Perspectives in Ecology and Conservation 22 (2024) 1–7

ABECO
ASSOCIAÇÃO BRASILEIRA DE CIÊNCIA ECOLÓGICA E CONSERVAÇÃO

Perspectives in ecology and conservation

Supported by Instituto Tecnológico Vale and CEPAN

www.perspectecolconserv.com

Policy Forums

Brazilian public funding for biodiversity research in the Amazon

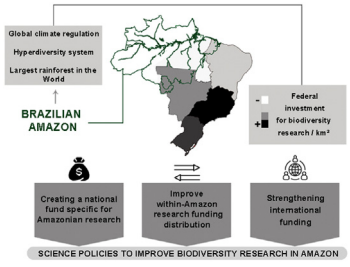
Lis F. Stegmann[a,*], Filipe M. França[b,c], Raquel L. Carvalho[d], Jos Barlow[e], Erika Berenguer[e,f], Leandro Castello[g], Leandro Juen[b], Fabrício B. Baccaro[h], Ima Célia Guimarães Vieira[i], Cássio Alencar Nunes[e,j], Rodrigo Oliveira[c], Eduardo M. Venticinque[i], Juliana Schietti[h], Joice Ferreira[a]

[a] *Embrapa Amazônia Oriental, Tv. Dr. Enéas Pinheiro, 66095-903, Belém-Pará, Brazil*
[b] *School of Biological Sciences, University of Bristol, Beacon House, Queens Rd, BS8 1QU, Bristol, UK*
[c] *Instituto de Ciências Biológicas, Universidade Federal do Pará, R. Augusto Corrêa, 01 - Guamá, 66075-110, Belém-Pará, Brazil*
[d] *Instituto de Estudos Avançados, Universidade de São Paulo, R. do Anfiteatro, 513, CEP: 05508-060, São Paulo, SP, Brazil*
[e] *Lancaster Environment Centre, Lancaster University, Bailrigg, LA1 4YQ, Lancaster, UK*
[f] *Environmental Change Institute, School of Geography, University of Oxford, S Parks Rd, OX1 3QY, Oxford, UK*
[g] *Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA 24060, Virginia, United States*
[h] *Departamento de Biologia, Universidade Federal do Amazonas, Av. General Rodrigo Octavio Jordão Ramos, 1200 CEP: 69067-005, Manaus-Amazonas, Brazil*
[i] *Departamento de Ecologia, Universidade Federal do Rio Grande do Norte, Campus Universitário - Lagoa Nova CEP 59072-970, Natal, RN - Brazil*
[j] *Departamento de Ecologia e Conservação, Universidade Federal de Lavras, Trevo Rotatório Professor Edmir Sá Santos, CEP: 37203-202, Lavras-Minas Gerais, Brazil*

HIGHLIGHTS

- The federal grants and scholarships are uneven distributed between Brazilian regions.
- The North region receives the least number of scholarships and grants per km^2 in Brazil.
- The current federal budget is insufficient to cover large-scale research in the Amazon.
- New national and international funds need to be created to improve Amazon biodiversity research.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 13 September 2023
Accepted 12 January 2024
Available online 17 January 2024

Keywords:
Amazon
Biodiversity research
Science policy
Brazil

ABSTRACT

The Brazilian Amazon is one of Earth's most biodiverse and ecologically important regions. However, research investments for biodiversity in the biome are disproportionately low compared with other regions of Brazil. In 2022, the Amazon received 13% of master's, doctoral and postdoctoral scholarships and hosted 11% of all researchers working in biodiversity postgraduate programs. Amazonian institutions received approximately 10% of all federal budget spent on grants and scholarships and about 23% of all resources destined to support long-term ecological sites. The cities of Manaus and Belém concentrate about 90% of all grants and scholarships available for the entire region. Despite per capita research investment in the Amazon being equal to or better than that available for the more economically developed regions of Brazil, the distribution of resources by area is highly unequal. Increasing research funding for the Amazon region requires differential input by federal agencies and more transnational collaborations and integration between Amazonian programs and international funds.

* Corresponding author.
E-mail address: lis.stegmann@gmail.com (L.F. Stegmann).

https://doi.org/10.1016/j.pecon.2024.01.003

Introduction

The Amazon Basin houses the largest rainforest and most complex drainage network in the planet (Moraes et al., 2021; Venticinque et al., 2016). Distributed over approximately 7 million km^2, the Amazon is one of Earth's most biodiverse regions for most taxonomic groups (Mittermeier et al., 2003; Zapata-Ríos et al., 2021) and provides crucial ecosystem services, such as climate stability through carbon storage and sequestration (Strand et al., 2018). Brazil harbors most of the Amazon (>5 million km^2), which covers approximately 59% of its territory (IBGE, 2022). The region also houses around 70% of all continental protected areas (CNUC, 2023) and 83% of all indigenous lands in Brazil (ISA, 2022). Far from being a homogenous forest, species are distributed across areas of endemism, with strong gradients in productivity, diversity and functional traits along edaphic and climatic gradients (Ter Steege et al., 2003; Dagosta and Pinna, 2018).

The Brazilian Amazon has also been a center for environmental change over the last four decades. Deforestation rates in the Brazilian Amazon are the highest among Amazonian countries (Smith et al., 2021) and have increased in the last decade (Silva Junior et al., 2021), placing it as a world leader in tropical primary forest loss (GFW, 2022). Add to that other different human activities that have degraded the remaining forest and threaten Amazonian biodiversity, such as timber exploitation, forest fires, and overfishing (Berenguer et al., 2021; Fearnside et al., 2021; Lapola et al., 2023). The Amazon also hosts some of the largest mining and hydropower plants in the world, such as the Carajás iron ore mine and the Belo Monte dam, and several new infrastructure projects are planned in the region (Fearnside, 2019; Rodrigues, 2023). These threats are co-occurring with climate change, which has increased temperatures by 2.5 degrees in some regions and reduced dry season rainfall by 34% (Gatti et al., 2021).

