2016/08/24/malaysia-challenges-the-world-over-palm-oil-on-peatland.html (accessed 24 August 2016).

Oil palm planting on peat soil handled well, says Uggah (2016b) BorneoPost. Available at: http://www.theborneopost.com/2016/08/19/oil-palm-planting-on-peat-soil-handled-well-says-uggah/ (accessed 19 August 2016).

Page SE, Hooijer A (2016) In the line of fire: the peatlands of Southeast Asia. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, **371**, 20150176.

Page SE, Siegert F, Rieley JO, Boehm HV (2002) The amount of carbon released from peat and forest fires in Indonesia during 1997. *Nature*, **1999**, 61–65.

Page SE, Rieley JO, Banks CJ (2011) Global and regional importance of the tropical peatland carbon pool. *Global Change Biology*, **17**, 798–818.

Posa MRC, Wijedasa LS, Corlett RT (2011) Biodiversity and conservation of tropical peat swamp forests. *BioScience*, **61**, 49–57.

President of Indonesia (2011) Instruction of the President of the Republic of Indonesia number 10 of 2011 about suspension of granting of new licenses and improvement of governance of natural primary forest and peatland.

President of Indonesia (2014) Government Regulation Number 71 of year 2014 about Protection and Management of Peat Ecosystems.

President of Indonesia (2016) Presidential Regulation Number 1 of year 2016 About Peat Restoration Agency.

Ramdani F, Hino M (2013) Land Use Changes and GHG Emissions from Tropical Forest Conversion by Oil Palm Plantations in Riau Province, Indonesia. *PLoS ONE*, **8**, 1–6.

Schrier-Uijl AP, Silvius M, Parish F, Lim KHH, Rosediana S, Anshari G (2013) *Environmental and Social Impacts of Oil Palm Cultivation on Tropical Peat: a Scientific Review*, pp. 131–168. Roundtable of Sustainable Palm Oil, Kuala Lumpur, Malaysia.

Sime Darby Plantation (2014) Sustainability: Peatland planting policy.

Stockwell CE, Jayarathne T, Cochrane MA *et al*. (2016) Field measurements of trace gases and aerosols emitted by peat fires in Central Kalimantan, Indonesia during the 2015 El Niño. *Atmospheric Chemistry and Physics Discussions*, **53**, 1–37.

Sumarga E, Hein L, Hooijer A, Vernimmen R (2016) Hydrological and economic effects of oil palm cultivation in Indonesian peatlands. *Ecology and Society*, **21**, 52.

Turetsky MR, Benscoter B, Page S, Rein G, Van Der Werf GR, Watts A (2015) Global vulnerability of peatlands to fire and carbon loss. *Nature Geoscience*, **8**, 11–14.

Warren M, Frolking S, Dai Z, Kurnianto S (2016) Impacts of land use, restoration, and climate change on tropical peat carbon stocks in the twenty-first century: implications for climate mitigation. *Mitigation and Adaptation Strategies for Global Change*, doi:10.1007/s11027-016-9712-1.

Wijedasa LS, Posa MRC, Clements GR (2015) Peat fires: consumers to help beat them out. *Nature*, **527**, 305.

Wilmar International (2013) *No Deforestation*, pp. 1–9. No Peat, No Exploitation Policy.

Wong J (2016) Yield of oil palm on peatland can be doubled. The Star.

Wösten JHM, Ismail AB, Van Wijk ALM (1997) Peat subsidence and its practical implications: A case study in Malaysia. *Geoderma*, **78**, 25–36.