

Social and Ecological Dimensions of Tropical Peatland Restoration

FOREWORD

Samantha Grover¹, Sarah Treby¹, Daniel S. Mendham², Tri W. Yuwati^{3,4},
Niken Sakuntaladewi³, James D. Langston², Andrea Rawluk⁵

¹ Applied Chemistry and Environmental Science, RMIT University, Melbourne, Australia

² CSIRO Environment, Black Mountain, Canberra, Australia

³ Research Centre for Ecology and Ethnobiology, BRIN, Cibinong, West Java, Indonesia

⁴ Faculty of Forestry, Gadjah Mada University, Yogyakarta, Indonesia

⁵ School of Agriculture, Food and Ecosystem Sciences, University of Melbourne, Australia

SUMMARY

Tropical peatlands in Indonesia have attracted international and domestic attention and concern in recent decades. Indonesian peatlands provide globally significant climate regulation and biodiversity provisioning ecosystem services and are central to the lives of local communities, yet they have undergone significant degradation via drainage and fire. There is a growing call for scientific knowledge of the social, environmental and practice dimensions of peatland restoration in Indonesia. This Special Volume of *Mires and Peat* is a collaborative effort by an Indonesian and Australian team of biophysical and social scientists to showcase primary research and systematic reviews that engage with the complexity of tropical peatland fire, conservation and restoration in Indonesia. We explore lives (of people and plants) above ground and processes below ground in the dynamic peat itself, and identify the following four themes that cut across the individual articles: 1) livelihoods and land use; 2) community engagement; 3) bringing together multiple knowledges; and 4) carbon; and draw out globally applicable lessons. We suggest that these themes highlight future directions for research which engage with the complexity of tropical peatland restoration in Indonesia, while centring the voices of local communities to support equity and sustainability in the transition to rewet peatlands.

KEY WORDS: carbon, Indonesia, interdisciplinary, land use, livelihoods, local community

INTRODUCTION

Tropical peatlands have made a grand entrance onto the stage of international concern over the past two decades, with enigmatic but high-profile roles in the global narratives on carbon cycling, biodiversity loss, ecosystem conversion and sustainable development. Contemporary research in restoration offers insights on the need to engage deeply with social and ethical dimensions of restoration (Hall *et al.* 2020) and provides people-centred principles for restoration (Elias *et al.* 2022). Elias *et al.* (2021) call for plural voices for sustainable restoration and de Sequeira *et al.* (2021) for the increasing involvement of women. While some research has begun to explore human-peatland relationships in tropical peatland restoration

in Indonesia (Tan *et al.* 2023), scientific understanding of the social and ecological dimensions of tropical peatlands remains largely superficial and disconnected in the peer-reviewed academic literature, albeit with some pockets of deep knowledge in Indonesia.

This Special Volume of *Mires and Peat* aims to start addressing the need for interdisciplinary biophysical and social research about Indonesian peatlands by bringing together an interconnected body of primary research and systematic reviews to grapple with the complexity of peatland fire and restoration in Indonesia. We explore key aspects of the interconnections between the lives of people and plants above ground and processes below ground in the dynamic peat itself. Indonesian voices are

foregrounded as part of an ongoing endeavour to amplify local knowledge of these globally significant ecosystems to international audiences concerned with the sustainable use of tropical peatlands. To introduce the volume, we first outline the context of tropical peatlands and this body of research, then we draw out emerging themes from the articles assembled here that cut across the social and ecological dimensions of tropical peatland fire and restoration. Finally, we arrive at reflections on, and recommendations for, future research to support socially and ecologically sustainable peatland restoration and conservation.

CONTEXT

Approximately 30 % of the world's tropical peatlands are found in Indonesia, distributed primarily across the islands of Sumatra, Kalimantan (Borneo) and Papua (Anda *et al.* 2021). Tropical peat swamp forests (PSFs) provide critically important ecosystem services including biodiversity provisioning, carbon cycling and hydrological regulation (e.g., Joosten & Clarke 2002, Page & Baird 2016, Turetsky *et al.* 2015, Gentine *et al.* 2019). Indonesian PSFs support the cultures and livelihoods of the millions of people who live with, use and depend on peatlands and peatland products (Limin *et al.* 2007, Harrison *et al.* 2019). In recent decades, tropical peatlands have been extensively degraded by drainage, deforestation and fire, leaving only 6 % now considered intact (Miettenen *et al.* 2016). Critically, peatland drainage and land use change have drastically increased peat flammability, leading to massive peat fires with widespread and detrimental implications for Indonesia's economy (Harrison *et al.* 2009), human health (e.g. Heil 2007, Uda *et al.* 2019, Hein *et al.* 2022, Santoso *et al.* 2022) and the environment (e.g. Stockwell *et al.* 2016, Wasis *et al.* 2019, Sulaeman *et al.* 2021).