The large number and enormous extent of threats to Amazonian ecosystems makes it crucial to create a better understanding of biodiversity conservation in the region. However, current knowledge is strongly biased toward some better documented taxonomic groups, as angiosperm and vertebrates (Oliveira et al., 2016), and research sites tend to cluster along major Amazonian rivers and urban areas, creating large information deficits (dos Santos et al., 2015; Carvalho et al., 2023). Research capacity in the North region of Brazil – which encompasses 87% of the Brazilian Amazon biome (Góes and Karpowicz, 2017) – is low when compared with other regions of the country, such as the Southeast and South, which host 13 of the 15 most productive universities in the country (Web of Science Group, 2019; Chaimovich and Pedrosa, 2021). The limited research infrastructure of the Brazilian Amazon leaves the region with very limited capacity to respond to the socio-environmental problems it faces.

With President Luis Inácio Lula da Silva assuming the presidency of Brazil in 2023, he established a government strongly committed to protecting the Brazilian Amazon (Rannard, 2022), including a plan for zero deforestation by 2030, which puts the biome at the centre of the global climate agenda (Alberti, 2023). The implementation of these ambitious plans depends on decentralizing science in the region, as well as integrating and applying diverse scientific knowledge to develop sustainable models for the management of territories and conserving its biodiversity (Vieira et al., 2005). For that, it is fundamental to develop a strategic plan for resource allocation that aligns research with the Amazonia's socio-environmental relevance to Brazil and the planet, and not only perform marginal adjustments in relation to previous budgets, following a purely incremental allocation model (Abreu et al., 2012).

To support this, we assess the distribution of grants and scholarships for biodiversity research across the country's five regions (i.e., South, Southeast, Northeast, Center-West, North) and the seven states that compose the Brazilian Amazon. We used the North region as a proxy for the Brazilian Amazon mainly for two reasons: first, there is no specific data for the biome, and second, regions represent the socioeconomic aggregation commonly used for designing and implementing public policies in Brazil. We assess three main datasets:

I The distribution of postgraduate and postdoctoral scholarships between regions funded by CAPES (The Coordination for the Improvement of Higher Education Personnel), the largest public agency for promoting personal training in Brazil. Although the main function of CAPES is not exactly to subsidize research per se, but rather to strengthen the academic body's ability to work in different areas of knowledge, postgraduate students and postdoc researchers are the main driving force of Brazilian science. This is so much the case that the number of scholarships denote the scientific capacity of each institution. We focused our evaluation of scholarship numbers for postgraduate courses (master and doctoral graduate courses) in the areas of biodiversity, which include Botany, Ecology, Zoology, Limnology and other natural sciences grouped by the funding agency as "biodiversity area" (see Supplementary Table S1 for the entire course list);

II The number of researchers hosted in biodiversity postgraduate programs over the country and the situation of the research staff of the two major Amazonian research institutions, the Emílio Goeldi Paraense Museum (MPEG) in Belém, and the National Research Institute of Amazonia (INPA) in Manaus;

III The resource distribution to support biodiversity scientific projects by the National Council for Scientific and Technological Development (CNPq), the largest governmental institution for research funding in Brazil. For this, we evaluated the results of the two main calls funded by CNPq: [1] The Universal Grant, which is open to all research areas and [2] the Long-Term Ecological Research program (PELD, in Portuguese).

We evaluated the distribution of grants and scholarships in relation to the population density of each region, which represents a general proxy for human resources training demand. We also evaluate the same metrics in relation to the total area of each region, since it is directly linked to the amount of financial resources needed to have a spatially balanced distribution of biological sampling. In addition, more balanced financial resources distribution by area means that people from the region itself have more chance to access institutions and get involved in research initiatives. We present the results below and propose key recommendations to reduce funding asymmetries and to improve the scientific capacity for biodiversity research on Amazonia.

Results

When compared to other regions, the number of grants and scholarships for biodiversity research in the Brazilian Amazon was rather limited. In 2022, the Brazilian Amazon received 13% of CAPES-funded scholarships associated with biodiversity research (Table 1), the second region that received the least resources the agency provided (Fig. 1A). The proportion of researchers in postgraduate programs in biodiversity is similar: only 12% are allocated in Brazilian Amazon institutions, while 55% are hosted in South and Southeast institutions. The outcome of the last three CNPq Universal calls (2016, 2018 and 2021) allocated US$ 4.5 million to projects related to Botany, Zoology, Ecology and Limnology, and awarded around 30% of all budget to support less favored regions, such as the North, Northeast, and Central-West. However, institutions in

Table 1
Indicators of public investment for biodiversity research between Brazilian states. Scholarships represent the number of master's, doctoral and postdoctoral individual grants financed by CAPES (Coordination for the Improvement of Higher Education) for biodiversity area in 2022; Budget for project is the investment made by CNPq-funded Universal Grants related to Botany, Zoology, Ecology and Limnology between 2016 and 2022; Budget for PELD is the resources delivered by CNPq in 2020 for monitoring Long-Term Ecological Research sites, according to the state of the executing institution. All values were calculated considering the currency monetary conversion of 1 USD to 5.34 BRL. Per capita relation was calculated using the total population of each state and region (IBGE, 2022), and per area relation was calculated using the total area (km^2) of each state. To access each state's population density and total area, see Supplementary Table S2.

