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CHAPTER 3

Seventeen years of the Heart of Borneo: Research trends, progress, challenges, and pathways toward a connected conservation landscape

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Abstract: Launched in 2007, the Heart of Borneo (HoB) represents one of Southeast Asia's most ambitious transboundary conservation collaborations, encompassing approximately 24 million hectares across Brunei Darussalam, Indonesia, and Malaysia. Seventeen years on, this paper examines the progress, challenges, and research trends within the HoB landscape through a systematic review of published studies and conservation activities. Research and conservation efforts remain unevenly distributed across taxa and localities, with limited integration between science, policy, and management. The analysis shows that the HoB has strengthened regional cooperation and elevated global recognition of Borneo's rich biodiversity. At the same time, it highlights important areas where continued, collaborative efforts can further enhance ecological integrity, particularly in managing land use, restoring habitats, and promoting long-term sustainability across the landscape. To achieve the Kunming –Montreal Global Biodiversity Framework's 30×30 target, there is a need to enhance ecological connectivity, establish other effective area-based conservation measures (OECMs), and strengthen governance across political boundaries. The HoB remains a globally significant yet fragile conservation experiment. Its success will depend on coordinated action, sustained political will, and equitable engagement with local communities.

INTRODUCTION

The Heart of Borneo (HoB) Initiative, launched in 2007, is a voluntary transboundary cooperation between Brunei Darussalam, Malaysia, and Indonesia, to enable conservation and environmental protection, while enhancing sustainable development that improve the welfare of those living on the island. The initiative covers approximately 24 million hectares of land encompassing diverse land uses, representing one of the most ambitious transboundary conservation collaborations in the region and perhaps the world. In 2018, Sarawak expanded the HoB area by 565,251 hectares to include additional regions, highlighting increasing recognition of its ecological significance and the need for stronger conservation efforts. The western expansion, incorporating areas up to Tanjung Datu National Park, underscores the importance of preserving biodiversity across diverse landscapes within Sarawak's jurisdiction. The HoB covers about 32% of Borneo's landmass, encompassing roughly 17 million ha (~70% of the HoB area) in Kalimantan, 4 million ha (~17%) in Sabah, 2.7 million ha (~12%)

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in Sarawak, and 340,000 ha (~1.7%) in Brunei Darussalam (Keong and Onuma 2021) (Figure 1). In relation to each jurisdiction's total land area, approximately 59% of Brunei Darussalam, 54.1% of Sabah, 31.6% of Kalimantan, and 21.7% of Sarawak, fall within the HoB boundary.

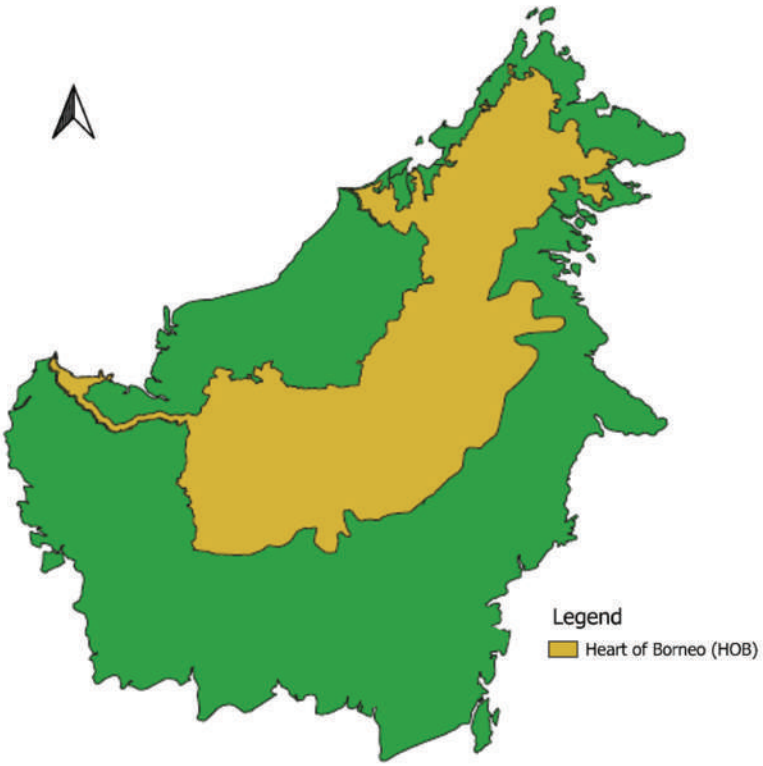

Figure 1. Map of the Heart of Borneo, including the 2018 extension by Sarawak that expands the boundary into western Sarawak.

The HoB initiative aligns closely with the Kunming-Montreal Global Biodiversity Framework (KMGBF) Global Target 3, which calls for at least 30% of terrestrial, inland water, marine, and coastal areas to be effectively conserved and managed by 2030, particularly those of high importance for biodiversity and ecosystem services. In Malaysia, the national commitment to this goal is articulated in the National Policy on Biological Diversity 2025 – 2030 (NPBD 2025 – 2030). Under Goal 3, Target 8, Malaysia aims to achieve the protection of 20% of its terrestrial areas by 2030, with a longer-term ambition to reach the 30% target within the subsequent five years. Furthermore, Goal 3, Target 10 of the NPBD 2025 – 2030 emphasises the establishment and management of key ecological corridors to strengthen landscape connectivity. Specifically, Target 10.2 seeks to enhance terrestrial ecological connectivity within Malaysian Borneo by securing, managing, and restoring key forest linkages within major forest complexes in Sabah and Sarawak. A key performance indicator for this target is a 10% increase in the protected area coverage within the HoB landscape. Similar commitments are expressed in the other two HoB countries. Indonesia has aligned its conservation agenda with global biodiversity goals, including the effective management of forest, as outlined in its Sixth National Report for the Convention on Biological Diversity (MoEF 2019) and the Forestry and Other Land Use (FOLU) Net Sink 2030 strategy (MoEF 2021). These frameworks have identified protection of forests, restoration of peatland and degraded land across major forest landscapes, including the Indonesian sector of HoB.

Brunei Darussalam showed a strong national conservation effort, aiming to increase its forest reserve from 41% to 55% of the total land area, heading towards a low carbon and climate-resilient nation and integrating biodiversity protection into national policy through the Brunei Darussalam National Climate Change Policy (BCCS 2020). Furthermore, Brunei's long-standing support for the HoB further confirms its stance in maintaining landscape connectivity and long-term ecosystem protection across Borneo. Together, these national frameworks highlight the alignment of HoB with the global "30×30" vision and shared responsibility for maintaining the ecological integrity of Borneo.