These peat fires have been recurring near-annually since the mid-1990s, burning millions of hectares of Indonesian peatland and creating smoke haze that reaches the neighbouring countries of Brunei, Malaysia, Singapore and Thailand (Edwards & Heiduk 2015). The damage to economies and human health in bordering nations, together with the global implications of massive peat fire CO₂ emissions (Page *et al.* 2002, Cochrane 2003, Hooijer *et al.* 2006) have made Indonesia's peat fires a global issue. Consequently, international pressure on Indonesia to reduce peat fires and smoke haze has been a catalyst for increasing national policy and governance, necessitating prompt and extensive

peatland restoration. In 1990 the Indonesian government issued the *Presidential Decree on the Management of Protected Areas*, which was the first national regulation to explicitly mandate the protection of peatland areas, specifically those which are at least three metres deep (Nurbaya & Efransjah 2022). Subsequent regulations have included a ban on land and forest fires in 2001 and a moratorium on palm oil cultivation on peat layers deeper than three metres in 2009, extended in 2011, 2013 and 2015 (Uda *et al.* 2020). The *Peatland Ecosystem Protection and Management Plan* (RPPEG), released in 2014 and amended in 2016, mandates the development of a plan to appropriately protect and manage peatland ecosystems, and has been followed by five environment and forestry ministerial rules since (Nurbaya & Efransjah 2020, 2022). In response to the extensive fires of 2015, in early 2016 the Indonesian government formed the peatland restoration agency Badan Restorasi Gambut (BRG; now BRGM, reflecting the inclusion of mangrove restoration), with the goal of restoring 2.4 M ha of degraded peatland (BRGM 2022). The current political landscape is focused on the BRGM's three key approaches to peatland restoration, known as the 'three Rs', namely Rewetting, Revegetation and Revitalisation of livelihoods (BRGM 2022). We adopt the 'three Rs' definition of restoration for the purposes of this volume.

The volume presents a body of work by an interdisciplinary team of researchers from two projects funded by the Australian Centre for International Agricultural Research (ACIAR):

- (1) *Improving Community Fire Management and Peatland Restoration*, known informally - and referred to hereafter - as 'Gambut Kita' (Our Peatlands); and
- (2) *Validating Technologies for Assessing and Monitoring the Impacts of Re-Wetting of Indonesian Peatland using Eddy Flux Towers coupled with the Chameleon Sensors*, known informally as 'Chameleon Flux'.

These projects have brought together over 100 researchers, practitioners, stakeholders and community members from Indonesia and Australia, investigating Indonesian peatland restoration. The work covers three geographical regions within Sumatra and Kalimantan, and research foci span from local communities through to national level. The research presented addresses a range of complex, intersecting social and environmental factors which are key to achieving effective and sustainable peatland restoration outcomes in Indonesia.

DEVELOPMENT PROCESS OF THE VOLUME

The volume was developed by a subgroup of approximately 30 people from the Gambut Kita and Chameleon Flux project teams, and is the culmination of five years of working together. We collaborated through the COVID-19 global pandemic, at great distance and in isolation, and pursued an ethic of critical reflection, learning and reciprocity in our research collaborations (Kanngieser & Todd 2021). Central to reciprocity is active listening where we engage through diversity (Dreher 2009), taking action to change structures and build equity (Kanngieser 2013).

In our case, sharing our research with international audiences involved building equity in collaborations. A key objective for this volume and the associated writing workshops was the creation of a space to work together and support the diversity of voices needed in peer-reviewed academic literature about Indonesian peatlands, and thus avoid the tendency for non-Indonesian researchers to dominate the author lists of international journal publications about peatlands in Indonesia. Doing this was an act of holding space for creating change (Pascoe *et al.* 2020). Focusing on genuine care and collaboration exemplified an ethic of rewriting success in (neoliberal) knowledge production and research institutions (Dickinson *et al.* 2020), which are typically driven by intense hierarchical productivity and competitiveness.