Region	Scholarships			Researchers			CNPq budget ($)			PELD budget ($)		
	Total	Per capita	Per area	Total	Per capita	Per area	Total	Per capita	Per area	Total	Per capita	Per area
DF	79	2.7^{-5}	1.3^{-2}	75	2.5^{-5}	1.3^{-2}	195590	0.07	33.95	66254	0.02	11.50
GO	96	1.3^{-5}	2.8^{-4}	61	8.7^{-6}	1.7^{-4}	182737	0.03	0.54	70027	0.01	0.21
MS	107	3.7^{-5}	2.9^{-4}	81	2.8^{-5}	2.2^{-4}	175323	0.06	0.49	63750	0.02	0.18
MT	87	2.3^{-5}	9.6^{-5}	68	1.7^{-5}	7.5^{-5}	61308	0.02	0.07	144836	0.02	0.16
Total Central-West	**369**	**2.2^{-5}**	**2.2^{-4}**	**285**	**1.7^{-5}**	**1.7^{-4}**	614960	**0.04**	**0.38**	344869	**0.01**	**0.21**
AL	39	1.2^{-5}	1.4^{-3}	16	5.1^{-6}	5.7^{-4}	0	0	0	60000	0.02	2.15
BA	245	1.6^{-5}	4.3^{-4}	200	1.3^{-5}	3.5^{-4}	192613	0.01	0.34	60068	0.004	0.11
CE	59	6.6^{-6}	3.9^{-4}	64	7.1^{-6}	4.2^{-4}	124376	0.01	0.84	74157	0.009	0.50
MA	12	1.8^{-6}	3.6^{-5}	36	5.2^{-6}	1.0^{-4}	22218	0.003	0.07	0.00	0.00	0.00
PB	96	2.3^{-5}	1.7^{-3}	70	1.7^{-5}	1.2^{-3}	6042	0.001	0.11	$0.00	0.00	0.00
PE	269	2.9^{-5}	2.7^{-3}	135	1.4^{-5}	1.3^{-3}	374003	0.04	3.81	141203	0.03	1.44
PI	6	1.8^{-6}	2.3^{-5}	16	4.8^{-6}	6.3^{-5}	12055	0.003	0.05	0.00	0.00	0.00
RN	82	2.4^{-5}	1.6^{-3}	48	1.4^{-5}	9.0^{-4}	134348	0.04	2.54	59962	0.02	1.14
SE	37	1.6^{-5}	1.7^{-3}	16	7.2^{-6}	7.2^{-4}	24072	0.01	1.10	0.00	0	0.00
Total Northeast	**845**	**1.5^{-5}**	**5.4^{-4}**	**601**	**1.0^{-5}**	**3.8^{-4}**	889732	**0.02**	**0.57**	395391	**0.007**	**0.25**
AC	5	6.0^{-6}	3.0^{-5}	12	1.4^{-5}	7.3^{-5}	0	0	0	0.00	0	0.00
AM	186	4.7^{-5}	1.1^{-4}	119	3.0^{-5}	7.6^{-5}	286624	0.07	0.18	284835	0.08	0.18
AP	35	4.5^{-5}	2.4^{-4}	14	1.8^{-5}	9.8^{-5}	16012	0.02	0.11	0.00	0	0.00
PA	255	3.0^{-5}	2.0^{-4}	157	1.8^{-5}	1.2^{-4}	157080	0.02	0.13	198791	0.03	0.16
RO	16	9.9^{-6}	6.7^{-5}	12	7.4^{-6}	5.0^{-5}	0	0	0	0.00	0	0.00
RR	0	0	0	0	0	0	16014	0.03	0.07	79196	0.14	0.35
TO	14	8.8^{-6}	5.0^{-5}	15	9.4^{-6}	5.4^{-5}	5927	0.003	0.02	67177	0.05	0.24
Total North	**511**	**2.8^{-5}**	**7.4^{-4}**	**329**	**1.8^{-5}**	**4.7^{-4}**	481659	**0.03**	**0.70**	630001	**0.04**	**0.16**
ES	25	6.3^{-6}	2.9^{-4}	32	8.0^{-6}	3.7^{-4}	40907	0.01	0.48	7756292	0.02	1.68
MG	378	1.8^{-5}	6.4^{-7}	279	1.3^{-5}	4.7^{-4}	583546	0.03	0.99	22343165	0.02	0.38
RJ	440	2.6^{-5}	1.0^{-2}	260	1.5^{-5}	5.9^{-3}	646708	0.04	14.78	25400823	0.02	5.81
SP	642	1.3^{-5}	2.6^{-3}	506	1.0^{-5}	2.0^{-3}	694389	0.02	2.80	280757	0.005	1.13
Total Southeast	**1485**	**1.7^{-5}**	**1.6^{-3}**	**1077**	**1.2^{-5}**	**1.1^{-3}**	1965551	**0.02**	**2.13**	835760	**0.01**	**0.90**
PR	280	2.3^{-5}	1.6^{-3}	198	1.6^{-5}	1.1^{-3}	303525	0.03	1.74	160432	0.005	0.92
RS	327	2.9^{-5}	1.4^{-3}	194	1.7^{-5}	8.5^{-4}	420672	0.04	1.85	281521	0.007	1.24
SC	66	8.5^{-6}	4.9^{-4}	60	7.7^{-6}	4.5^{-4}	137118	0.02	1.04	121555	0.006	0.92
Total South	**673**	**2.1^{-5}**	**1.3^{-3}**	**452**	**1.4^{-5}**	**8.4^{-4}**	861316	**0.03**	**1.61**	563509	**0.005**	**1.05**