If the protected areas within the HoB can be effectively linked into a connected network, wildlife populations will be able to move between habitats and also along elevational gradients, reducing the risk of local extinctions that occur when species become confined to isolated parks surrounded by converted landscapes or are affected by climate change impacts. Effective management is equally crucial to ensure that both protected areas and wildlife corridors are safeguarded from overhunting, poaching, and illegal encroachment. A landscape or protected area network is well connected if organismal movement is sufficient to maintain the long-term persistence of species or ecological functions (including ecosystem services) relative to counterfactuals with the same amount of intact habitat and no barriers to movement (Brodie *et al.* 2025a).

Connectivity within the HoB should also be considered for aquatic and riparian organisms. Fourteen of Borneo's 20 major rivers originate from the HoB, and their watersheds extend well beyond the initiative's boundaries. Maintaining forest cover and riparian connectivity in these upper catchments therefore supports freshwater biodiversity by allowing dispersal and migration for fish and other aquatic animals, though these effects are considered far less often than in terrestrial systems. Riparian forest cover and connectivity also help regulate sedimentation, flooding, water quality, and downstream water supply. Coordinated management across entire river basins is especially important because ecological processes cross administrative and national boundaries (Witteveen+Bos 2011).

Thus, while the HoB encompasses several large and biologically significant protected areas, the long-term viability of large-bodied and wide-ranging species depends on maintaining ecological connectivity among these sites, including conserving lands outside of these protected areas. A well-connected HoB landscape will ensure that these species can persist and adapt in the face of ongoing habitat fragmentation and environmental change (Bennett 2003; Clements *et al.* 2014; Brodie *et al.* 2015). About 11 – 36% of Bornean mammal species are projected to lose 30% of their habitat based on climate projection, with increased economic cost of creating corridors estimated to be 65% higher in 2080 (Struebig *et al.* 2015, 2024).

Since its declaration, the three governments, along with NGOs, have conducted numerous scientific expeditions, conservation initiatives, and research projects to promote sustainable forest management and protect Borneo's natural heritage. Since 2007, Sabah has developed three Strategic Plans of Action (2009, 2015, and 2022) for HoB implementation, focusing on (1) protected area expansion and management, (2) sustainable resource use and biodiversity conservation, (3) ecotourism development, (4) transboundary management, and (5) capacity building, while Sarawak has reviewed its Project Implementation Framework (PIF) in 2019 to enhance its implementation. A remarkable milestone was reached in 2013 when the Sarawak Government set a goal for concession areas within the HoB to achieve sustainable forest management (FMC) certification by 2017 (Alek and Kader 2021). This initiative paved the way for the Government's subsequent commitment in 2022 to require all long-term Forest Timber Licences to obtain FMC certification, reinforcing Sarawak's dedication to sustainable forestry and responsible resource management.

Beyond Malaysia, the HoB member countries have taken parallel steps. In Indonesia, the national authorities together with NGOs, have promoted sustainable forest management, landscape-scale green economy planning, and community-based conservation within HoB zones (WWF 2017a, 2022; Firdaus *et al*. 2018). In April 2017, Indonesia established a National Task Force to advise on the development of a long-term roadmap for coordinated implementation, including opportunities for sustainable investment benefiting nature, communities, and the regional economy (WWF 2017a). Brunei Darussalam has likewise remained an active and committed partner. The country continues to play a key role in trilateral cooperation, including hosting several Trilateral Meetings and dynamically participating in the planning of transboundary initiatives such as the proposed HoB Corridor Project linking protected areas across the three countries (WWF 2017b; Keong and Onuma 2021).

Seventeen years after its inception, several positive developments have emerged, including increasing adoption of High Conservation Value (HCV) and sustainable forest management (SFM) standards. To ensure continued progress, a clearer picture of the knowledge gaps, issues, and challenges across the HoB landscape is needed. Accordingly, two central questions emerge: (1) What are the research trends and prevailing issues and challenges within the HoB, and; (2) How evenly are research and conservation efforts distributed across taxa and localities? To address these issues, a Systematic Literature Review (SLR) following a multi-step screening process was conducted. Studies were examined to assess publication trends, identify the taxa and regions that have received the most research attention, international collaborations, and funding sources. In total, 831 journal articles were initially identified, from which 438 publications met the selection criteria and were included in the analysis.

All spatial analyses were conducted in ArcGIS Pro version 3.5. Area calculations were performed using the Calculate Geometry tool. Village, river, and road features were buffered before calculating the areas to provide measurable polygon-based estimates (Village: 1km; River: 10 m; Road: 7.4 m). This assessment offers valuable insights into the threats, existing knowledge, and conservation challenges within the HoB landscape. It also highlights key research and management gaps, while providing guidance that may help shape future research directions and policy priorities.

Biodiversity research gaps

The understanding of research patterns within HoB is important as environmental and human pressures continue to influence the ecosystem resilience and research priorities. Biodiversity studies across the HoB exhibit a noticeable bias towards particular charismatic or readily accessible taxa. For flora, most publications are concentrated on a few prominent groups such as orchids, trees (including dipterocarps, mangroves, and other non-dipterocarps), gingers, and shrubs. In contrast, pitcher plants, palms, and many other groups have received comparatively less research attention (Figure 2a). For fauna, research shows a strong taxonomic bias toward mammals and herpetofauna, which together represent more than half of all studies conducted between 2007 and 2024 (Figure 2b). Although birds, fish, and invertebrates are critical for ecosystem processes such as pollination, seed dispersal, and nutrient cycling (Ng *et al.* 2020; Kamal *et al*. 2022; Nursyamin *et al.* 2023), they remain comparatively underrepresented in the HoB.

Flora studies were published predominantly in regionally oriented journals like *Reinwardtia*, *Gardens' Bulletin*, *Scientia Bruneiana* and the *Journal of Tropical Biology and Conservation*, accounting for a high share of flora studies (Figure 2e). For fauna, The *Raffles Bulletin of Zoology* and *Journal of Tropical Biology and Conservation* represent the largest number of publications followed by the few Malaysian-based journals such as *Borneo Journal of Resource Science and Technology*, *Malaysian Applied Biology*, *Malayan Nature Journal*, and a few international publishers such as *Zootaxa* and *Oryx* (Figure 2f).

