LETTERS

Since 2016, when this photo was taken, much of Kulhudhuffushi island's small mangrove patch has been destroyed.

Edited by **Jennifer Sills**

The value of small mangrove patches

Mangroves provide crucial services to humanity, including food, coastal protection, fisheries support, and carbon sequestration (*1*). However, up to 35% of mangrove area has been lost since the 1980s, primarily due to coastal development (*2*). Mangroves are protected under a plethora of international agreements, and they are key to meeting commitments of the Paris Climate Agreement and mitigating the impacts of a changing climate on coastal communities (*3*). Despite warnings about the ramifications of losing mangroves (*4*), conversion and degradation still occur (*5*), especially for smaller mangrove patches.

The global disdain for small mangrove patches is exemplified by the 2017 decision by the Maldivian government to construct a new local airport on the regionally significant mangrove patch (12 ha) on Kulhudhuffushi island (*6*). This decision was made despite the socioeconomic importance of the mangrove to the local community, the viable alternative solutions that were identified (*6*), the island's high risk for cyclones and tsunamis (*6*), and the substantial funding the Maldives received for climate change mitigation and adaptation [e.g., (*7*)]. Despite assurances that only 30% of the mangrove would be directly affected by this project, nearly 70% may have already been destroyed (*8*).

The loss of relatively small patches of mangrove may seem less concerning than large-scale deforestation. However, these patches are especially important to low-lying island nations vulnerable to climate change and sea-level rise (*1*). Their interconnectedness with adjacent habitats, such as coral reefs, allows them to provide substantial ecosystem services relative to their size (*9*). The continued loss of mangrove patches further fragments mangrove habitat, which creates barriers to species movement and dispersal (*10*). The loss also drastically erodes local coastal resilience and pushes key mangrove ecosystems toward collapse.

Given the recent Intergovernmental Panel on Climate Change's projections (*11*), we simply cannot afford to lose more mangrove forests, irrespective of their size. We call on governments to move away from policy decisions that prioritize large areas and short-term local political gains and instead adopt a more holistic long-term vision (*12*), whereby the value of smaller mangrove patches is better appreciated and safeguarded.

David J. Curnick[1,2], Nathalie Pettorelli[1,2], A. Aldrie Amir[1,3], Thorsten Balke[1,4], Edward B. Barbier[1,5], Stephen Crooks[1,6], Farid Dahdouh-Guebas[1,7,8], Clare Duncan[1,2], Charlie Endsor[1,9], Daniel A. Friess[1,10], Alfredo Quarto[1,11], Martin Zimmer[1,12], Shing Yip Lee[1,13]
[1]Mangrove Specialist Group, International Union for the Conservation of Nature (IUCN), Conservation Programmes, Zoological Society of London, Regents Park, London NW1 4RY, UK. [2]Zoological Society of London, Institute of Zoology, Regents Park, London NW1 4RY, UK. [3]Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia. [4]University of Glasgow, School of Geographical and Earth Sciences, Glasgow G12 8QQ, UK. [5]Department of Economics and School of Global Environmental Sustainability, Colorado State University, Fort Collins, CO 80523, USA. [6]Silvestrum Climate Associates, San Francisco, CA 94103, USA. [7]Systems Ecology and Resource Management, Université Libre de Bruxelles, B-1050 Brussels, Belgium. [8]Department of Ecology and Biodiversity, Vrije Universiteit Brussel, B-1050 Brussels, Belgium. [9]Conservation Programmes, Zoological Society of London, Regents Park, London NW1 4RY, UK. [10]Department of Geography, National University of Singapore, Singapore 117570, Singapore. [11]Mangrove Action Project, Seattle, WA 98104, USA. [12]Leibniz Centre for Tropical Marine Research, ZMT-GmbH, Bremen, Germany. [13]School of Life Sciences and Earth System Science Programme, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong SAR, China.
*Corresponding author. Email: david.curnick@zsl.org