the Brazilian Amazon received just 10% of the total investment, the lowest percentage in the country (Table 1), resulting in only each research group receiving an average of only U$18,000 to cover all project costs, including field expeditions, personnel hire, and the purchase and maintenance of laboratory and field equipment. For long-term ecological monitoring projects, in 2020, the CNPq-funded PELD Call allocated approximately US$ 2.7 million to fund 36 research projects (Table 1). Seven of these PELDs were funded in the Brazilian Amazon, which received approximately US$ 630 thousand (or 22.7%) of the total funding available.

Investment *per capita* and *per area*

The distribution of grants and scholarships in relation to population density and territorial area demonstrates contrasting scenarios (Fig. 1B and C). Due to the low population density of the Brazilian Amazon, the availability of scholarships per capita in the region is similar to or even better than that allocated in more economically-developed regions of Brazil, such as the South and Southeast (Fig. 1B). For example, while the North region had about 34 thousand people for each scholarship in 2022, the Southeast region had around 58 thousand (Supplementary Table S1). The same pattern was observed for the proportion of researchers working in biodiversity postgraduate courses. In 2022, the Brazilian Amazon had 1.5 more researchers per capita than the Southeast. In practical terms, these data could indicate that although the North region receives a small portion of the total federal grants and scholarships, training opportunities for the local population can be considered adequate, at least given the national average. However, we found the opposite pattern when we considered the territorial area of each region (Fig. 1C). While the Southeast region received around US$ 2.0 per km^2 by the Universal grant between 2016 and 2020, the North region received US$ 0.13. The inequalities remained when we evaluated funding for the PELD program. Considering the amount allocated per km^2 in 2022, the South region received about six times more resources than the North region. Putting this into perspective, the budget for Brazilian Amazon PELD sites would need to increase from US$ 630 thousand to approximately US$ 4 million to meet the same area-based investment received in the South region.

Intra-Amazonia resource distribution and challenges

Resource distribution in the Brazilian Amazon is concentrated in the two largest cities, Manaus and Belém, which received 90% of all scholarships financed by CAPES. Even when considering population density differences, training opportunities for biodiversity-related graduate courses between states of the Brazilian Amazon were strongly uneven (Table 1). The state of Roraima, which hosts a singular mosaic of natural and anthropogenic non-forest and forest ecosystems (Barbosa et al., 2007), is the only Brazilian state with no postgraduate degree in biodiversity. Research institutions based in Manaus and Belém also concentrated 92% of all budgets provided by CNPq through Universal Grants for biodiversity projects in the north region, and only three of the 25 Amazonian researchers contemplated by the CNPq Universal Grants works outside these two cities. This indicates that the science produced in the Brazilian Amazon is heavily dependent on the institutions present in these