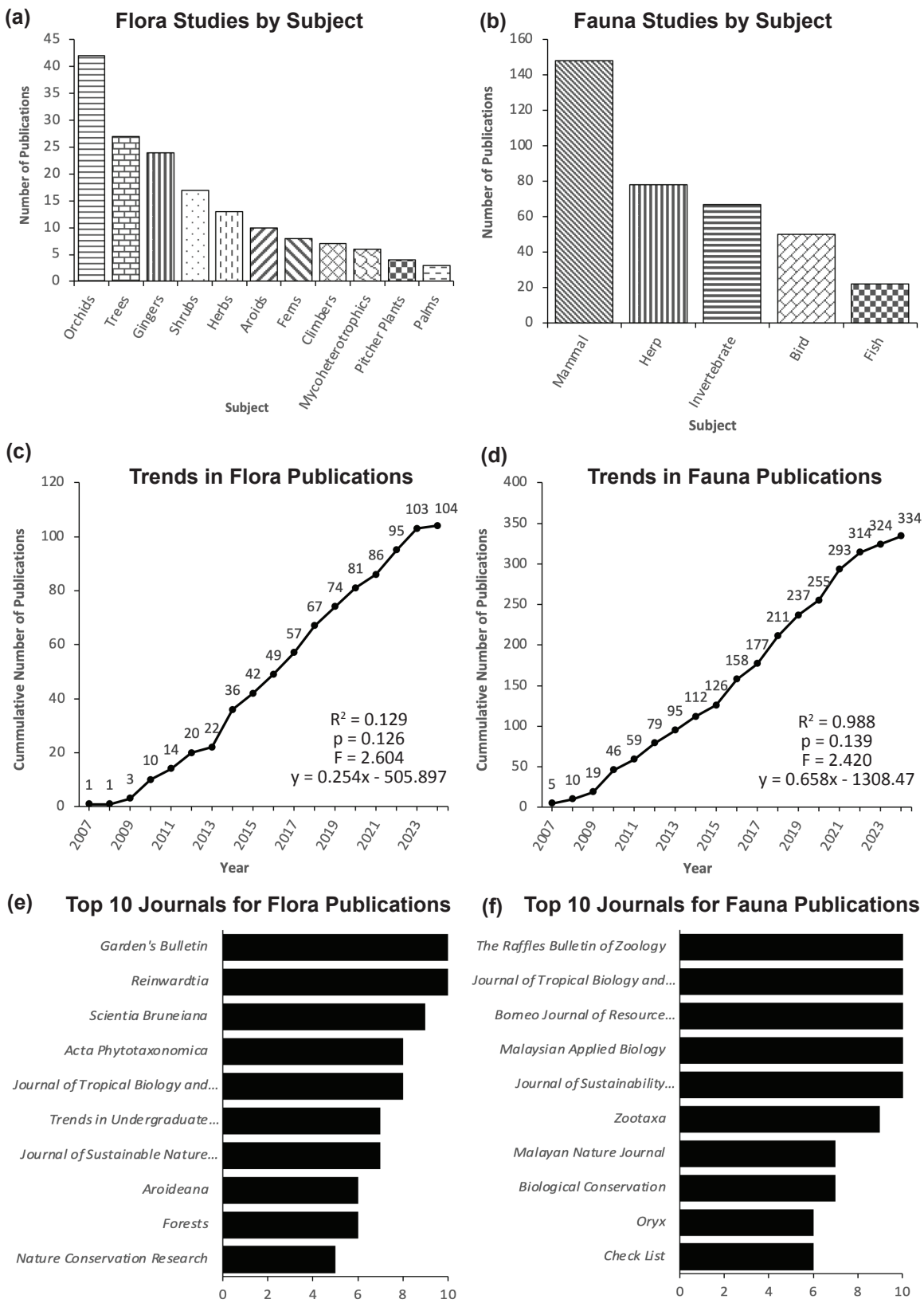

Figure 2. Distribution of flora and fauna research in HoB. Number of studies by subject/taxa categories for **(a)** flora, **(b)** fauna; annual trend in publications for **(c)** flora, **(d)** fauna; and, top 10 published journals for **(e)** flora, **(f)** fauna.

