Received: 23 May 2025 | Accepted: 28 May 2025
DOI: 10.1002/ppp3.70062

Plants People Planet PPP Open Access

EDITORIAL

Madagascar's grassy biomes, from Holocene to Anthropocene

Madagascar, home to almost 30 million people, faces the challenge of ensuring both adequate living standards for its growing population and the persistence of its unique and highly threatened biodiversity (Ralimanana et al., 2022). Almost 80% of the island is covered by open, grass-dominated biomes (Food and Agriculture Organisation [FAO], 2010), characterised by fire and herbivory as is common across the tropics (Parr et al., 2014). Grassy biomes in Madagascar are remarkable in their relatively short shared history with humans through the Holocene and into the current Anthropocene event: the island is one of the most recent land masses where humans settled, between 2000 and 10,000 years ago (Douglass et al., 2019; Hansford et al., 2018). Since then, people have depended on, and interacted with, Madagascar's diverse ecosystems, including grassy biomes. These have played a central role in Malagasy history, culture and economy that is supported through feeding large stocks of zebu cattle. The ecology of Madagascar's grassy biomes and how it relates to interactions with humans have been the focus of much recent work and debate, with integration of research across disciplines needed. In 2021, we organised a virtual workshop bringing together around 40 participants over 4 days to combine multiple perspectives on Madagascar's grassy biomes. This workshop had two outcomes: a joint paper outlining perspectives for transdisciplinary collaboration (Phelps et al., in press) and the present special collection, for which we served as co-ordinators and guest editors, supported by the *Plants, People, Planet* editorial board.

The 13 papers in this collection offer an interdisciplinary view on Madagascar's grassy biomes. Contributions range from the geosciences (Cox et al., 2024) to human geography (Joseph, Rakotoarivelo, & Seymour, 2024), (palaeo-)ecology (Crowley, Godfrey, & Samonds, 2023; Crowley, Schmidt, & Vorontsova, 2023; Hixon et al., 2023; Joseph, Rakotoarivelo, Pedrono, & Seymour, 2024; Joseph, Randriatsara, Rakotoarivelo, et al., 2024; Joseph, Seymour, & Rakotoarivelo, 2024; Razafimanantsoa & Razanatsoa, 2024; Silander et al., 2024; Tiley et al., 2024) and plant taxonomy (Ramiandrisoa et al., 2024; Randrianarimanana et al., 2024). They use various approaches, including literature reviews (Cox et al., 2024; Silander et al., 2024), novel interpretation of existing datasets (Joseph, Rakotoarivelo, Pedrono, & Seymour, 2024; Joseph, Randriatsara, Rakotoarivelo, et al., 2024; Joseph, Seymour, & Rakotoarivelo, 2024) and novel data gathering (Crowley, Godfrey, & Samonds, 2023; Hixon et al., 2023; Joseph, Rakotoarivelo, & Seymour, 2024; Ramiandrisoa et al., 2024; Randrianarimanana et al., 2024; Razafimanantsoa & Razanatsoa, 2024; Tiley et al., 2024). These diverse perspectives do not always result in consensus and include diverging interpretations. Although contention remains, and some readers, and even collection authors or members of the guest editor group, may not support all of the conclusions put forward, this special collection takes an important step in presenting existing perspectives and highlighting the areas where further refinement of our methods and interpretations are needed.

One long-standing debate—on the nature of grassy biomes in Madagascar's central highlands—continues in this collection, with some articles supporting the old-growth hypothesis (Silander et al., 2024; Tiley et al., 2024) and others supporting the human-origin hypothesis (Crowley, Schmidt, & Vorontsova, 2023; Joseph, Rakotoarivelo, Pedrono, & Seymour, 2024; Joseph, Seymour, & Rakotoarivelo, 2024). The old-growth hypothesis proposes that grassy biomes were substantial and potentially extensive parts of Madagascar's landscapes prior to human arrival (Bond et al., 2008); the human-origin hypothesis suggests that the current extent of grassy biomes results primarily from landscape degradation, especially deforestation (Joseph & Seymour, 2020). This continued debate likely reflects that new complementary datasets are needed to understand the complexity of Madagascar's landscape to move forward. The diverse methodologies used in this collection—interviews (Cox et al., 2024; Randrianarimanana et al., 2024), stable isotope analysis (Crowley, Godfrey, & Samonds, 2023; Crowley, Schmidt, & Vorontsova, 2023; Hixon et al., 2023), grass taxonomy (Ramiandrisoa et al., 2024; Randrianarimanana et al., 2024), palynology (Razafimanantsoa & Razanatsoa, 2024), toponymy (Joseph, Rakotoarivelo, & Seymour, 2024) and genetic modelling (Tiley et al., 2024)—offer some perspectives for future work to be expanded across Madagascar.