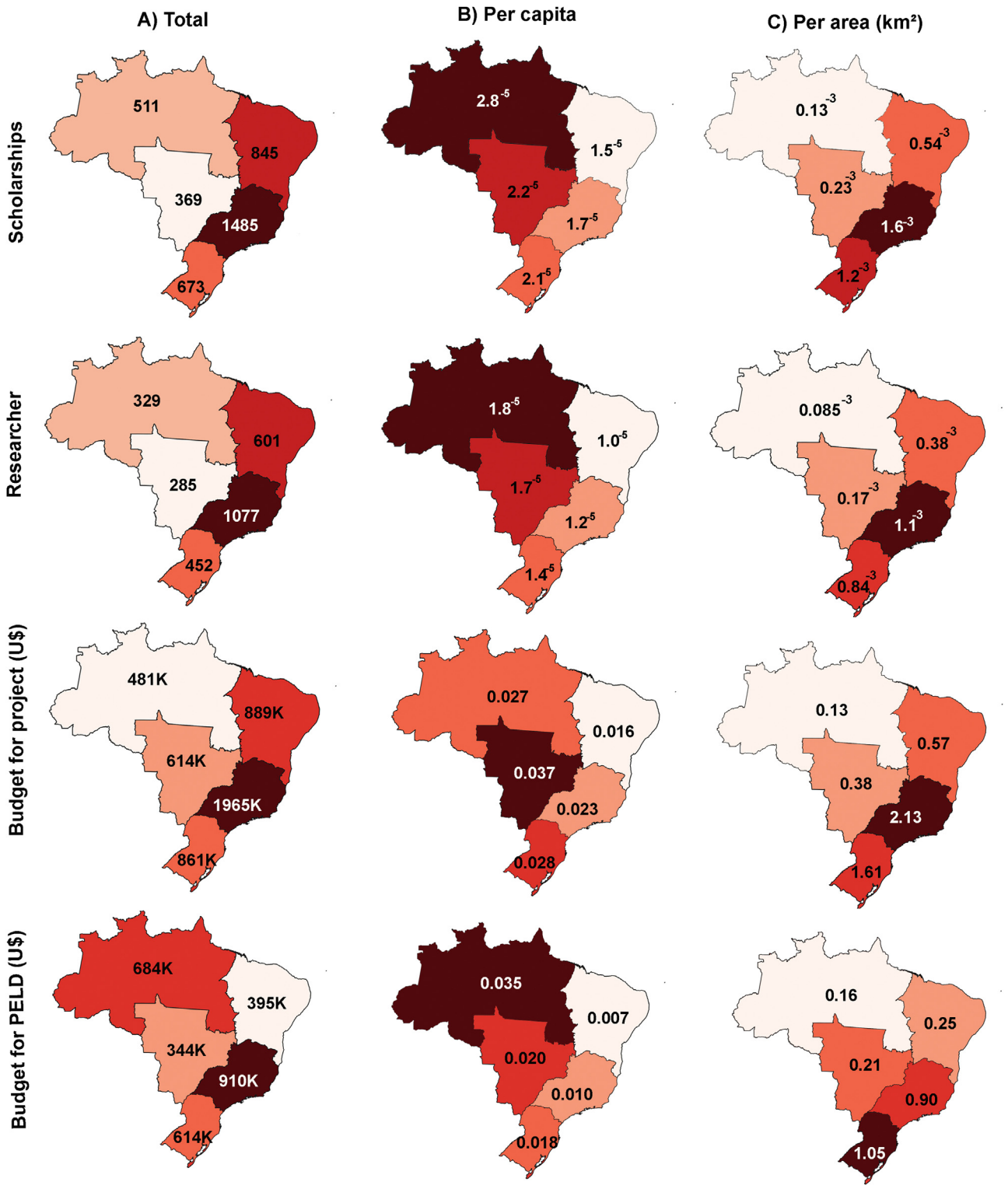


Fig. 1. Distribution of financial resources for research projects and scholarships between Brazilian macroregions. Scholarships represent the number of master's, doctoral and postdoctoral individual grants financed by CAPES (Coordination for the Improvement of Higher Education) for biodiversity area in 2022; Budget for the project is the investment made by CNPq-funded Universal Grants related to Botany, Zoology, Ecology and Limnology between 2016 and 2022; Budget for PELD is the resources delivered by CNPq in 2020 for monitoring Long-Term Ecological Research sites, according to the state of the executing institution. All values were calculated considering the currency monetary conversion of 1 USD to 5.34 BRL. Column (A) indicates the total values; (B) the relation between the total values and total population of each macroregion (IBGE, 2022); and (C) the relation between the total values and total area (km^2) of each macroregion.

cities, including two major biodiversity research centers, MPEG and INPA. These institutions are chronically underfunded and understaffed (Weigel, 2001). For example, in 2022, 68% of the staff at MPEG and INPA were eligible to retire, which represents the loss of 110 researchers in the coming years (Fig. 1 of supplement material). This erosion in the Amazonian research staff is greater than the 51 and 19 new research positions due to be filled in 2024 for INPA and MPEG, respectively (BRASIL, 2023a).

Discussion

Our assessment of grants and scholarships distribution across Brazil highlights that while allocation on a per capita basis is evenly distributed, more is needed to account for the geographic size and ecological relevance of the Brazilian Amazon. This stark deficit in research investment by area is incompatible with the great environmental heterogeneity and hyper-diversity of the Amazon (Zapata-Rios et al. 2021). It is important to mention that each Brazilian state has its own research support foundation, which acts in complement to the federal agencies. However, the annual budget of these foundations varies widely over the country, as its most significant source is state tax income, which reflects the economic activity of each region. For example, while the annual budget for the Foundation for Research Support of Amazonas (FAPEAM) in 2022 was about US$ 28 million, the budget for the Foundation for Research Support of São Paulo (FAPESP) was US$ 411 million. Although Amazonian foundations play an important role in financing local research, their budgets are insufficient to subvert the challenges of carrying out ecological research in the region. Given the complexity of Amazonian landscapes and the urgency to improve our knowledge about its biodiversity and resilience (Carvalho et al., 2023), the spatial scale is an aspect that needs to be considered in new national science policies to support biodiversity research.

The limited amount of funding allocated to the Amazon by the most important federal grants directly impacts biodiversity research in the Amazon, where biological inventories and fieldwork are often complex and expensive due to high inaccessibility and logistical limitations (Gardner et al., 2008). Most of the large ecological research in the region has been heavily financed by international funds. For example, the Amazon Tall Tower Observatory (ATTO), a project that aims to continuously record meteorological, chemical and biological data from the Amazon atmosphere, has been made possible only by the German government investment, as well as the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), a program originally strongly financed by the US National Aeronautics and Space Administration (NASA). The UK's support for the Amazon Free-Air CO^2 Enrichment Program (AmazonFace) was around R$17 million in 2022 (Sugimoto, 2021), which is more than the total budget available to support PELD sites over the country in 2020. While this international funding has enabled important research in a limited number of sites, it also contrasts with the limited budget by the Brazilian government to build capacity and develop long-term research across the basin. Here, we suggest a three-pronged approach to address it: (i) Creating a national funding specific for Amazon; (ii) Improve resource distribution within the Amazon; and iii. Strengthening international funding and cooperation.

i. Creating a national fund specific for Amazonian research: The Brazilian government recently announced a record investment of U$ 561 million for research and development initiatives in Amazonian states (MCTI, 2023). The consolidation of this initiative, not just as an isolated action, but as a permanent national science policy, could be a game changer for scientific infrastructure in the region. The creation of a special secretariat for the Amazon within the Ministry of Science, Technology and Innovation, as Candotti et al. (2023) suggested, can also support intersectoral articulation to prospect and implement these new investments. Part of these funds must be allocated to finance biodiversity studies, in order to help to avoid and mitigate both the climate and the biodiversity crisis.

