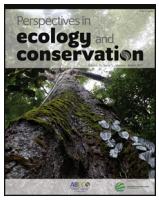
Perspectives in Ecology and Conservation xxx (2017) xxx–xxx

Perspectives in ecology and conservation

Supported by Boticário Group Foundation for Nature Protection

www.perspectecolconserv.com



Policy Forums

Dismantling Brazil's science threatens global biodiversity heritage

G. Wilson Fernandes[a,*], Mariana M. Vale[b], Gerhard E. Overbeck[c], Mercedes M.C. Bustamante[d], Carlos E.V. Grelle[b], Helena Godoy Bergallo[e], William E. Magnusson[f], Alberto Akama[g], Suelen S. Alves[h], André Amorim[i], Joaquim Araújo[j], Claudia Franca Barros[k], Freddy Bravo[l], Marcelo J. Veiga Carim[m], Rui Cerqueira[b], Rosane Garcia Collevatti[n], Guarino R. Colli[o], Catia Nunes da Cunha[p], Paulo Sergio D'Andrea[q], José Carmine Dianese[r], Soraia Diniz[p], Pedro Cordeiro Estrela[s], Mariluce R.M. Fernandes[t], Carla Suertegaray Fontana[u], Leandro L. Giacomin[v], Luis Fernando P. Gusmão[l], Flora Acuña Juncá[l], Ana Carolina Borges Lins-e-Silva[w], Celia R.A.S. Lopes[x], Maria Lucia Lorini[y], Luciano Paganucci de Queiroz[l], Luiz R. Malabarba[z], Beatriz Schwantes Marimon[aa], Ben Hur Marimon Junior[aa], Marcia C.M. Marques[bb], Bruno M. Martinelli[cc], Marlucia Bonifacio Martins[g], Hermes Fonseca de Medeiros[dd], Marcelo Menin[ee], Paula Benevides de Morais[ff], Francisca Helena Muniz[gg], Selvino Neckel-Oliveira[hh], João Alves de Oliveira[ii], Reyjane P. Oliveira[l], Fernando Pedroni[jj], Jerry Penha[p], Luciana R. Podgaiski[kk], Domingos J. Rodrigues[ll], Aldicir Scariot[mm], Luís Fábio Silveira[nn], Marcos Silveira[oo], Walfrido Moraes Tomas[pp], Marcos J. Salgado Vital[qq], Valério D. Pillar[kk]

[a] *Ecologia Evolutiva e Biodiversidade, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil*
[b] *Departamento de Ecologia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[c] *Departamento de Botânica, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil*
[d] *Departamento de Ecologia, Universidade de Brasília, Brasília, DF, Brazil*
[e] *Departamento de Ecologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[f] *Instituto Nacional de Pesquisas da Amazônia, Manaus, AM, Brazil*
[g] *Museu Paraense Emílio Goeldi, Belém, PA, Brazil*
[h] *Universidade Federal de Santa Maria, Santa Maria, RS, Brazil*
[i] *Universidade Estadual de Santa Cruz, Ilhéus, BA, Brazil*
[j] *Instituto Biotrópicos, Diamantina, MG, Brazil*
[k] *Diretoria de Pesquisa Científica· Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[l] *Departamento de Ciências Biológicas, Universidade Estadual de Feira de Santana, Feira de Santana, BA, Brazil*
[m] *Núcleo do PPBio Amapá, Macapá, AP, Brazil*
[n] *Instituto de Ciências Biológicas, Universidade Federal de Goiás, Goiânia, GO, Brazil*
[o] *Departamento de Zoologia, Universidade de Brasília, Brasília, DF, Brazil*
[p] *Departamento de Ecologia e Botânica, Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil*
[q] *Instituto Oswaldo Cruz/FIOCRUZ, Rio de Janeiro, RJ, Brazil*
[r] *Departamento de Fitopatologia, Universidade de Brasília, Brasília, DF, Brazil*
[s] *Universidade Federal da Paraíba, João Pessoa, PB, Brazil*
[t] *Universidade Federal de Rondônia, Porto Velho, RO, Brazil*
[u] *PUCRS, Museu de Ciências e Tecnologia, Porto Alegre, RS, Brazil*
[v] *Instituto de Ciências e Tecnologia das Águas & Herbário HSTM, Universidade Federal do Oeste do Pará, Santarém, PA, Brazil*
[w] *Universidade Federal Rural de Pernambuco, Recife, PE, Brazil*
[x] *Universidade do Estado de Mato Groso, Alta Floresta, MT, Brazil*
[y] *Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brazil*
[z] *Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil*
[aa] *Universidade do Estado de Mato Grosso, Nova Xavantina, MT, Brazil*
[bb] *Departamento de Botânica, SCB, Universidade Federal do Paraná, Curitiba, PR, Brazil*
[cc] *PPG Desenvolvimento, Sociedade e Cooperação Internacional, UnB, Brasília, DF, Brazil*
[dd] *Faculdade de Ciências Biológicas, Universidade Federal do Pará, Altamira, PA, Brazil*