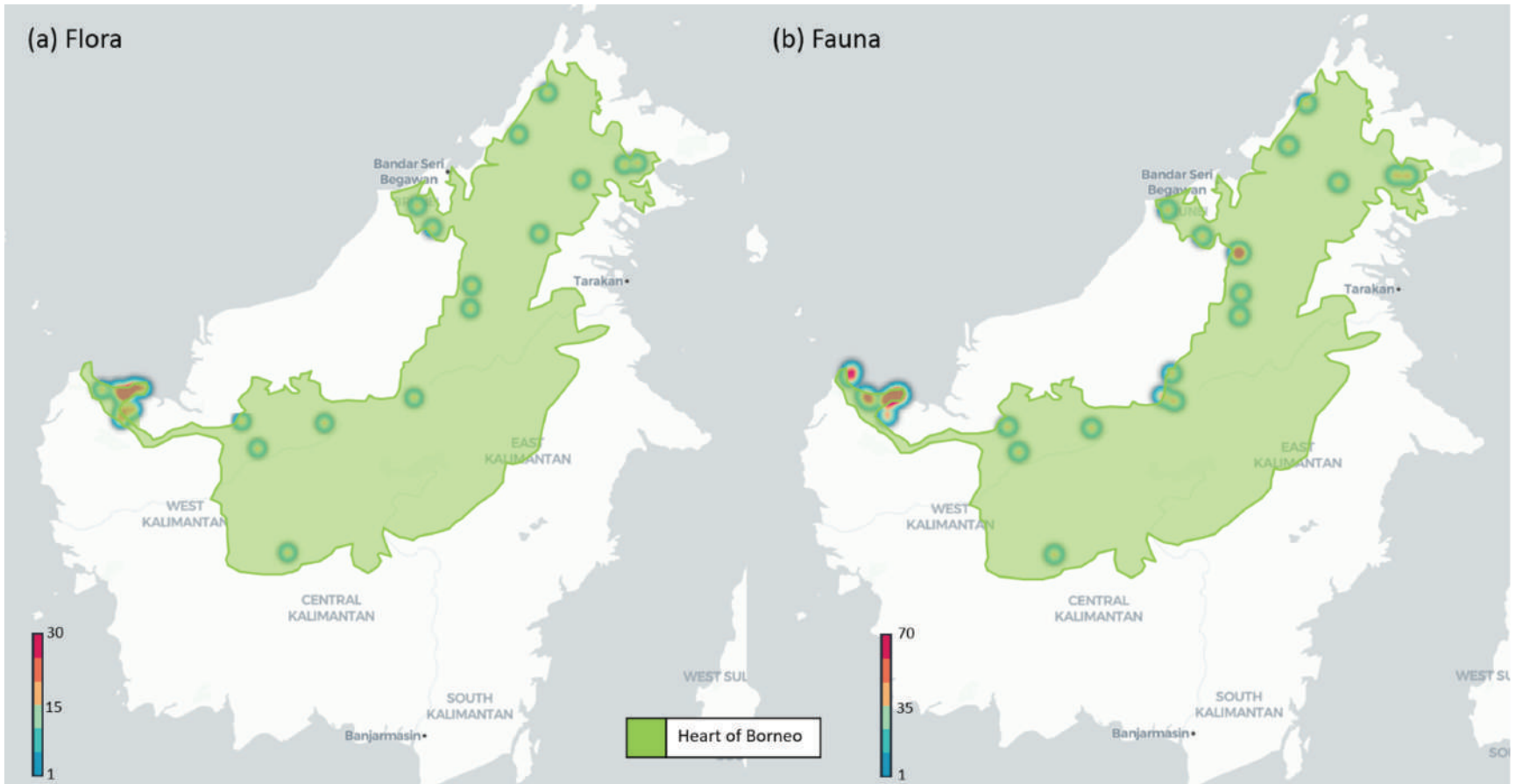

Figure 3. Research intensity heat maps for HoB of **(a)** flora and **(b)** fauna studies.

These findings indicate that the biodiversity research in HoB is largely driven by regional institutions and networks, with participation in international publication platforms still limited.

Studies of both plants and animals show that there are clear biases towards research areas in the HoB that are easy to access and well-known, such as Gunung Mulu, Kubah, and Pulong Tau National Parks (Figure 3). Much of the HoB's interior remains poorly documented scientifically. This geographic imbalance is caused by limited access and difficult logistics (Yang *et al.* 2019). Maps of research intensity (Figure 3) make these patterns even clearer and further highlight that biodiversity assessments covering the whole HoB would greatly contribute to management-relevant knowledge generation across the area.

Research in the HoB mainly consists of short-term and site-specific sampling. Over 17 years, 37 scientific expeditions were conducted across 47 forest reserves within Sabah's HoB area, generating biodiversity data that informed forest management plans and strengthened conservation efforts. Long-term monitoring with standardised survey designs is infrequent, limiting the detection of population trends, community turnover, and ecosystem responses to land-use and climate change. Several field facilities in the HoB do support long-term ecological research, including Danum Valley and Maliau Basin in Sabah, Kuala Belalong in Brunei, Lalut Birai in Kayan Mentarang, and the recently established Bako Research Station in Sarawak. But these facilities do not operate as a coordinated HoB-wide monitoring network. Linking research stations and other long-term study sites through common sampling protocols, shared data infrastructure and coordinated training would allow trends to be compared across jurisdictions, elevations, forest types and river basins. Such research should also incorporate interdisciplinary methodologies, and open-access data platforms that facilitate the comparison and analysis of results across taxa and regions.

Institutionally, funding patterns vary slightly between flora and fauna studies (Figure 4). For flora, the studies are supported mainly by national sources, showing strong domestic commitment to botanical work. In contrast, fauna studies show a near equal balance between local and international funding. This shows that both strong regional commitment and active global collaboration are taking place. Collaborations are further reflected in authorship patterns, with 49.4% (n = 254) of publications on the flora and fauna of the HoB involving co-authors from countries outside the island. The geographical distribution of all institutions (flora, n = 154; fauna, n = 71) and their publication output is illustrated in Figure 5. Together, these patterns highlight the importance of integrated local and international partnerships in biodiversity research and conservation in the HoB.

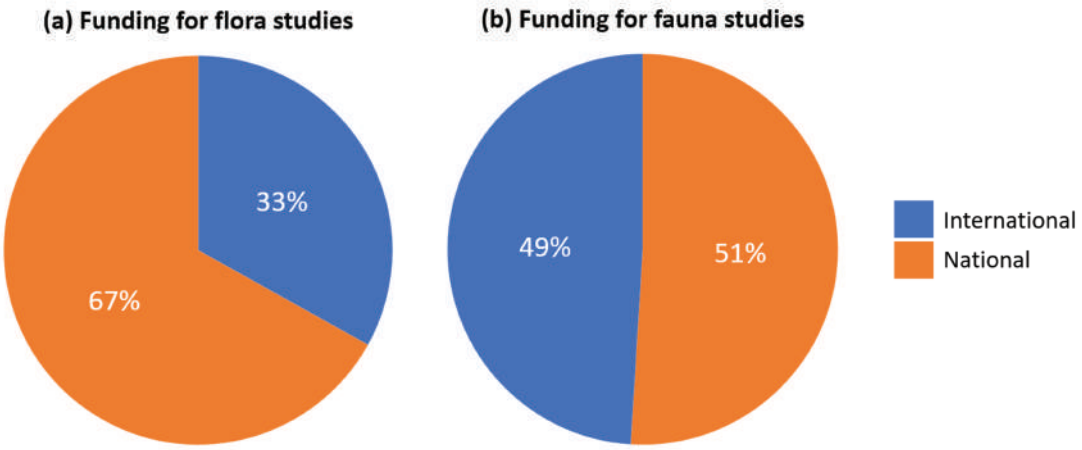

Figure 4. Scope of institutional funding for HoB research of **(a)** flora and **(b)** fauna.



Figure 5. Heatmap from geographical scope of the institutions that published flora and fauna studies on HoB from 2007 to 2024.

CHALLENGES WITHIN THE HEART OF BORNEO INITIATIVE

While the HoB faces emerging challenges, such as balancing conservation priorities with economic development, these present valuable opportunities to strengthen collaborative efforts, integrate sustainable resource management, and mobilise political and community support to safeguard the region's ecological integrity for the future. Indeed, Borneo shows the high rate of forest degradation and loss (Miettinen *et al.* 2011; Gaveau *et al*. 2016) and across much of the region, natural forests have been reduced to isolated fragments. Forest cover continues to decline, largely due to land conversion for agriculture, plantations, and infrastructure development (Gaveau *et al.* 2014). Between 2015 and 2019, there was a decrease of 2.8% in forest cover in Borneo, with lowland rainforest recording the highest loss of 2.8 million ha (WWF 2020). In the interior, logging activities intensified the construction of roads (Figure 6a), which led to further degradation of the forests.