Humans interact with grassy biomes in complex and dynamic ways. One such interaction includes afforestation of grassy biomes across Madagascar with exotic tree species like pines or eucalypts. Silander et al. (2024) warn against the harmful effects such activities might have on ecosystem function, while Razafimanantsoa and Razanatsoa (2024) show that modern sediment pollen records can be used to track the invasion of alien trees. Regarding livestock raised in grassy biomes, Joseph, Rakotoarivelo, Pedrono and Seymour (2024) argue that dominant grass species may have low palatability. On a more local scale, a striking landscape feature, especially in the central highlands, are erosion gullies (*lavaka*). Although *lavakas* are often viewed as the result of environmental degradation, the review by

Cox et al. (2024) shows how such gully erosion is a process that had already occurred before human arrival and leads to colluvial deposits, which are exploited by farmers for growing trees and field crops. In contrast, Joseph, Rakotoarivelo and Seymour (2024) cite forest-related toponyms close to erosion sites now deforested as evidence for human topsoil degradation. Also on a local scale, Randrianarimanana et al. (2024), show that farmers use specialist grass identification skills to recognise the most damaging weed species. What emerges from these studies is that the diverse facets of human–grassy biome coexistence and interactions require interdisciplinary research approaches that engage with a variety of spatial and temporal scales of observation (Phelps et al., in press).

Grassy biome dynamics on Madagascar are perhaps best understood and studied as part of vegetation mosaics, a point made by several contributors. Mosaics can be created by geophysical processes such as the aforementioned gully erosion that provides habitat patches for tree islands in a grassy landscape (Cox et al., 2024). The potential role of extinct megafauna in creating and maintaining vegetation mosaics in the past is discussed in three contributions (hippos in wet habitats: Crowley, Schmidt, & Vorontsova, 2023; giant tortoises: Joseph, Randriatsara, Rakotoarivelo, et al., 2024; Silander et al., 2024), with potential to test proposed hypotheses, at least for tortoises, in ongoing rewilding experiments (Pedrono et al., 2020). Finally, Hixon et al. (2023) demonstrate that dogs, introduced by humans, actively cross forest–grassy biome edges for hunting in remaining forest around settlements. A better understanding of mosaic dynamics across Madagascar may help to apply function-based biome typology (Keith et al., 2022) to Malagasy grassy biomes, both old-growth and derived, which remain difficult to classify (Antonelli et al., 2022).

The work presented in this collection broadens the geographic scope of research on Madagascar's grassy biomes. The central highlands, where the highest population density and the most expansive grasslands are found, have been the focus of the debate on human impact. New data on the photosynthetic status of central highland grasses, presented here by Crowley, Godfrey and Samonds (2023), will be valuable for improving interpretations of diet composition in present-day and extinct herbivore remains. Tiley et al. (2024) suggest that a common open-habitat grass species, *Loudetia simplex*, has spread in Madagascar from a central highland origin before the Holocene and human arrival. Importantly, contributors have also studied other areas where limited information on grassy biomes was available so far. While the dog diet study of Hixon et al. (2023) is set in the secondary grasslands in the eastern humid forests region, Ramiandrisoa et al. (2024) provide the first grass checklist from the northeast of Madagascar where the old-growth nature of grasslands is less contentious, recording 70 species including regional endemics. More data from beyond the central highlands will be necessary to refine our understanding of grassy biome ecology.

The multifaceted relationships people have with grassy biomes in Madagascar calls for more diverse, interdisciplinary and inclusive research. On the academic side, this requires more open data to facilitate synthesis, a point emphasised by Razafimanantsoa and Razanatsoa (2024) for pollen records. It also means acknowledging the inherent cultural biases researchers often bring into the interpretation of data. There is disagreement even on these biases: Some authors in this collection identify a persisting, colonial-origin narrative of continuous forest cover in Madagascar before human contact (Silander et al., 2024); others instead see 'foreign, often paternalistic' narratives of pastoralism providing ecosystem services and defining culture (Joseph, Rakotoarivelo, Pedrono, & Seymour, 2024). Going forward, resolving these debates will require the direct involvement and contributions of those who live in and depend on these grassy ecosystems. This collection includes a fine example of such inclusive research, where local surveys were undertaken with the explicit consent and implication of communities, respecting local customs and traditions (Randrianarimanana et al., 2024). To address some of the outstanding research needs identified here on several fronts (Cox et al., 2024; Joseph, Randriatsara, Rakotoarivelo, et al., 2024; Randrianarimanana et al., 2024; Razafimanantsoa & Razanatsoa, 2024; Silander et al., 2024), inclusive and collaborative approaches will be the most fruitful in the long term if contributions aim to address current environmental and societal challenges in Madagascar.

AUTHOR CONTRIBUTIONS

J. H. and L. N. P. wrote the first draft of this manuscript. All authors contributed to and accepted the final version.

ACKNOWLEDGEMENTS

We thank all participants who contributed to our online workshop, particularly those who submitted papers to this collection. The research on grassy biomes is only possible with the support from Malagasy institutions and communities, which we would like to acknowledge here.

FUNDING INFORMATION

We acknowledge the following funding sources: a National Science Foundation fellowship (SBE-2203789) to D. S. D.; a Future Leader in Plant and Fungal Science Fellowship from the Royal Botanic Gardens, Kew to J. H.; an International Foundation for Science grant (D-6490-1), a National Geographic Society grant (EC-74884R-21) and a University of Cape Town Research Committee JRF Fellowship Award (2021/22 – PCU) to E. R.; funding from the OBT Lab at Columbia Climate School and the Swiss National Science Foundation (SNSF Postdoc. Mobility Grant P500PN_206663, P500PN_206663/2; Early Postdoc. Mobility Grant P2LAP2_187745, P2LAP2_187745/2) to L. N. P. This project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No. 101026923 awarded to G. P. T.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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Disclaimer: The New Phytologist Foundation remains neutral with regard to jurisdictional claims in maps and in any institutional affiliations.

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