REFERENCES

1. S. Y. Lee *et al.*, *Glob. Ecol. Biogeogr.* **23**, 726 (2014).
2. B. A. Polidoro *et al.*, *PLOS ONE* **5**, 10.1371/journal.pone.0010095 (2010).
3. P. Taillardat, D. A. Friess, M. Lupascu, *Biol. Lett.* **14**, 20180251 (2018).
4. N. C. Duke *et al.*, *Science* **317**, 41 (2007).
5. S. E. Hamilton, D. Casey, *Glob. Ecol. Biogeogr.* **25**, 729 (2016).
6. Z. Hameed, "Environmental Impact Assessment for the airport development project at Haa Dhaal Kulhudhuffushi" (2017).
7. Green Climate Fund (2018); www.mv.undp.org/content/maldives/en/home/operations/projects/environment_and_energy/GreenClimateFund.html.
8. Transparency Maldives (2018); http://transparency.mv/2018/09/joint-press-statement-we-call-on-the-authorities-to-ensure-the-protection-of-the-kulhudhuffushi-mangrove/.
9. E. B. Barbier, in *Seascape Ecology*, S. J. Pitmann, Ed. (Wiley-Blackwell, NY, 2017), pp. 465–481.
10. L. Triest, *Aquat. Bot.* **89**, 138 (2008).
11. O. Hoegh-Guldberg *et al.*, in "Global warming of 1.5°C," V. Masson-Delmotte *et al.*, Eds. (2018); www.ipcc.ch/sr15/.
12. A. A. Amir, *Science* **359**, 1342 (2018).

10.1126/science.aaw0809

PHOTO: EYEWELL PORTRAIT

Brazil's endangered postgraduate system

Over the past decade, Brazilian scientists have faced a dramatic reduction in financial support (*1*–*3*). In 2017, the Ministry of Science and Technology had a budget of only 2.8 billion reais, the equivalent of US$700 million (*4*), the lowest in the past 14 years (*5*). Dwindling funding affects a crucial population in Brazil's scientific system: students working toward master's and Ph.D. degrees.

Brazil's postgraduate system plays a pivotal role in scientific output. A major portion of scientific research takes place in publicly funded universities, and most scientific publications are driven by postgraduate programs (*6*, *7*). Brazil's 6303 master's and Ph.D. programs (*8*) are primarily funded by the Coordination for the Improvement of Higher Education Personnel (CAPES), a governmental agency within the Ministry of Education (*9*). The CAPES budget has plunged from the equivalent of US$1.9 billion in 2015 to the equivalent of US$1 billion in 2018 (*10*). The budget for 2019 projects an additional cut of nearly 40% (*11*). The funding cuts will likely translate into a substantial drop in federal grants, postdoctoral fellowships, support for international collaborations, and student scholarships. As student support falls, scientific output will likely decrease as well.

Brazil's scientific enterprise cannot function without qualified human resources, who will in turn strengthen social and economic development. Despite the polarized political atmosphere, Brazil must implement a strategic plan to improve the quality of science and innovation by investing in the postgraduate system.

Hercílio Martelli Júnior[1,2], Daniella R. Martelli[1], Ana Cristina Simões e Silva[2,3], Maria Christina L. Oliveira[3,4], Eduardo A. Oliveira[3,4*]

[1]Health Science/Primary Care Postgraduate Program, State University of Montes Claros (Unimontes), Montes Claros, MG 39401-089, Brazil. [2]Interdisciplinary Programs, CAPES, Brasília, DF 70.040-031, Brazil. [3]Health Sciences Postgraduate Program, School of Medicine, Federal University of Minas Gerais (UFMG), Belo Horizonte, MG 30130-100, Brazil. [4]University of California, San Diego, La Jolla, CA 92093–0630, USA.
*Corresponding author.
Email: eduolive812@gmail.com

REFERENCES

1. E. Gibney, *Nature* **526**, 16 (2015).
2. C. Angelo, *Nature* **533**, 19 (2016).
3. F. Marquez, "Funding in crisis," *Revista Pesquisa FAPESP* **256**, 1 (2017).
4. C. Angelo, *Nature* 10.1038/nature.2017.21766 (2017).
5. Ministério da Ciência, Tecnologia, Inovações e Comunicações, Recursos Aplicados—Governo Federal (2018); www.mctic.gov.br/mctic/opencms/indicadores/detalhe/recursos_aplicados/governo_federal/2_2_4.html [in Portuguese].
6. A. F. Helene, P. L. Ribeiro, *Scientometrics* **89**, 677 (2011).
7. E. A. Oliveira *et al.*, *Scientometrics* **90**, 429 (2011).
8. Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Ministério da Educação, "Avaliação quadrienal em números" (2017); www.ucs.br/site/midia/arquivos/Avalia%C3%A7%C3%A3o_Quadrienal_em_n%C3%BAmeros.pdf [in Portuguese].
9. Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Plano nacional de pós-graduação (PNPG) 2011-2020 (2010); www.capes.gov.br/plano-nacional-de-pos-graduacao [in Portuguese].
10. Coordination for the Improvement of Higher Education Personnel (CAPES), "Budget—Evolution in Reais" (2018); www.capes.gov.br/orcamento-evolucao-em-reais [in Portuguese].
11. A. C. Moreno, "Quase 200 mil bolsistas da Capes podem ficar sem bolsa se orçamento de 2019 sofrer corte, diz conselho," globo.com (2018); https://g1.globo.com/educacao/noticia/2018/08/02/quase-200-mil-podem-ficar-sem-bolsa-se-orcamento-de-2019-sofrer-corte-diz-conselho-da-capes.ghtml [in Portuguese].