Rural settlements (Figure 6b) form the social foundation of the HoB landscape, covering approximately 1.15% of the total HoB area (n = ~1300). Many local communities rely on forest resources for food and other needs, and many have created traditional systems of ownership that control who can use the resources and how (Wiersum 1997; Meijaard *et al.* 2013). Indigenous and local communities also play an essential role in sustaining biodiversity through traditional knowledge, customary land stewardship, and community-based conservation initiatives. Recognising and supporting these contributions is central to the long-term success of the HoB Initiative.

The hunting activities within the HoB appears under reported. Several publications reported hunting activities in these areas (Figure 6c). Local communities are generally permitted to hunt non-protected species for subsistence. Strengthening collaborative monitoring with communities can help integrate traditional knowledge with biodiversity management, supporting both sustainable livelihoods and conservation outcomes.

Within HoB, protected areas collectively cover approximately 35% of the landmass (Figure 6d), indicating that the size of protected areas remains limited relative to the region's biodiversity value. Although about 65% of the HoB remains unprotected and vulnerable to land-use change, its 35% protection exceeds global targets. The establishment of terrestrial protected areas in Sarawak appears progressing, currently covering close to 900,000 ha.

WAY FORWARD

The dynamic land-use changes within the HoB landscape strengthen the opportunity for Brunei Darussalam, Indonesia, and Malaysia to further strengthen coordinated and transboundary management. By enhancing forest connectivity, promoting sustainable land-use practices, and advancing ecological restoration, the HoB can continue to safeguard its ecological integrity. Strengthened governance and effective law enforcement, particularly in areas surrounding protected zones will support a resilient, well-connected landscape that sustains viable wildlife populations and delivers essential ecosystem services for generations to come.

A key strategy under the HoB framework involves strengthening ecological connectivity through the identification and protection of wildlife corridors linking existing protected areas and HCV areas. These efforts aim to reduce habitat fragmentation, enhance gene flow among wildlife populations, and improve ecosystem resilience (Coad *et al.* 2019). In Sarawak, the Batang Ai-Lanjak Entimau Wildlife Sanctuary, adjacent to Betung-Kerihun National Park in Kalimantan, is a good example of transboundary orang-utan conservation initiative that maintains ecological linkages and forest continuity for species movement.

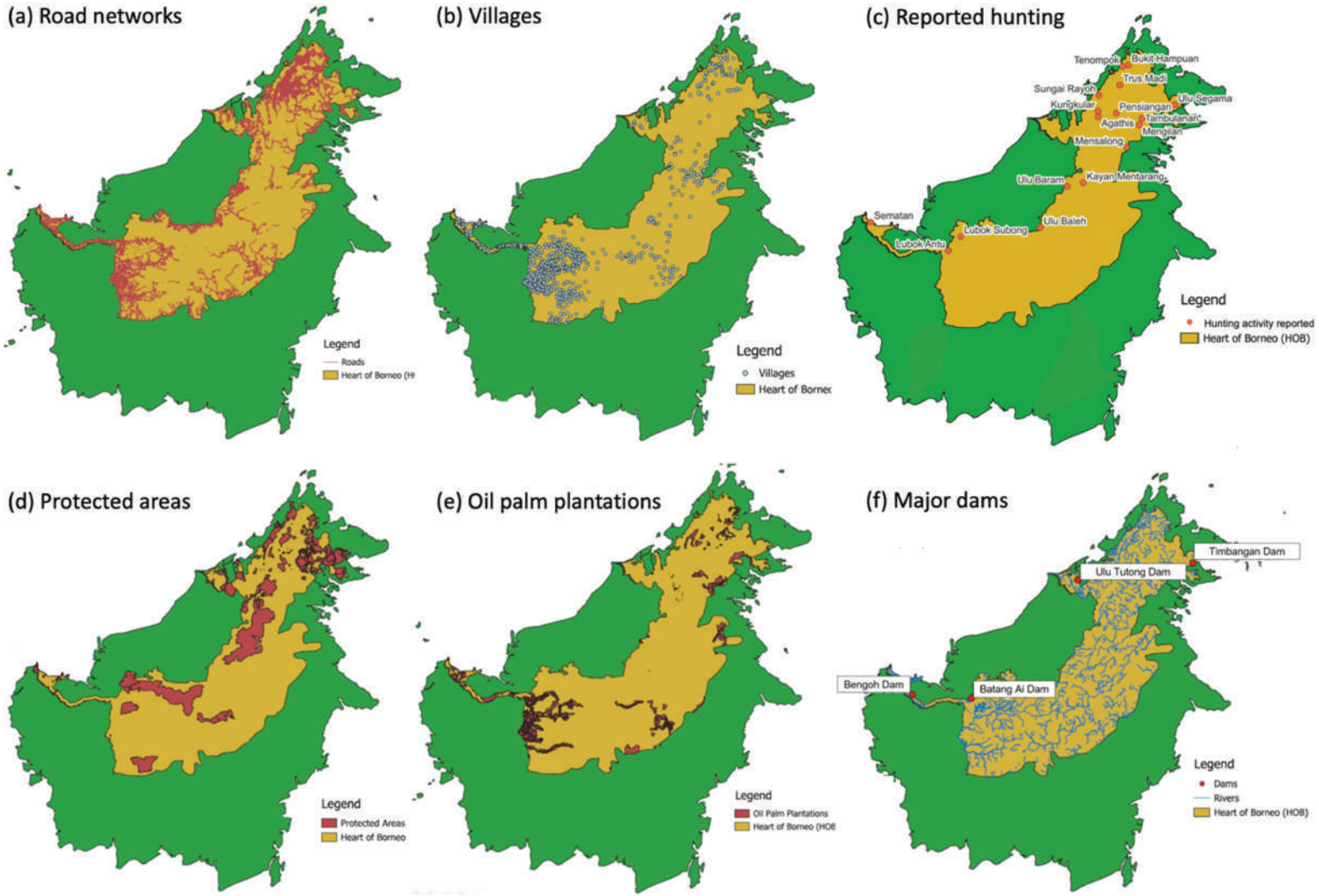

Figure 6. The land use in HoB area: **(a)** distribution of roads, **(b)** villages, **(c)** reported hunting activities, **(d)** protected areas, **(e)** distribution of oil palm areas, and **(f)** major dam projects across the HoB landscape.