Grounded in a process called Adaptive Doing (Rawluk *et al.* 2020), the collaborative and reflective learning to support practice change began in 2018 when the first Gambut Kita writing workshop was held in Indonesia. The driver for this workshop was the desire of Indonesian team members for greater support and learning in the space of publishing in peer reviewed international academic journals and developing strong scientific writing practices. We quickly realised that, to move towards equitable knowledge sharing and learning, supportive writing processes were needed over a longer period of time. In isolation during changing COVID-19 restrictions, we organised a series of online writing workshops that enabled interdisciplinary capacity building for all authors in the project who wished to take part. Between September 2021 and October 2022, we met weekly (102 hours in total) to write together as well as to discuss writing process, practice, and challenges to navigating the experience of academic writing. While a few team members coordinated the sessions, all members contributed by sharing skills.

CROSS-CUTTING THEMES

Four themes have emerged from this body of research, which cut across the disciplines, spatial scales and focal topics of the articles themselves (Figure 1).

Livelihoods and land use

How people work with land to support their families' lives is the most prevalent theme, and an explicit focus for Akbar *et al.* (2024), Fleming *et al.* (2024), Jalilov *et al.* (2024), Kunarso *et al.* (2024), Mendham *et al.* (2024), Rochmayanto *et al.* (2024), Sakuntaladewi *et al.* (2024) and Toumbourou *et al.* (2024). Language around how people use or rely upon peatlands tends to align with the disciplinary background of lead and/or senior authors, with the term 'livelihood' used in articles stemming from a more social sciences perspective (Fleming *et al.* 2024, Jalilov *et al.* 2024, Mendham *et al.* 2024, Rochmayanto *et al.* (2024), Sakuntaladewi *et al.* 2024), while 'land use' conveys this concept in articles grounded in the biophysical sciences (Kunarso *et al.* 2024). Akbar *et al.* (2024) and Toumbourou *et al.* (2024) include the more human-centred term 'livelihoods' as well as the more biophysical 'land use', evidencing the interdisciplinary cross-pollination of knowledge systems (epistemologies) achieved within this diverse team of researchers.

Community engagement

Several articles explore and reveal the importance of supporting community leadership and participation across peatland conservation, restoration and fire. Fleming *et al.* (2024) discuss how communities need to be involved in the decision-making on rewetting for restoration to support local agency and livelihoods. Considering conservation with a community in South Sumatra, Jalilov *et al.* (2024) expand upon community involvement, suggesting that local communities should be key decision-makers in the conservation governance of peatlands to improve the efficacy of policy. Mendham *et al.* (2024) identify cultural and livelihood barriers to restoration efforts that need to be overcome to secure community-driven responses; whilst Sakuntaladewi *et al.* (2024) recognise multiple vulnerabilities related to fire, flooding and climate change that peatland communities face and which require community-specific engagement. Further considering fire prevention and response across multiple communities, Rochmayanto *et al.* (2024) discuss how government support needs to empower