ii. Improve the distribution of research funding within the Amazon: The funding centralization in Manaus and Belém institution's highlights the challenges faced by Amazon-based researchers working outside major centers. While our assessment does not delve into the reasons explaining this, there are three possibilities: a comparative lack of researchers based outside the megacities, the low number of applications submitted by these researchers, or the low success rate of the applications. Future research exploring these reasons is required to help find solutions, which could vary from changing evaluation criteria to give greater recognition of socio-economic context or enhancing cooperation. The Amazon+10 initiative and the last call (CNPq, 2023) is welcome as it places greater emphasis on the latter, requiring the involvement of several Amazonian states in the same research project, as well as the participation of indigenous researchers.

iii. Strengthening international funding: The expansion and strengthening of transnational cooperation focused on supporting research projects in the Amazon could also play a key role in the scientific capacity of the region. The Amazon Fund is a good example of how large-scale international cooperation can transform local reality (Correa et al., 2020), although biodiversity research projects funded by the program are still rare. Despite environmental monitoring being one of the structuring axes of the fund, the current projects supported by the Amazon Fund focus predominantly on remote sensing (Amazon Fund, 2022). Making only a small percentage of this fund available for biodiversity research could enable a step change in our understanding of the biology and distribution of species.

Research on biodiversity could also be boosted by bilateral agreements between Amazonian countries and states and overseas funding agencies; both NSF and UKRI have successful bilateral agreements with FAPESP (i.e., São Paulo state agency for research funding), but there has been much less co-funding of projects with Amazonian research funding agencies. Longer-term support for the state agencies in the Amazon could facilitate greater opportunities for collaboration within the Amazon itself. Although the collaboration of developed countries in transnational calls is fundamental to improving local science, it needs to guarantee the recognition and protagonism of Amazonian researchers and institutions rather than reproduce colonial models of doing science (Trisos et al., 2021).

Conclusion

It is a huge challenge to promote science in such an extensive and complex territory as the Amazon, but much can be done based on strong intersectoral cooperation and strategic political decisions. The inequalities we have pointed out here do not reflect an exclusive scenario of biodiversity research, but rather a structural aspect that Brazilian science has not yet overcome. Although research may seem expensive, the amounts required pale in comparison to other government expenditure: for example, the parliamentarians of Pará state spent five times more on travel and phone expenses than the total funds provided by the Universal call for research projects in the state between 2016 and 2021 (BRASIL, 2023b). Enhancing research in the world's most biodiverse ecosystem has the potential to unlock important benefits for society; while we welcome the positive steps made by the new government in Brazil - including region specific research calls - boosting capacity in the longer term will require sustained investment in the research infrastructure and human resources.

Funding

The work was developed by the Synergize Network through funding from the Brazilian Research Council (CNPq) under the Brazilian Synthesis Centre on Biodiversity and Ecosystem Services (SinBiose) (grant: CNPq/MCTIC 442354/2019-3). LS also received research grants from the Brazilian Research Council (150013/2022-1; 300027/2023-0) and from FAPESPA (Nº 007/2021). FMF thanks the University of Bristol (PolicyBristol, 1989427; Climate and Net

Zero Impact Awards, 170839). EMV, IV, JF received research grants from CNPq (308543/2021-1, 350182/2022-1 and 314242/2021-0, respectively). JB thanks the Climate and Biodiversity Initiative of the BNP Paribas Foundation (Project BIOCLIMATE). LC thanks NSF award #1852113 and Project SABERES (BNP Paribas Foundation).

Conflicts of interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pecon.2024.01.003.

References

Abreu, W.M., Neiva, V.M., Lima, N., 2012. Modelos de tomada de decisão no processo orçamentário brasileiro: uma agenda de pesquisas. Revista do do Serviço Público 63 (2), 135–155, http://dx.doi.org/10.21874/rsp.v63i2.92.

Alberti, M., https://edition.cnn.com/2023/05/26/americas/brazil-cop30-climate-change-amazon-intl-latam/index.html, 2023 (accessed 28 May 2023).

Amazon Fund. 2022. Activity Report. https://www.amazonfund.gov.br/export/sites/default/en/.galleries/documentos/rafa/RAFA_2022_en.pdf (accessed 12 September 2023).

Barbosa, A.R.I., Campos, C., Pinto, F., Fearnside, P.M., 2007. The "Lavrados" of Roraima: biodiversity and conservation of Brazil's Amazonian Savannas. Funct. Ecosyst. Communities. 1, 29–41.

Berenguer, E., Armenteras, D., Lees, A.C., Fearnside, P.M., Smith, C.C., Alencar, A., Almeida, C., Aragão, L., Barlow, J., Bilbao, B., Brando, P., Bynoe, P., Finer, M., Flores, B.M., Jenkins, C.N., Silva Junior, C.H.L., Souza, C., García-Villacorta, R., Nascimento, N., 2021. Chapter 19: Drivers and Ecological Impacts of Deforestation and Forest Degradation. In: Nobre, C., Encalada, A., Anderson, E., Roca Alcazar, F.H., Bustamante, M., Mena, C., Peña-Claros, M., Poveda, G., Rodriguez, J.P., Saleska, S., Trumbore, S., Val, A.L., Villa Nova, L., Abramovay, R., Alencar, A., Rodríguez Alzza, C., Armenteras, D., Artaxo, P., Athayde, S., Barretto Filho, H.T., Barlow, J., Berenguer, E., Bortolotto, F., Costa, F.A., Costa, M.H., Cuvi, N., Fearnside, P.M., Ferreira, J., Flores, B.M., Frieri, S., Gatti, L.V., Guayasamin, J.M., Hecht, S., Hirota, M., Hoorn, C., Josse, C., Lapola, D.M., Larrea, C., Larrea-Alcazar, D.M., Lehm Ardaya, Z., Malhi, Y., Marengo, J.A., Melack, J., Moraes, R.M., Moutinho, P., Murmis, M.R., Neves, E.G., Paez, B., Painter, L., Ramos, A., Rosero-Peña, M.C., Schmink, M., Sist, P., ter Steege, H., Val, P., van der Voort, H., Varese, M., Zapata-Ríos, G. (Eds.), Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA https://www.theamazonwewant.org/spa-reports/.