Further north of this complex, Baleh National Park was gazetted after a successful expedition, indicating the role of the scientific community in extending this significant ecological connectivity. In Sabah, Ulu Segama-Malua, Northern Gunung Rara, and Maliau Basin forests are among the largest contiguous forests that serve as important wildlife corridors with HoB areas.

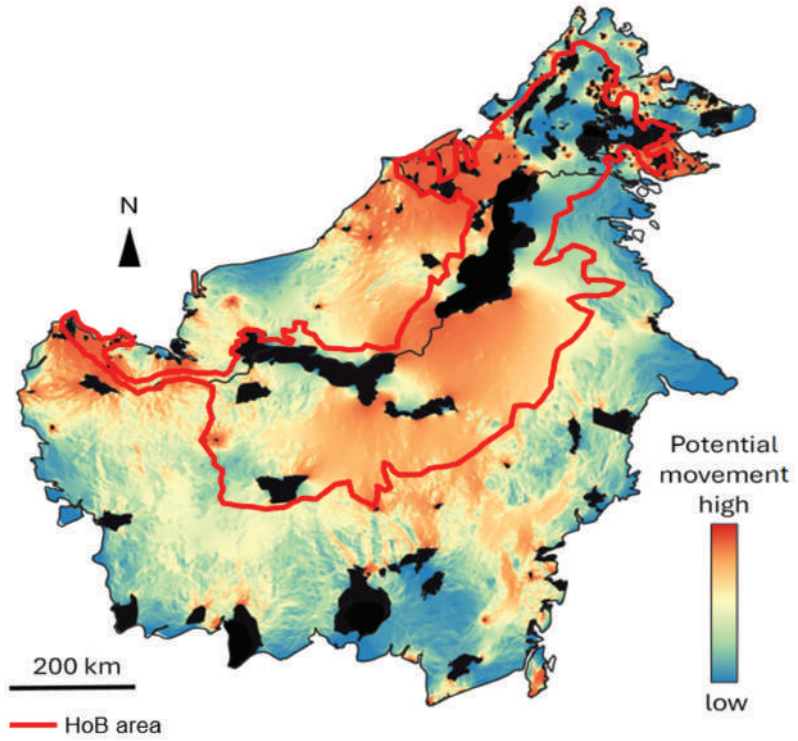

Figure 7. Landscape connectivity simulations performed using circuit theory algorithms (McRae *et al.* 2009). Landscape resistance was represented as the inverse of forest cover derived from spaceborne LiDAR measurements (Burns *et al.* 2025). The depicted potential movement values were log10-transformed (cf. Deith and Brodie 2020) and expressed without units.

Many of these national commitments are already reflected in SFM principles, implemented through various forestry frameworks and certification systems across Borneo. To build on these achievements, the HoB Initiative should continue to actively promote sustainable land-use practices through community-based forest management, HCV assessments, and credible certification schemes for both timber and palm oil. These mechanisms serve as an intervention measure to balancing conservation with economic development, especially in regions where communities depend heavily on forest resources (Azhar *et al.* 2017). The HCV approach is an effective tool for identifying not only key ecological and cultural values (Tuen *et al.* 2014), but for prescribing key management and conservation actions such as delineating conservation priority areas and reducing the uncontrolled extraction of natural resources (Areendran 2020).

Expanding OECMs within the HoB presents an opportunity to advance the 30×30 goal in a way that is inclusive, collaborative, and benefits both people and nature. OECM areas that benefit biodiversity even when conservation is not their primary objective can complement protected areas by safeguarding additional species, ecosystems, and ecosystem services, especially where formal protection is socioeconomically or politically unfeasible (Brodie *et al.* 2025b).