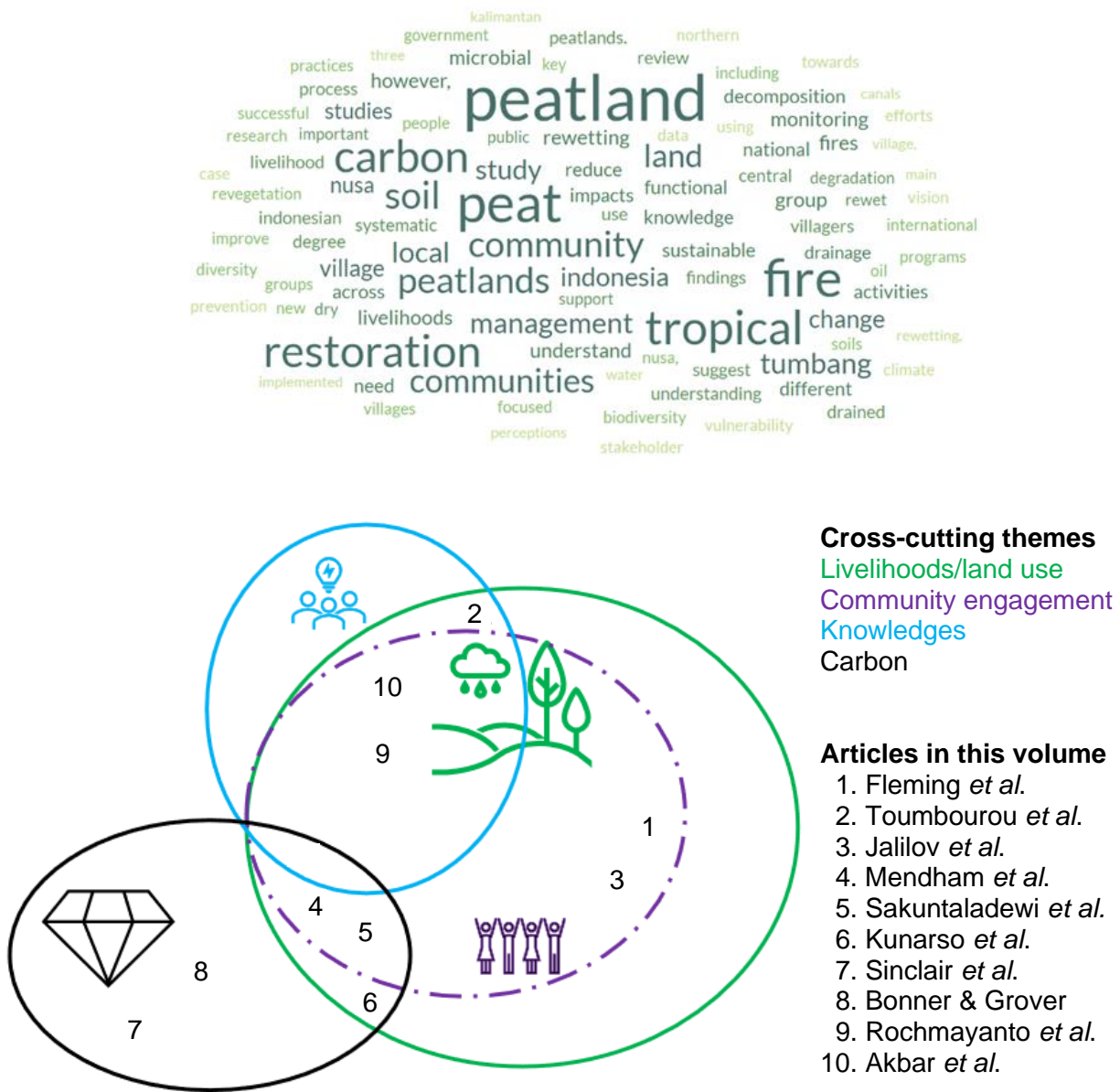


Figure 1. Above: word cloud generated from the Summaries of articles submitted for this volume, showing the 100 most common words with font size reflecting frequency; below: diagram indicating how the topic of each published article intersects with the cross-cutting themes identified in the text.

Village Heads as key champions of fire prevention and Akbar *et al.* (2024) suggest that it is critical to understand community members’ needs, motivations and uses for fire to improve targeted fire management approaches.

Bringing together multiple knowledges

Building on the previous theme of centring community needs and voices in peatland restoration and conservation, we recognise a requirement to include multiple knowledges in decision making, collaboration and research. Rochmayanto *et al.*

(2024) suggest that knowledge exchange and learning between villagers is key to fire prevention and management. Toumbourou *et al.* (2024) develop and utilise a collaborative process to arrive at a shared understanding and vision of tropical peatland restoration that brings together the multiple knowledges and asks individuals to challenge their initial understanding of a context. Ongoing attention is needed to ensure critical reflection, knowledge sharing and integration; and to build and refine collaborative processes that value knowledge from communities, stakeholders, government and researchers.



Carbon

The current climate crisis, and the imperative need to curb Indonesia's peat fire CO₂ emissions, make carbon-focused research a critical component of tropical peatland restoration. Sinclair *et al.* (2024) highlight that carbon monitoring research in Southeast Asian peatlands is extremely limited at present, leaving uncertainty about the long-term effects of rewetting, fire and revegetation on peatland carbon cycling. Thus, although purportedly undertaking restoration activities that will reduce CO₂ emissions meantime, practitioners cannot be sufficiently informed to effect adaptive management in which carbon cycling outcomes are incorporated into improved interventions, until more research is undertaken. Kunarso *et al.* (2024) show that the most intensively managed areas of peatland (oil palm plantations) have drastically altered peat carbon chemistry indicative of a greater degree of peat decomposition than under undisturbed peatland forest and other managed land uses. By comparing the chemical compositions of tropical and northern peats, Bonner & Grover (2024) explore the likelihood that a temperature-dependent oxidation process is occurring in tropical peatlands and suggest this could have significant implications for peatland carbon release across different latitudinal zones and climate change scenarios.