* Corresponding author.
E-mail address: gw.fernandes@gmail.com (G.W. Fernandes).

http://dx.doi.org/10.1016/j.pecon.2017.07.004

Please cite this article in press as: Fernandes, G.W., et al. Dismantling Brazil's science threatens global biodiversity heritage. Perspect Ecol Conserv. (2017). http://dx.doi.org/10.1016/j.pecon.2017.07.004

[ee] Departamento de Biologia, ICB, Universidade Federal do Amazonas, Manaus, AM, Brazil
[ff] Universidade Federal do Tocantins, Palmas, TO, Brazil
[gg] Universidade Estadual do Maranhão, São Luiz, MA, Brazil
[hh] Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Santa Catarina, Brazil
[ii] Departamento de Vertebrados, Museu Nacional do Rio de Janeiro, Rio de Janeiro, RJ, Brazil
[jj] Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Mato Grosso, Barra do Garças, MT, Brazil
[kk] Departamento de Ecologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil
[ll] Universidade Federal de Mato Grosso, Sinop, MT, Brazil
[mm] Embrapa Genetic Resources and Biotechnology (Cenargen), Brasília, DF, Brazil
[nn] Museu de Zoologia, Universidade de São Paulo, São Paulo, SP, Brazil
[oo] Universidade Federal do Acre, Rio Branco, AC, Brazil
[pp] Embrapa Pantanal, Corumbá, MS, 79320-900, Brazil
[qq] Universidade Federal de Roraima, Boa Vista, RR, Brazil

ARTICLE INFO

Article history:
Received 4 June 2017
Accepted 19 July 2017

Keywords:
Biodiversity research network
Brazil
Global environmental commitments
Political and fiscal crisis

ABSTRACT

In the middle of a political and fiscal crisis, the Brazilian government is applying successive budget cuts, including in science funding. Recent cuts radically affect research programs on biodiversity that are crucial components for the design and monitoring of public policies for nature conservation and sustainable development. We analyze the consequences of such cuts on the Research Program on Biodiversity (PPBio), the largest biodiversity research network in Brazil (626 researchers, nine networks in all Brazilian biomes). Brazil holds a substantial part of the world's biodiversity and of tropical forests that play a significant role for regional and global climate stability. If underfunding is maintained, the dismantling of the Brazilian PPBio will have consequences that go beyond biodiversity knowledge itself but affect society as a whole. Brazil will likely fail to reach the National Targets for Biodiversity 2011–2020, and it will be difficult to fulfill the restoration target of the Brazilian NDC and to advance with the sustainable development goals.