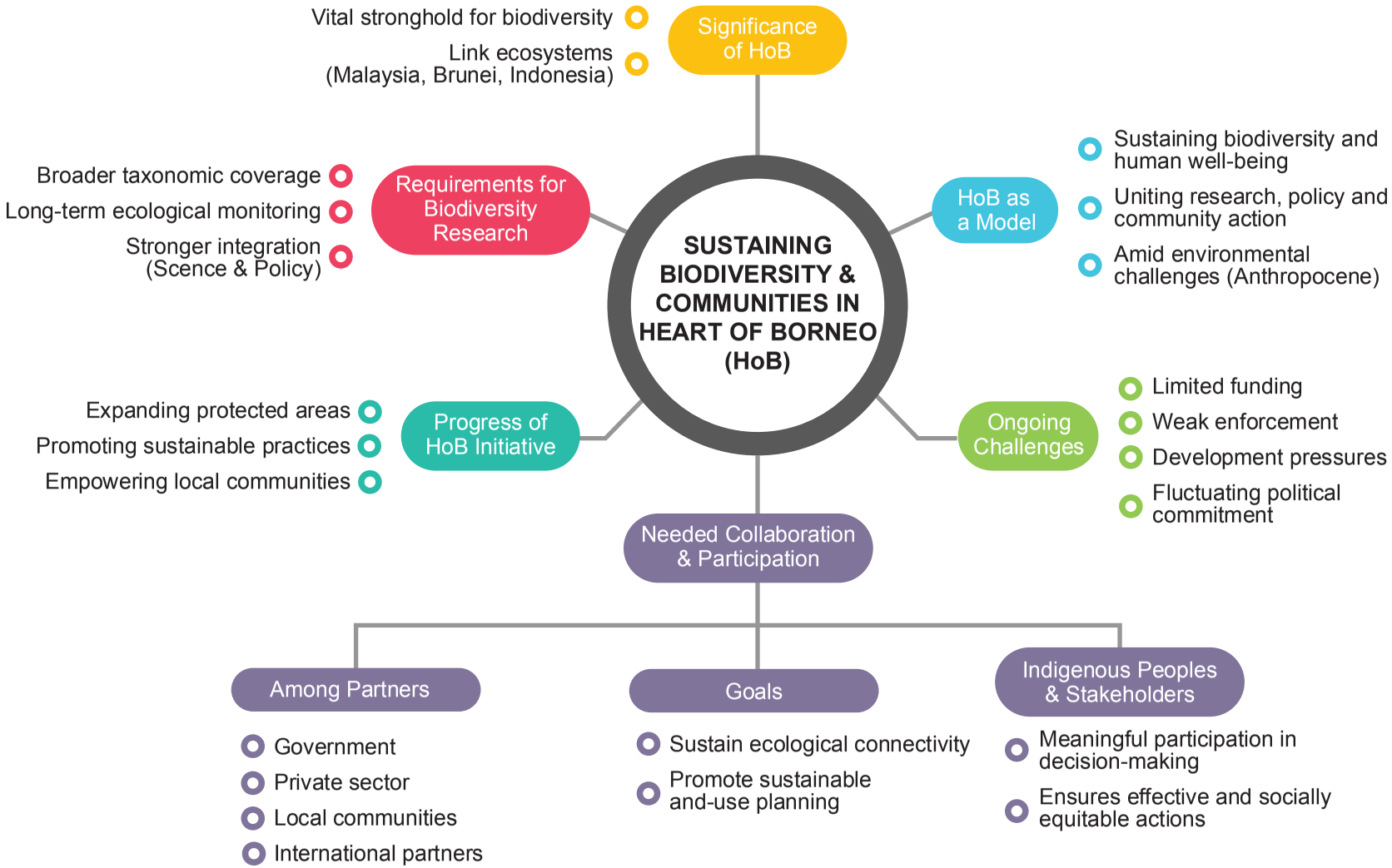

Figure 8. Summary of key elements needed to sustain biodiversity and community well-being in the Heart of Borneo (HoB), highlighting its ecological significance, research priorities, progress of current initiatives, stakeholder roles, collaboration needs, and ongoing conservation challenges.

The HoB represents a vital stronghold for biodiversity, linking ecosystems across Malaysia, Brunei, and Indonesia. Strengthening biodiversity research in this transboundary landscape requires broader taxonomic coverage, long-term standardised monitoring, and stronger integration between science and policy (Figure 8). Equally important is fostering collaborations among governments, the private sector, local communities, and international partners to sustain ecological connectivity and promote sustainable land-use planning. Meaningful participation of Indigenous Peoples and local stakeholders in decision-making can ensure that conservation actions are both effective and socially equitable. Collaboration among Malaysia, Indonesia, and Brunei has strengthened at different stages, most notably during the Brunei-hosted trilateral meeting in 2019. However, progress has been uneven in the past five years. Renewed commitment to joint monitoring, data sharing, and transboundary corridor planning could help to enhance the collective conservation efforts across the HoB landscape.

CONCLUSION

While the HoB Initiative has already made commendable progress in expanding protected areas, promoting sustainable practices, and empowering local communities, there remains ample opportunity to further strengthen its impact through enhanced funding, consistent enforcement, and sustained political support. With continued collaboration across research, policy, and community action, the HoB is well-positioned to become a global model for protecting biodiversity while uplifting human well-being. After 17 years, the HoB initiative has made steady and measurable progress toward its conservation goals. Protected area coverage has continued to expand, research collaboration has become more integrated, and transboundary partnerships have strengthened institutional capacity. Although challenges persist, they can be addressed through continued collaboration and collective commitment, strengthening the HoB role in supporting sustainable landscape management across the island.

REFERENCES

Alek, R.J. and Kader, W.A. 2021. We have not won yet, but we have not failed either – Forest Management Certification in Sarawak. In *Towards a Sustainable Forest Management for a Progressive Sarawak: Proceedings of Knowledge Sharing During Movement Control Order*, 20-24 April 2020, pp. 14–22. Kuching: Forest Department Sarawak.

Areendran, G., Sahana, M., Raj, K., Kumar, R., Sivadas, S., Kumar, A., Deb, S., and Gupta, V.D. 2020. A systematic review on high conservation value assessment (HCVs): challenges and framework for future research on conservation strategy. *Science Total Environment* 709: 135425. https://doi.org/10.1016/j.scitotenv.2019.135425

Azhar, B., Saadun, N., Prideaux, M., and Lindenmayer, D.B. 2017. The global palm oil sector must change to save biodiversity and improve food security in the tropics. *Journal of Environmental Management* 203: 457-466. https://doi.org/10.1016/j.jenvman.2017.08.021

Bennett, A.F. 2003. *Linkages in the landscape: The role of corridors and connectivity in wildlife conservation* (2nd ed.). Gland: IUCN.

Brodie, J.F., Deith, M.C.M., Burns, P., Goetz, S., Cunningham, C., Hill, J.K., Reynolds, G. and Mohd-Azlan, J. 2025a. The contribution of other effective area-based conservation measures (OECMs) to protecting global biodiversity. Nature Communications 16: 7886. https://doi.org/10.1038/s41467-025-63205-8

Brodie, J.F., Gonzalez, A., Mohd-Azlan, J., Nelson, C.R., Tabor, G., Vasudev, D., Zeller, K.A. and Fletcher Jr., R.J. 2025b. A well-connected Earth: The science and conservation of organismal movement. *Science* 388(6745): eadn2225. https://doi.org/10.1126/science.adn2225

Brodie, J.F., Giordano, A.J., Zipkin, E.F., Bernard, H., Mohd-Azlan, J. and Ambu, L. 2015. Correlates of mammal and bird declines in Bornean rainforests: logging, hunting, and forest edges. *Conservation Biology* 29(4): 1243–1253. https://doi.org/10.1111/cobi.12389

Brunei Climate Change Secretariat (BCCS). 2020. *Brunei Darussalam National Climate Change Policy (BNCCP)*. Brunei: Government of Brunei Darussalam. http://www.mod.gov.bn/Shared%20Documents/BCCS/Brunei%20National%20Climate%20Change%20Policy.pdf

Burns, P., Kaszta, Z., Cushman, S.A., Brodie, J.F., Hakkenberg, C.R., Jantz, P., Deith, M. *et al.* 2025. The utility of dynamic forest structure from GEDI lidar fusion in tropical mammal species distribution models. *Frontiers in Remote Sensing* 6: 1563430. https://doi.org/10.3389/frsen.2025.1563430

Clements, G.R., Lynam, A.J., Gaveau, D.L.A., Yap, W.L., Lhota, S., Goosem, M., Laurance, W.F. and Aziz, S.A. 2014. Where and how are roads endangering mammals in Southeast Asia's forests? *PLoS ONE* 9(12): e115376. https://doi.org/10.1371/journal.pone.0115376

Coad, L., Watson, J.E., Geldmann, J., Burgess, N.D., Leverington, F., Hockings, M., Knights, K. and Di Marco, M. 2019. Widespread shortfalls in protected area resourcing undermine efforts to conserve biodiversity. *Frontiers in Ecology and the Environment* 17(5): 259–264. https://doi.org/10.1002/fee.2042

Firdaus, R., Wibowo, P.M. and Rochmayanto, Y. 2018. Developing strategies for landscape sustainability: an Indonesian national strategic plan of action in the heart of Borneo. In *Landscape Ecology for Sustainable Society*, pp. 67–84. Cham: Springer International Publishing.