While these articles make clearer the potential consequences of tropical peatland degradation for the global carbon cycle, Mendham *et al.* (2024) and Sakuntaladewi *et al.* (2024) highlight an opportunity to counteract them. Carbon markets, which pay credits to local communities for CO₂ emission reduction through successful peat rewetting, offer a promising financial mechanism to support livelihoods for peatland restoration (Mendham *et al.* 2024). While existing carbon traders have expressed interest in this opportunity, there remains a need for local communities to grow their understanding of, and engagement with, carbon trading, to ultimately drive peatland restoration from the community level (Sakuntaladewi *et al.* 2024).

GLOBALLY APPLICABLE LESSONS

The body of work presented here is purposively place-based and yet it has generated insights that are globally applicable, which are outlined below.

Bonner and Grover (2024) propose the existence of an as-yet undescribed mechanism comprising part of the process of peat accumulation that, as temperatures continue to rise, may lead to a rapid disappearance of northern hemisphere peatlands,

based on the chemistry of tropical peatlands and the energetic economics of microbial decomposition. This idea emerged from the open-minded engagement across disciplines and cultures created within this multidisciplinary team. Toumbourou *et al.* (2024) consciously lean in to the differences and disparate perspectives that can make interdisciplinary work challenging, and build a new methodology for developing a shared vision in the context of social and ecological dimensions of peatland restoration. The resulting three-phase 'Delphi survey + focus group discussion' approach can be used productively by researchers and stakeholders seeking to articulate a desired future state at any location on the planet where people and place interact. The implementation of this process for developing a shared vision marked a turning point in our research initiative that enabled truly interdisciplinary outputs - such as this volume - to emerge.

Another globally applicable lesson has manifested in the process of synthesising such a diverse body of research into this Foreword introducing the articles. This lesson is the central position afforded to how people use peatlands by researchers, community members and government stakeholders across what is often considered to be a disciplinary divide between the social and biophysical sciences. Livelihoods and land use, as the most prevalent cross-cutting theme in this volume, is universally agreed to be critical to tropical peatland restoration, fire prevention and sustainable management. Both contributing to the problem of peatland degradation and providing the seed of the only realistic and sustainable solutions, people and their interaction with place at local scale has emerged from this body of work as the pathway towards a future in which peatlands support equitable local livelihoods alongside global climate change mitigation.

OPPORTUNITIES FOR FUTURE RESEARCH

The future of peatland restoration and conservation in Indonesia involves understanding and engaging across social, biophysical and practice-based dimensions. In this volume we capture a simultaneously responsive and reciprocal practice (Kanngieser & Todd 2021) in writing and collaboration, as well as the findings of the included studies. We emerge with a treatise, illuminating opportunities to guide future research efforts in tropical peatlands. We highlight a clear need for future efforts that are community-centred, prioritise social and ecological care, and use radical collaborative practices.

Peatland practices and studies need to integrate many knowledges and disciplines, seeing the context as a complex social ecological system. From this systems-based approach, we can focus on more specific threads and contexts of restoration and conservation challenges. Greater understanding of the socio-technical dimensions are needed, such as how to successfully rewet peatlands and support the reactivation of peat accumulation so they become net sinks of carbon (Kunarso *et al.* 2024, Sinclair *et al.* 2024), while directly benefitting community livelihoods (Mendham *et al.* 2024, Sakuntaladewi *et al.* 2024). Further, we need to explore how to work across broad-based societal values - from local to global - and how to support opportunities for greater benefit to communities from their home peatlands. Efforts that serve the needs and aspirations of communities are a critical link for all aspects of peatland restoration, and there is a need for processes that enable all interested actors to refine ongoing research and knowledge generation efforts, ensuring fit-for-purpose approaches, questions and methodologies. Critical practice-based approaches are needed to bring together the multiple dimensions of peatland conservation and restoration to guide transitions which centre social and ecological equity to provide clear benefits for livelihood and social aspects of local communities, environments, and global-scale sustainability.

ACKNOWLEDGEMENTS

This work was supported by the ACIAR (Australian Centre for International Agricultural Research) projects FST/2016/144 “Improving community fire management and peatland restoration; Gambut Kita” and SLaM/2020/118 “Validating technologies for assessing and monitoring the impacts of re-wetting of Indonesian peatland using eddy flux towers coupled with the Chameleon sensors”. The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Writing - original draft: DSM, NS, TWY, JDL, AR, SG, ST; writing - review and editing: ST, SG, AR, DSM, JDL; conceptualisation: SG; funding acquisition: DSM, SG; project administration: SG, ST.