National investment in science and technology is critical for sustainable social, environmental and economic development in face of pressing environmental changes that demand innovative ways to reconcile the conservation and use of natural resources with the reduction of poverty and inequity (see e.g. Tallis et al., 2008; Scarano, 2017). Nevertheless, the giant and natural resources-rich Brazil seems to swim against the current. Since 2016 important international scientific journals are reporting on the impacts of the current political and fiscal crises on Brazilian Science (Escobar, 2016; Angelo, 2017). Evidence of the weakening of investment in Brazilian science – both in political and financial terms – include the merger of the Ministry of Science and Technology with the Ministry of Communications and successive budget cuts. A 20-year federal budget freeze (Angelo, 2017) was approved in 2016 by the National Congress, with alarming consequences for future science funding, bringing the 2017 budget of the National Council for Scientific and Technological Development (CNPq), the main federal research funding institution in Brazil, to values below those of 2004 when corrected for inflation (Fig. 1). In the wake of a drastic linear reduction of the federal budget across all areas (except education and health), the Ministry of Science, Technology, Innovation and Communications (MCTIC) suffered an additional 44% budget cut in March 2017. If this 44% cut to the MCTIC were applied to the CNPq, federal funding for research in 2017 will be 2/3 below the values of 2004 (Fig. 1). Between 2004 and 2013 there was a nearly steadily increase of research funding in Brazil, which has had positive consequences on research outcomes in general, and also in the field of ecology and biodiversity, as indicated by an annual growth rate of 12.7% in the number of articles and of 18.3% in citation between 2004 and 2015 (Fig. 2). This was paralleled by an expansion of the graduate programs in ecology and biodiversity across the country, which allowed an annual growth rate of 9.1% for new MSc and 9.3% for new PhD titles between 1996 and 2014 (Fig. 3). While the budget cuts were applied to and will have deep effects in many policy areas, they are especially worrisome for the area of science and technology which – as a driver of innovation and future development – should be a priority area. Further, the continuation of the present dismantling process radically affects research programs on biodiversity that are crucial components for the design and monitoring of public policies for nature conservation and sustainable development with potential negative consequences for fulfillment of Brazil's international commitments.

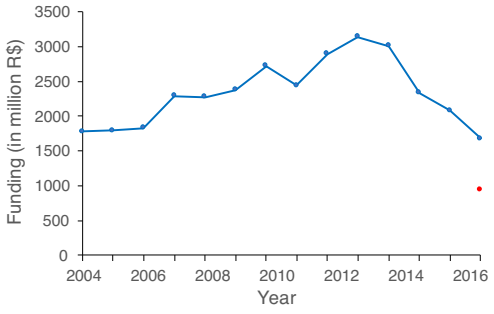


Fig. 1. Resources of the Brazilian National Council for Scientific and Technological Development (CNPq) for research funding from 2004 to 2017. Values between 2004 and 2016 are actual expenditures corrected for inflation until the end of 2016. Values for 2017 correspond to the approved budget: Blue line – without the April 2017 cut (43.7%). Red dot – projected valued considering the April 2017 budget cut (43.7%) of the Ministry of Science, Technology, Innovation and Communications (MCTIC) applied to the CNPq budget. Source for CNPq expenditure and budget data: Transparency Portal at: http://www.portaldatransparencia.gov.br.

Reduction in funds for biodiversity research impacts severely the national capacity to generate new knowledge on biodiversity itself but also on ecosystem services essential to human well-being. Brazil is the most species-rich country in the world (Mittermeier

Please cite this article in press as: Fernandes, G.W., et al. Dismantling Brazil's science threatens global biodiversity heritage. Perspect Ecol Conserv. (2017). http://dx.doi.org/10.1016/j.pecon.2017.07.004

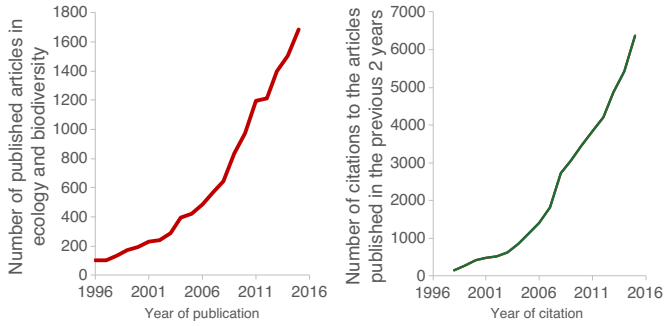


Fig. 2. Publication and citation in ecology and biodiversity conservation by authors from Brazil. Data compiled from the Web of Science considering the total number of articles, reviews and letters published in each year that presented at least one author from Brazil in the journals classified under the Web of Science categories "Ecology" or "Biodiversity Conservation", as well as in ecology topics identified by keywords (i.e., plant, animal, aquatic or microbial communities, ecosystem, ecophysiology, biodiversity conservation, population ecology, landscape ecology, molecular ecology, or paleoecology) to detect articles published in periodicals classified under other categories. The number of published articles increased at an annual growth rate of 15.9% between 1996 and 2015, and 12.7% between 2004 and 2015, while the number of citations in each year to the articles published in the previous two years increased at an annual growth rate of 24.4% between 1998 and 2015, and 18.3% between 2006 and 2015.