BRASIL, https://www.in.gov.br/en/web/dou/-/portaria-mcti-n-7.227-de-12-de-julho-de-2023-496003670, 2023a (accessed 05 August 2023).

BRASIL, https://www.camara.leg.br/transparencia/gastos-parlamentares#cota, 2023b (accessed 10 December 2023).

Candotti, E., Bemerguy, E., Moreira, I., Vieira, I., Câmara, G., Elias, L.A., Correa, M., Gabas, N., Monteiro, R., http://www.jornaldaciencia.org.br/amazonia-em-14-tempos/, 2023.

Carvalho, R.L., Resende, A.F., Barlow, J., França, F., Moura, M.R., Maciel, R., Alves-Martins, F., Shutt, J., Nunes, C.A., Elias, F., Silveira, J.M., Stegmann, L., Baccaro, F.B., Juen, L., Schietti, J., Aragão, L., Berenguer, E., Castello, L., Costa, F.R.C., Guedes, M.L., Leal, C.G., Lees, A.C., Isaac, V., Nascimento, R.O., Phillips, O., Schmidt, F.A., ter Steege, H., Vaz-de-Mello, F., Venticinque, E.M., Vieira, I.C.G., Zuanon, J., The Synergize Consortium, Ferreira, J., 2023. Pervasive gaps in Amazonian ecological research. Curr. Biol., http://dx.doi.org/10.1016/j.cub.2023.06.077.

Chaimovich, H., Pedrosa, R., 2021. Brazil. In: Schneegans, S., Straza, T., Lewis, J. (Eds.), UNESCO Science Report: the Race Against Time for Smarter Development. Paris, pp. 256–257.

CNPq, https://www.gov.br/cnpq/pt-br/assuntos/noticias/cnpq-em-acao/em-parceria-com-o-cnpq-iniciativa-amazonia-10-lanca-a-chamada-expedicoes-cientificas, 2023 (accessed 11 December 2023).

CNUC, https://shre.ink/cGz8, 2023 (accessed 02 March 2023).

Correa, J., Cisneros, E., Börner, J., Pfaff, A., Costa, M., Rajão, R., 2020. Evaluating REDD+ at subnational level: Amazon fund impacts in Alta Floresta, Brazil. For. Policy Econ. 116, 102178, http://dx.doi.org/10.1016/j.forpol.2020.102178.

Dagosta, F.C.P., Pinna, M.C.C., 2018. A history of the biogeography of Amazonian fishes. Neotrop. Ichthyol. 16, 1–19, http://dx.doi.org/10.1590/1982-0224-20180023.

Dos Santos, J.G., Malhado, A.C.M., Ladle, R.J., Correia, R.A., Costa, M.H., 2015. Geographic trends and information deficits in Amazonian conservation research. Biodivers. Conserv. 24, 2853–2863, http://dx.doi.org/10.1007/s10531-015-0981-x.

Fearnside, P., 2019. Hidrelétricas na Amazônia: impactos ambientais e sociais na tomada de decisões sobre grandes obras. Editora do INPA, Manaus, pp. 148.

Fearnside, P., Berenguer, E., Armenteras, D., Duponchelle, F., Mosquera, G.F., Jenkins, C.N., et al., 2021. Chapter 20: Drivers and impacts of changes in aquatic ecosystems. In: Nobre, C., Encalada, A., Anderson, E., Roca Alcazar, F.H., Bustamante, M., Mena, C., Peña-Claros, M., Poveda, G., Rodriguez, J.P., Saleska, S., Trumbore, S., Val, A.L., Villa Nova, L., Abramovay, R., Alencar, A., Rodríguez Alzza, C., Armenteras, D., Artaxo, P., Athayde, S., Barretto Filho, H.T., Barlow, J., Berenguer, E., Bortolotto, F., Costa, F.A., Costa, M.H., Cuvi, N., Fearnside, P.M., Ferreira, J., Flores, B.M., Frieri, S., Gatti, L.V., Guayasamin, J.M., Hecht, S., Hirota, M., Hoorn, C., Josse, C., Lapola, D.M., Larrea, C., Larrea-Alcazar, D.M., Lehm Ardaya, Z., Malhi, Y., Marengo, J.A., Melack, J., Moraes, R.M., Moutinho, P., Murmis, M.R., Neves, E.G., Paez, B., Painter, L., Ramos, A., Rosero-Peña, M.C., Schmink, M., Sist, P., ter Steege, H., Val, P., van der Voort, H., Varese, M., Zapata-Ríos, G. (Eds.), Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA https://www.theamazonwewant.org/spa-reports/.

Gardner, T.A., Barlow, J., Araujo, I.S., Ávila-Pires, T.C., Bonaldo, A.B., Costa, J.E., Esposito, M.C., Ferreira, Lv., Hawes, J., Hernandez, M.I.M., Hoogmoed, M.S., Leite, R.N., Lo-Man-Hung, N.F., Malcolm, J.R., Martins, M.B., Mestre, L.A.M., Miranda-Santos, R., Overal, W.L., Parry, L., Peters, S.L., Ribeiro, M.A., Da Silva, C.M., Peres, C.A., 2008. The cost-effectiveness of biodiversity surveys in tropical forests. Ecol. Lett. 11 (2), 139–150, http://dx.doi.org/10.1111/j.1461-0248.2007.01133.x.