Deith, M.C., and Brodie, J.F. 2020. Predicting defaunation: Accurately mapping bushmeat hunting pressure over large areas. *Proceedings of the Royal Society B* 287: 20192677. https://doi.org/10.1098/rspb.2019.2677

Gaveau, D.L.A., Sheil, D., Husnayaen, Salim, M.A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., and Meijaard, E. 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific Reports* 6: 32017. https://doi.org/10.1038/srep32017

Gaveau, D.L.A., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N. K., Ancrenaz, M. *et al.* 2014. Four decades of forest persistence, clearance and logging on Borneo. *PLoS ONE* 9(7): e101654. https://doi.org/10.1371/journal.pone.0101654

Kamal, A.H.M., Sinden, A., Idris, M.H., Hamli, H., Musa, N., Piah, R.M., Wahid, R.A.L. and Shahabuddin, A. 2022. Diversity of fisheries in Sarawak, Northwest Borneo: Present status and conservation issues. *Borneo Journal of Resource Science and Technology* 12(1): 32–51. https://doi.org/10.33736/bjrst.4651.2022

Keong, C.Y., and Onuma, A. 2021. Transboundary ecological conservation, environmental value, and environmental sustainability: lessons from the Heart of Borneo. *Sustainability* 13(17): 9727. https://doi.org/10.3390/su13179727

McRae, B.H., Shah, V.B., and Mohapatra, T. 2009. Circuitscape user's guide. Santa Barbara: University of California, Santa Barbara. http://www.circuitscape.org.

Meijaard, E., Abram, N.K., Wells, J.A., Pellier, A.S., Ancrenaz, M., Gaveau, D.L., Runting, R.K. and Mengersen, K. 2013. People's perceptions about the importance of forests on Borneo. *PloS ONE* 8(9): e73008. https://doi.org/10.1371/journal.pone.0073008

Miettinen, J., Shi, C. and Liew, S. C. 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology* 17(7): 2261–2270. https://doi.org/10.1111/j.1365-2486.2011.02398.x

Ministry of Environment and Forestry (MoEF) Indonesia. 2019. Sixth National Report for the Convention on Biological Diversity. Montreal: Convention on Biological Diversity. https://asean.chm-cbd.net/sites/acb/files/2020-04/6NR_IDN.pdf

Ministry of Environment and Forestry (MoEF). 2021. Indonesia Forestry and Other Land Use (FOLU) Net Sink 2030. Jakarta: Ministry of Environment and Forestry, Indonesia. https://planologi.kehutanan.go.id/assets/img/publication/BUKU_RENOPS_FOLU_NETSINK_2030_(English).pdf

Ng, W.S., Mohd-Azlan, J. and Wong, S.Y. 2020. Floral biology and pollination strategy of *Durio* (Malvaceae) in Sarawak, Malaysian Borneo. *Biodiversitas Journal of Biological Diversity* 21(12): 5687–5697. https://doi.org/10.13057/biodiv/d211203

Nursyamin, Z., Yahya, M.S., Atikah, S.N., Tohiran, K.A., Norhisham, A.R., Othman, N.W., Lechner, A.M. and Azhar, B. 2023. Identifying indicator bird species for sustainable oil palm plantation certification. *Journal of Cleaner Production* 415: 137852. https://doi.org/10.1016/j.jclepro.2023.137852

Struebig, M.J., Wilting, A., Gaveau, D.L.A., Meijaard, E. and Smith, R.J. 2015. Targeted conservation to safeguard a biodiversity hotspot from climate and land-cover change. *Current Biology* 25: 372–378. https://doi.org/10.1016/j.cub.2014.11.067

Struebig, M.J., Wenzler, M., Runting, R.K., Law, E., Budiharta, S., Seaman, D. and Kramer-Schadt, S. 2024. Connectivity conservation to mitigate climate and land-cover change impacts on Borneo. *Biological Conservation* 299: 110838. https://doi.org/10.1016/j.biocon.2024.110838

Tuen, A.A., Sayok, A., Das, I., Noweg, G., Laman, C. and Met, L. 2014. Applying the HCVF toolkit to assess the conservation value of Gunung Singai, Sarawak, East Malaysia. In *Sustaining Livelihood through Prudent Utilization and Management of Natural Resources*, pp. 52–62. Kota Samarahan: IBEC, UNIMAS.

Wiersum, K.F. 1997. Indigenous exploitation and management of tropical forest resources: an evolutionary continuum in forest-people interactions. *Agriculture, Ecosystems & Environment* 63(1): 1-16. https://doi.org/10.1016/S0167-8809(96)01124-3

Witteveen+Bos. 2011. *Quick scan watershed services: Heart of Borneo* (Report No. INA598-1-P/sumt2/006). Indonesia: WWF Indonesia, WWF Heart of Borneo Initiative.

WWF. 2017a. Visit the Heart of Borneo. *WWF-Indonesia*. http://www.wwf.id/en/blog/visit-heart-borneo

WWF. 2017b. HoB Week kicks off with Expert Dialogue in Celebration of the 10th Anniversary of the Heart of Borneo Initiative. *WWF-Indonesia and WWF-Malaysia*. https://wwf.panda.org/es/?314972/HoB-Week-kicks-off-with-Expert-Dialogue-in-Celebration-of-the-10th-Anniversary-of-the-Heart-of-Borneo-Initiative

WWF. 2020. Environmental Status of Borneo 2020: Balancing the Needs of People and Nature. WWF-Indonesia and WWF-Malaysia.

Yang, Y., Ren, G., Li, W., Huang, Z., Lin, A.K., Garber, P.A., Ma, C. *et al.* 2019. Identifying transboundary conservation priorities in a biodiversity hotspot of China and Myanmar: Implications for data poor mountainous regions. *Global Ecology and Conservation* 20: e00732. https://doi.org/10.1016/j.gecco.2019.e00732