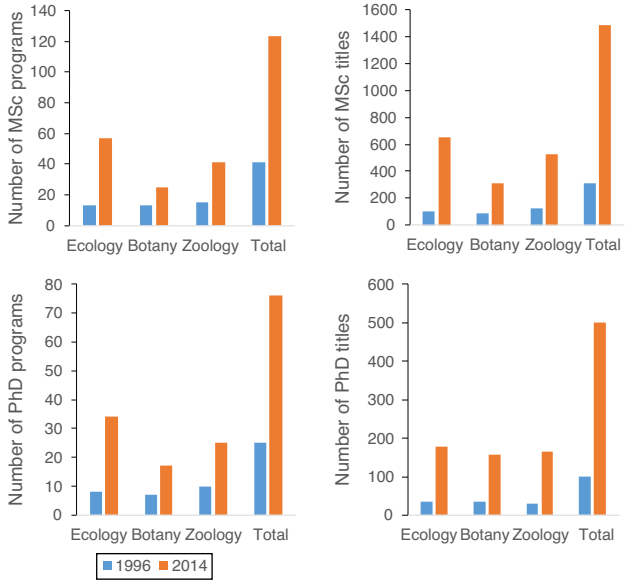


Fig. 3. Expansion of the graduate programs in ecology and biodiversity in Brazil between 1996 and 2014.
Source: Data compiled from Centro de Gestão e Estudos Estratégicos – CGEE. Mestres e doutores 2015 – Estudos da demografia da base técnico-científica brasileira. Brasília, DF: 2016. 348 p. https://www.cgee.org.br/web/rhcti/mestres-e-doutores-2015.

et al., 1997). This biodiversity is found not only in forests, but also in non-forest ecosystems, some unique to Brazil, and many under threats (Overbeck et al., 2015; Fernandes et al., 2016). The reduced spending in science will jeopardize the established efforts to evaluate and monitor biodiversity and ecosystem services, including the MCTIC's Research Program on Biodiversity (PPBio), the largest network of biodiversity research in Brazil (Fig. 4 and Appendix 1). PPBio was established in 2005 to address the main issues raised by the Convention on Biological Diversity (CBD), such as the Aichi targets (CBD; MCT 2007; and Appendix 2), to which the Brazilian government is committed and which requires biodiversity inventories, monitoring and analyses. The program, which was designed in conjunction with the scientific community, now has 626 researchers from 93 institutions working in nine networks in all Brazilian biomes. PPBio is the basis of countrywide efforts, built over a decade, to fill the gaps in biodiversity knowledge and ecosystem monitoring, especially in remote locations such as in Amazonia. Results from the PPBio research network – together with those from other research efforts – are providing new knowledge and perspectives, which are essential for a well-informed and robust decision-making process of economic and environmental policies. The importance of the program is illustrated by the large number of newly recorded plant species. Data mining from Brazilian herbaria and new specimens from field inventories raised the total recorded native seed plants in Brazil by 1674 species in only three years (Brazil Flora Group, 2015). PPBio research is especially important in those regions where biodiversity previously has not been studied and had been underestimated. For instance, in the Caatinga, the most populated semi-arid region of the world and that has already lost approximately 50% of its original vegetation cover (see Fig. 4), the program has led to the description of more than 250 species in the past 10 years, including the discovery of new families. However, the effects of PPBio go far beyond data collection itself. The program has contributed to the establishment of ecological research capacity and infrastructure, including scientific collections, especially in remote and previously virtually unknown areas of the country. It has also been involved in the development of a free and open-access biodiversity database, the SiBBr (Information System for Brazilian Biodiversity), launched in 2014, easing the compilation, sharing and analysis of biodiversity data and evaluation of the effects of land use and climate changes. It is contradictory that external funds of the Global Environment Fund (GEF) are being used by Brazil for the implementation of the SiBBr while national funds to support the generation of the information for the system are being cut.