REFERENCES

Articles in this volume

- Akbar, A., Applegate, G.B., Kurniawan, A., Hadi, E.E.W., Idrus, N.I., Arifanti, V. (2024) Tropical peatland village communities’ self-perceived attitude and behaviour changes regarding fire usage. *Mires and Peat*, 30, 10, 22 pp.
- Bonner, M.T.L., Grover, S.P. (2024) Patterns of global peat chemistry suggest a novel temperature-dependent carbon cycling mechanism. *Mires and Peat*, 30, 08, 7 pp.
- Fleming, A., Mendham, D.S., Sakuntaladewi, N., Grover, S., Jalilov, S.-M., Paul, B., Nasution, A.H., Lestari, S., Sinclair, A.L., Rachmanadi, D., Yuwati, T.W., Winarno, B. (2024) Community perceptions of peat rewetting in Tumbang Nusa Village, Indonesia. *Mires and Peat*, 30, 01, 17 pp.
- Jalilov, S.-M., Lestari, S., Winarno, B., Yuwati, T.W., Sakuntaladewi, N., Mendham, D.S. (2024) Why is tropical peatland conservation so challenging? Findings from a livelihood assessment in Sumatra, Indonesia. *Mires and Peat*, 30, 03, 20 pp.
- Kunarso, A., Farquharson, R., Rachmanadi, D., Hearn, K., Blanch, E., Grover, S. (2024) Land use change alters carbon composition and degree of decomposition of tropical peat soils. *Mires and Peat*, 30, 06, 23 pp.
- Mendham, D.S., Sakuntaladewi, N., Ramawati, Yuwati, T.W., Budiningsih, K., Prasetyo, B.D., Handoyo (2024) Facilitating new livelihoods to promote peatland restoration in Indonesia - what are the challenges for ensuring sustainable and equitable livelihood transitions? *Mires and Peat*, 30, 04, 14 pp.
- Rochmayanto, Y., Sakuntaladewi, N., Iqbal, M., Winarno, B., Lestari, S., Qirom, M.A., Ardhana, M.A., Malau, L.R.E., Anjani, R., Yulni, T., Akbar, A., Mendham, D.S., van Kerkhoff, L., Robins, L. (2024) Stakeholder mapping for peatland fire management in Indonesia: The case of Kayu Labu and Tumbang Nusa Villages. *Mires and Peat*, 30, 09, 16 pp.
- Sakuntaladewi, N., Mendham, D.S., Subarudi, Rochmayanto, Y., Jalilov, S.-M., Djaenudin, D., Effendi, R., Astana, S., Wibowo, A. (2024) Vulnerability of communities living on peatlands to climate change and peatland degradation: A case study in Tumbang Nusa Village, Central Kalimantan, Indonesia. *Mires and Peat*, 30, 05, 18 pp.
- Sinclair, A.L., Graham, L.L.B., Grover S.P. (2024) More field-based carbon monitoring of tropical



peatland restoration is urgently needed: findings from a systematic literature review. *Mires and Peat*, 30, 07, 23 pp.

Toumbourou, T.D., Grover, S., Arifanti, V.B., Budiningsih, K., Idrus, N.I., Lestari, S., Rachmanadi, D., Sakuntaladewi, N., Salminah, M., Treby, S., Winarno, B., Yuwati, T.W., Ramawati, Rawluk, A. (2024) Identifying a shared vision for peatland restoration: adapting the Delphi method to enhance collaboration. *Mires and Peat*, 30, 02, 24 pp.

Other references

Anda, M., Ritung, S., Suryani, E., Sukarman, Hikmat, M., Yatno, E., Mulyani, A., Subandiono, R.E., Suratman, Husnain (2021) Revisiting tropical peatlands in Indonesia: Semi-detailed mapping, extent and depth distribution assessment. *Geoderma*, 402, 115235, 14 pp.

BRGM (2022) *Laporan Kinerja 2022 (Performance Report 2022)*. Badan Restorasi Gambut dan Mangrove (BRGM), Jakarta, 81 pp. (in Indonesian). Online at: <https://brgm.go.id/publikasi/>, accessed 11 Dec 2023.