10.1126/science.aav9015

Airborne in the era of climate change

The Intergovernmental Panel on Climate Change (IPCC) recently released its special report on limiting global warming to 1.5°C (*1*). The IPCC's 2050 target of carbon neutrality is strongly challenged by sectors with unavoidable emissions, such as aviation. Forecasts of the sector's growth predict that by 2050 it could have consumed up to one-quarter of the total global carbon budget for 1.5°C (*2*). The absence of substantial technical gains in aircraft emissions implies that reduction of aviation impact will be unfeasible without a decrease in demand (*3*). Air travel contributes substantially to the carbon footprint of academic communities (*4*), despite calls to travel less (*5*). In the current academic system, avoiding flying means accepting trade-offs, such as greater challenges to collaboration and networking. However, the cost of inaction and business as usual is the growing global threat of climate change, and scientists, given the alarms they regularly raise, should model responsible behavior to the planet. To encourage low-impact mobility, scientific institutions should adopt an avoid-mitigate-compensate approach similar to that developed in ecosystem conservation (*6*).

Air travel accounts for much of the science community's carbon footprint.

PHOTO: ISTOCK.COM/GUVENDEMIR

To avoid unnecessary journeys, institutions, department heads, and principal investigators should encourage scientists to consider or provide alternatives, such as teleconferencing and virtual scientific conferences. To mitigate emissions resulting from travel, scientists who must travel should replace flights with cleaner modes of travel as much as possible. Participants should prioritize local meetings, and organizers should reduce distances traveled by choosing central locations. To compensate for travel, scientists should financially contribute to credible and traceable projects for reducing and removing carbon emissions. This should be the last resort, given the questionable effectiveness of carbon offsetting (*7*).

There is increasing discussion about the best way to evaluate scientists, teams, and research projects (*8*), and including a carbon sobriety criterion could be a good way to reduce scientists' carbon footprint. Individual involvement is crucial, but supportive institutional environments [e.g., (*9*)] are also required to incentivize carbon-neutral behavior at the scale and speed required. Institutions invariably have policies for preventing and reducing harm, which address problems such as physical safety and data security. Surely the protection of planetary health, through the dramatic carbon cuts that are now urgently required, has a place in institutional policy, too.

Kévin Jean[1,2*] and Chris Wymant[3]

[1]Laboratoire MESuRS, Conservatoire National des Arts et Métiers, Paris, France. [2]Unité PACRI, Institut Pasteur, Conservatoire National des Arts et Métiers, Paris, France. [3]Big Data Institute, Li Ka Shing Centre for Health Information and Discovery, Nuffield Department of Medicine, University of Oxford, Oxford, UK.
*Corresponding author. Email: kevin.jean@lecnam.net

REFERENCES

1. "Global warming of 1.5°C," V. Masson-Delmotte *et al.*, Eds. (2018); www.ipcc.ch/sr15/.
2. "Analysis: Aviation could consume a quarter of 1.5C carbon budget by 2050," *Carbon Brief* (2016); www.carbonbrief.org/aviation-consume-quarter-carbon-budget.
3. A. Macintosh, L. Wallace, *Energ. Pol.* **37**, 264 (2009).
4. A. Stohl, *Atmos. Chem. Phys.* **8**, 6499 (2008).
5. X. Anglaret, *Lancet Planet Health* **2**, e382 (2018).
6. "An integrated framework and guidelines for avoiding, mitigating, and compensating for wetland losses: Resolution XI.9" (Ramsar Convention, 2012); www.ramsar.org/sites/default/files/documents/library/cop11-res09-e.pdf.
7. K. Hyams, T. Fawcett, *Wiley Interdisc. Rev.: Clim. Change* **4**, 91 (2013).
8. D. Moher *et al.*, *PLOS Biol.* **16**, e2004089 (2018).
9. Tyndall Centre, "Tyndall Travel Strategy—Towards a culture of low carbon research for the 21st Century" (2014); https://tyndall.ac.uk/travel-strategy.

10.1126/science.aaw1145

Science

The value of small mangrove patches

David J. Curnick, Nathalie Pettorelli, A. Aldrie Amir, Thorsten Balke, Edward B. Barbier, Stephen Crooks, Farid Dahdouh-Guebas, Clare Duncan, Charlie Endsor, Daniel A. Friess, Alfredo Quarto, Martin Zimmer and Shing Yip Lee

Science **363** (6424), 239.
DOI: 10.1126/science.aaw0809