Brazil holds a substantial part of the world's biodiversity and remaining tropical forests that play a significant role in the regional and global climate system. If underfunding of biodiversity research is maintained, there will likely be deep and perhaps irreversible consequences. The interruption of ongoing fieldwork and data analyses will reduce bio-prospection activities, evaluation of environmental impacts, and effective land-use planning, all of which depend on biodiversity data. Reduced funding will affect ecosystem conservation and the services provided to humanity, including food security and human health, also for indigenous and traditional populations that depend on natural resources. It will also interrupt the maintenance and improvement of the SiBBr database, which has been sharing new biodiversity data worldwide and which is important for decision-making processes, as recommended by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), launched in 2012, and its Brazilian counterpart BPBES. As reduced spending will have long-term negative impacts on science and technology training, Brazil's capability to predict and mitigate negative impacts of land use and climate changes on biodiversity and ecosystems as well as to plan adequate adaptation strategies will also be reduced. We need to remember that solid knowledge on biodiversity is at the very basis of any policy on conservation of biodiversity, the ecosystems it is contained in and the services it provides. Reduced biodiversity knowledge and research can lead to unrecorded extinctions. In addition, underfunding will contribute to Brazil's potential failure to reach the National Targets for Biodiversity 2011–2020, established to meet the CBD's goals (Resolution CONABIO N° 06/2013; see Appendix 2). Other important national environmental goals are also at risk, such as the aim to restore 21 million hectares of degraded land in order to comply with the major Brazilian native vegetation protection law ("Forest Code"), including 12 million hectares by 2030 as part of Brazil's Nationally Determined Contribution (NDC) for the Paris Agreement in the context of the United Nations Framework Convention on Climate Change (UNFCCC): the identification of suitable areas for restoration and the planning and implementation of the

Please cite this article in press as: Fernandes, G.W., et al. Dismantling Brazil's science threatens global biodiversity heritage. Perspect Ecol Conserv. (2017). http://dx.doi.org/10.1016/j.pecon.2017.07.004

Fig. 4. Distribution of biodiversity monitoring sites of the Brazilian Research Program in Biodiversity (PPBio) within the country's six major biomes (gray lines): Amazonia forest, Caatinga xeric shrubland, Cerrado savanna, Pantanal wetland, Atlantic Forest, and Pampa grassland. Human modified landscapes include areas converted to urban, agriculture, cultivated pastures, and forestry uses.
Source: 2014 Land use and land cover map from the Brazilian Institute of Geography and Statistics (http://downloads.ibge.gov.br/downloads_geociencias.htm).

restoration activities depend on biodiversity data (e.g., Bustamante et al., 2016). Clearly, any failure of Brazil to reach its conservation and restoration targets will have global implications, including biodiversity losses, increased carbon emissions and facilitated spread of infectious diseases.

The dismantling of Brazil's largest biodiversity research program is especially worrisome in tandem with the many recent attempts to reduce environmental protection in the country. This includes the weakening of the environmental impact assessment legislation for approval of enterprises (Tollefson, 2016), the weakening of the legislation regarding native vegetation protection (Metzger et al., 2010), including the use of exotic species plantations to restore illegally deforested areas (Law 12.651/2012), and the reduction of protected and indigenous areas (Bernard et al., 2014). The creation of protected areas and indigenous lands is threatened by proposed amendments to the federal constitution by congressional representatives of large landowners (known as *ruralistas*) (Fearnside, 2016, 2017), making it an almost impossible task as the decision to create new protected areas and indigenous lands will be transferred to the legislative branch, dominated by ruralists. Indigenous lands have an important role in reducing deforestation but in light of these recent developments, the increasing levels of deforestation in Amazonia, after years of reduction (Fearnside, 2017), may just gain momentum and revert the trend. Major cuts in research funding are also taking place at the level of federal states. Extreme cases are the attempts to extinguish renowned natural history museums holding some of the country's most important biological collections, such as the *Fundação Zoobotânica* in southern Brazil. The cuts are also affecting biodiversity research at state public universities, where researchers are receiving their wages with considerable delay, impeding the continuity of their research (Siqueira and Rocha, 2017).