Cochrane M.A. (2003) Fire science for rainforests. *Nature*, 421, 913–919.

de Siqueira, L.P., Tedesco, A.M., Meli, P., Diederischen, A., Brancalion, P.H.S (2021) Gender inclusion in ecological restoration. *Restoration Ecology*, 29(7), e13497, 5 pp.

Dickinson, H., Shipp, L., Noka, V. (2020) “Reclaiming Success.” Online at: <https://reclaim-success.wordpress.com/>, accessed 18 Feb 2020.

Dreher, T. (2009) Listening across difference: Media and multiculturalism beyond the politics of voice. *Continuum*, 23(4), 445–458.

Edwards, S.A., Heiduk, F. (2015) Hazy days: Forest fires and the politics of environmental security in Indonesia. *Journal of Current Southeast Asian Affairs*, 34(3), 65–94.

Elias, M., Joshi, D., Meinsen-Dick, R. (2021) Restoration for whom, by whom? A feminist political ecology of restoration. *Ecological Restoration*, 39(1–2), 3–15.

Elias, M., Kandel, M., Mansourian, S., Meinsen-Dick, R. and 43 others (2022) Ten people-centered rules for socially sustainable ecosystem restoration. *Restoration Ecology*, 30(4), e13574, 8 pp.

Gentine, P., Green, J.K., Guérin, M., Humphrey, V., Seneviratne, S.I., Zhang, Y., Zhou, S. (2019) Coupling between the terrestrial carbon and water cycles—a review. *Environmental Research Letters*, 14(8), 083003, 19 pp.

Hall, M.M., Wehi, P.M., Whaanga, H., Walker, E.T., Koia, J.H., Wallace, K.J. (2020) Promoting social

and environmental justice to support Indigenous partnerships in urban ecosystem restoration. *Restoration Ecology*, 29(1), e13305, 7 pp.

Harrison, M.E., Page, S.E., Limin, S.H. (2009) The global impact of Indonesian forest fires. *Biologist*, 56(3), 156–163.

Harrison, M.E., Ottay, J.B., D’Arcy, L.J., Cheyne, S.M. and 27 others (2019) Tropical forest and peatland conservation in Indonesia: Challenges and directions. *People and Nature*, 2(1), 4–28.

Heil, A. (2007) *Indonesian Forest and Peat Fires: Emissions, Air Quality, and Human Health*. PhD thesis, Reports on Earth System Science 50, Max-Planck Institute for Meteorology, Hamburg, Germany, 142 pp.

Hein, L., Spadaro, J.V., Ostro, B., Hammer, M., Sumarga, E., Salmayenti, R., Boer, R., Tata, H., Atmoko, D., Castañeda, J.-P. (2022) The health impacts of Indonesian peatland fires. *Environmental Health*, 21(1), 62, 16 pp.

Hooijer A., Silvius M., Wösten H., Page S. (2006) *Peat-CO₂: Assessment of CO₂ Emissions from Drained Peatlands in SE Asia: Report R&D Projects Q3943/Q3684/Q4142*. Report Q3943, Delft Hydraulics, Delft, The Netherlands, 36 pp.

Joosten, H., Clarke, D. (2002) *Wise Use of Mires and Peatlands: Background and Principles Including a Framework for Decision-Making*. International Mire Conservation Group and International Peat Society, Saarijärvi, 304 pp.

Kanngieser, A. (2013) Towards a careful listening. In Plotegher, P., Zechner, M., Hansen, B.R. (eds.) *Nanopolitics Handbook*, Minor Compositions, London, 235–247.

Kanngieser, A., Todd, Z. (2021) From environmental case study to environmental kin study. *History and Theory*, 59(3), 309–496.

Limin, S.H., Jentha, Ermiasi, Y. (2007) History of the development of tropical peatland in Central Kalimantan, Indonesia. *Tropics*, 16, 291–301.

Miettinen, J., Shi, C., Liew, S.C. (2016). Land cover distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with changes since 1990. *Global Ecology and Conservation*, 6, 67–78.

Nurbaya, S., Efransjah (eds.) (2020) *The State of Indonesia’s Forests 2020*. Ministry of Environment and Forestry, Jakarta, 189 pp. Online at: <https://kemlu.go.id/download/L1NoYXJlZCUyMERvY3VtZW50cy9Eb2t1bWVuX0luZm9ybWFzaS9UaGUIMjBTdGF0ZSUyMG9mJTIwSW5kb25lc2lhJTIwRm9yZlZlX0JTIwMjAyMCUyMChSZXByaW50ZWQpLnBkZg==>, accessed 04 Dec 2023.