While Brazil has made an internationally recognized effort in achieving the UN Millennium Development Goals (IPEA, 2014), its most recent commitment to the sustainable development goals will be seriously compromised by the recent setbacks in environmental issues. Successful research programs, such as Brazil's PPBio, are built up over decades as an investment into the future. Dismantling them in an attempt to solve a budget crisis is a short-sighted option that will critically reduce the country's capability to respond present and future challenges, not only in the environmental sector, but in all aspects of society. In countries, such as Brazil, with immense knowledge gaps on management of the environment and, at the same time, prevailing unsustainable use of natural resources, investments in biodiversity research need to be seen not as a problem, but as an essential part of long-term solution to the crisis.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

Authors thank two anonymous reviewers for their comments on earlier versions of this manuscript, the support of PPBio/CNPq/MCTIC, and Brazilian state foundations for science.

Please cite this article in press as: Fernandes, G.W., et al. Dismantling Brazil's science threatens global biodiversity heritage. Perspect Ecol Conserv. (2017). http://dx.doi.org/10.1016/j.pecon.2017.07.004

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.pecon.2017.07.004.

References

Angelo, C., 2017. Nat. News Comment, http://dx.doi.org/10.1038/nature.2017.21766.
Bernard, E., Penna, L.A.O., Araújo, E., 2014. Downgrading, downsizing degazettement, and reclassification of protected areas in Brazil. Conserv. Biol. 28, 939–950, http://dx.doi.org/10.1111/cobi.12298.
Brazil Flora Group, 2015. Growing knowledge: an overview of seed plant diversity in Brazil. Rodriguesia 66, 1085–1113, http://dx.doi.org/10.1590/2175-7860201566411.
Bustamante, M.M., Roitman, I., Aide, T.M., et al., 2016. Toward an integrated monitoring framework to assess the effects of tropical forest degradation and recovery on carbon stocks and biodiversity. Glob. Chang. Biol. 22, 92–109, http://dx.doi.org/10.1111/gcb.13087.
Escobar, H., 2016. Budget cap would stifle Brazilian science, critics say. Science, http://dx.doi.org/10.1126/science.aal0276.
Fearnside, P., 2017. Business as usual: a resurgence of deforestation in the Brazilian Amazon. Yale Environ. 360 https://e360.yale.edu/features/business-as-usual-a-resurgence-of-deforestation-in-the-brazilian-amazon (accessed 06.01.17).
Fearnside, P.M., 2016. Brazilian politics threaten environmental policies. Science 353, 746–748, http://dx.doi.org/10.1126/science.aag0254.
Fernandes, G.W., Goulart, F.F., Ranieri, B.D., et al., 2016. Deep into the mud: ecological and socio-economic impacts of the dam breach in Mariana, Brazil. Nat. Conserv. 14, 35–45, http://dx.doi.org/10.1016/j.ncon.2016.10.003.
IPEA, 2014. Objetivos de Desenvolvimento do Milênio–V Relatório Nacional de Acompanhamento. http://www.ipea.gov.br/portal/images/stories/PDFs/140523_relatorioodm.pdf (accessed 06.01.17).
Metzger, J.P., Lewinsohn, T.M., Joly, C.A., et al., 2010. Brazilian law: full speed in reverse? Science 329, 276–277, http://dx.doi.org/10.1126/science.329.5989.276-b.
Mittermeier, R.A., Robles Gil, P., Mittermeier, C.G., 1997. Megadiversity. CEMEX, Mexico City.
Overbeck, G.E., Velez-Martin, E., Scarano, F.R., et al., 2015. Conservation in Brazil needs to include non-forest ecosystems. Div. Distr. 21, 1455–1460, http://dx.doi.org/10.1111/ddi.12380.
Scarano, F., 2017. Ecosystem-based adaptation to climate change: concept, scalability and a role for conservation science. Persp. Ecol. Conserv. 15.
Siqueira, C.C., Rocha, C.F.D., 2017. Brazil's public universities in crisis. Science 356, 812, http://dx.doi.org/10.1126/science.aan2527.
Tallis, et al., 2008. An ecosystem services framework to support both practical conservation and economic development. Proc. Natl. Acad. Sci. U. S. A. 105, 9457–9464.
Tollefson, J., 2016. Political upheaval threatens Brazil's environmental protections. Nature 539, 147–148, http://dx.doi.org/10.1038/539147a.

Please cite this article in press as: Fernandes, G.W., et al. Dismantling Brazil's science threatens global biodiversity heritage. Perspect Ecol Conserv. (2017). http://dx.doi.org/10.1016/j.pecon.2017.07.004