Nurbaya, S., Efransjah (eds.) (2022) *The State of*

- Indonesia's Forests 2022*. Ministry of Environment and Forestry, Jakarta, 96 pp. Online at: <https://backpanel.kemlu.go.id/Shared%20Documents/The%20State%20of%20Indonesias%20Forest%202022.pdf>, accessed 05 Dec 2023.
- Page, S.E., Baird, A.J. (2016) Peatlands and global change: response and resilience. *Annual Review of Environment and Resources*, 41, 35–57.
- Page, S.E., Siegert, F., Rieley, J.O., Boehm, H.-D.V., Jaya, A., Limin, S.H. (2002) The amount of carbon released from peat and forest fires in Indonesia during 1997. *Nature*, 420, 61–65.
- Pascoe, S., Sanders, A., Rawluk, A., Satizábal, P., Toumbourou, T. (2020) Intervention - “Holding space for alternative futures in academia and beyond”. *Antipode Online*, 22 Apr 2020. Online at: <https://antipodeonline.org/2020/04/22/holding-space-for-alternative-futures-in-academia-and-beyond/>, accessed 05 Dec 2023.
- Rawluk, A., Beilin, R., Bender, H., Ford, R.M. (2020) *Practices in Social Ecological Research: Interdisciplinary Collaboration in ‘Adaptive Doing’*. Palgrave-McMillan, London, 137 pp.
- Sakuntaladewi, N., Rachmanadi, D., Mendham, D.S., Yuwati, T.W., Winarno, B., Premono, B.T., Lestari, S., Ardhana, A., Ramawati, Budiningsih, K., Hidayat, D.C., Iqbal, M. (2022) Can we simultaneously restore peatlands and improve livelihoods? Exploring community home yard innovations in utilizing degraded peatland. *Land*, 11(2), 150, 22 pp.
- Santoso, M., Hopke, P.K., Damastuti, E., Lestiani, D.D., Kurniawati, S., Kusmartini, I., Prakoso, D., Kumalasari, D., Riadi, A. (2022) The air quality of Palangka Raya, Central Kalimantan, Indonesia: The impacts of forest fires on visibility. *Journal of the Air & Waste Management Association*, 72(11), 1191–1200.
- Stockwell, C.E., Jayarathne, T., Cochrane, M.A., Ryan, K.C., Putra, E.I., Saharjo, B.H., Nurhayati, A.D., Albar, I., Blake, D.R., Simpson, I.J., Stone, E.A., Yokelson, R.J. (2016) Field measurements of trace gases and aerosols emitted by peatland fires in Central Kalimantan, Indonesia during the 2015 El Niño. *Atmospheric Chemistry and Physics*, 16(18), 11711–11732.
- Sulaeman, D., Sari, E.N.N., Westhoff, T.P. (2021) Effects of peat fires on soil chemical and physical properties: a case study in South Sumatra. *IOP Conference Series: Earth and Environmental Science*, 648, 012146, 11 pp.
- Tan, Z.D., Sutikno, S., Carrasco, L.R., Taylor, D. (2023) Local community representations of tropical peatlands and implications for restoration in Riau, Indonesia. *Restoration Ecology*, 31(5), e13900, 14 pp.
- Turetsky, M.R., Benscoter, B., Page, S., Rein, G., van der Werf, G.R., Watts, A. (2015) Global vulnerability of peatlands to fire and carbon loss. *Nature Geoscience*, 8, 11–14.
- Uda, S.K., Hein, L., Atmoko, D. (2019) Assessing the health impacts of peatland fires: a case study for Central Kalimantan, Indonesia. *Environmental Science and Pollution Research*, 26, 31315–31327.
- Uda, S.K., Schouten, G., Hein, L. (2020) The institutional fit of peatland governance in Indonesia. *Land Use Policy*, 99, 103300, 8 pp.
- Wasis, B., Saharjo, B.H., Putra, E.I. (2019) Impacts of peat fire on soil flora and fauna, soil properties and environmental damage in Riau Province, Indonesia. *Biodiversitas*, 20(6), 1770–1775.

Submitted 19 Oct 2023, final revision 09 Dec 2024
 Editor: Olivia Bragg

Author for correspondence:

Dr Samantha Grover, Applied Chemistry and Environmental Science, RMIT University, 124 La Trobe Street, Melbourne, 3000 Australia. Tel: +61 458 197 540; E-mail: samantha.grover@rmit.edu.au