Gatti, L.V., Basso, L.S., Miller, J.B., Gloor, M., Gatti Domingues, L., Cassol, H.L.G., Tejada, G., Aragão, L.E.O.C., Nobre, C., Peters, W., Marani, L., Arai, E., Sanches, A.H., Corrêa, S.M., Anderson, L., von Randow, C., Correia, C.S.C., Crispim, S.P., Neves, R.A.L., 2021. Amazonia as a carbon source linked to deforestation and climate change. Nature 595 (7867), 388–393, http://dx.doi.org/10.1038/s41586-021-03629-6.

GFW. Global Forest Watch. https://research.wri.org/gfr/latest-analysis-deforestation-trends (accessed 22 August 2022).

Góes, C., Karpowicz, I., 2017. Inequality in Brazil: a regional perspective. IMF Working Papers 17 (225), 1, http://dx.doi.org/10.5089/9781484324776.001.

IBGE, https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/15761-areas-dos-municipios.html, 2022 (accessed 19 June 2022).

ISA, https://terrasindigenas.org.br/, 2022 (accessed 5 June 2022).

Lapola, D.M., Pinho, P., Barlow, J., Aragão, L.E.O.C., Berenguer, E., Carmenta, R., Liddy, H.M., Seixas, H., Silva, C.V.J., Silva-Junior, C.H.L., Alencar, A.A.C., Anderson, L.O., Armenteras, D., Brovkin, V., Calders, K., Chambers, J., Chini, L., Costa, M.H., Faria, B.L., Fearnside, P.M., Ferreira, J., Gatti, L., Gutierrez-Velez, V.H., Han, Z., Hibbard, K., Koven, C., Lawrence, P., Pongratz, J., Portela, B.T.T., Rounsevell, M., Ruane, A.C., Schaldach, R., da Silva, S.S., von Randow, C., Walker, W.S., 2023. The drivers and impacts of Amazon forest degradation. Science 379 (6630), http://dx.doi.org/10.1126/science.abp8622.

MCTI-Ministério da Ciência, https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2023/08/ministra-luciana-santos-anuncia-volume-recorde-de-investimentos-em-ciencia-e-tecnologia-na-amazonia, 2023 (accessed 12 August 2023).

Mittermeier, R.A., Mittermeier, C.G., Brooks, T.M., Pilgrim, J.D., Konstant, W.R., Da Fonseca, G.A.B., Kormos, C., 2003. Wilderness and biodiversity conservation. PNAS 100 (18), 10309–10313, http://dx.doi.org/10.1073/pnas.1732458100.

Moraes, R.M., Correa, S.B., Rodrigues da Costa Doria, C., Duponchelle, F., Miranda, G., Montoya, M., et al., 2021. Chapter 4: Amazonian Ecosystems and Their Ecological Functions. United Nations Sustainable Development Solutions Network, New York, http://dx.doi.org/10.55161/ikrt9380.

Oliveira, U., Paglia, A.P., Brescovit, A.D., Carvalho, C.J.B., Silva, D.P., Rezende, D.T., Leite, F.S.F., Batista, J.A.N., Barbosa, J.P.P.P., Stehmann, J.R., Ascher, J.S., Vasconcelos, M.F., de Marco, P., Löwenberg-Neto, P., Dias, P.G., Ferro, V.G., Santos, A.J., 2016. The strong influence of collection bias on biodiversity knowledge shortfalls of Brazilian terrestrial biodiversity. Divers. Distrib. 22 (12), 1232–1244, http://dx.doi.org/10.1111/ddi.12489.

Rannard, G., 2022. COP27: Brazil is back on the world stage, Lula tells climate summit. BBC https://www.bbc.com/news/science-environment-63625698 (accessed 3 December 2022).

Rodrigues, M., 2023. Oil from the Amazon? Proposal to drill at river's mouth worries researchers. Nature https://www.nature.com/articles/d41586-023-02187-3.

Silva Junior, C.H.L., Moura, Y.M., Pessôa, A.C.M., Trevisan, D.P., Mendes, F.S., Reis, J.B.C., Picoli, M.C.A., Wiederkehr, N.C., Carvalho, N.S., Dalagnol, R., Kuck, T.N., Rosan, T.M., Silva, T.S.F., Liesenberg, V., Bispo, P.C., 2021. Surviving as a young scientist in Brazil. Science 6570, 948, http://dx.doi.org/10.1126/science.abm8160.

Smith, C.C., Healey, J.R., Berenguer, E., Young, P.J., Taylor, B., Elias, F., Espírito-Santo, F., Barlow, J., 2021. Old-growth forest loss and secondary forest recovery across Amazonian countries. Environ. Res. Lett. 16 (8), 085009, http://dx.doi.org/10.1088/1748-9326/ac1701.

Strand, J., Soares-Filho, B., Costa, M.H., Oliveira, U., Ribeiro, S.C., Pires, G.F., Oliveira, A., Rajão, R., May, P., van der Hoff, R., Siikamäki, J., da Motta, R.S., Toman, M., 2018. Spatially explicit valuation of the Brazilian Amazon Forest's Ecosystem Services. Nat. Sustainability 1 (11), 657–664, http://dx.doi.org/10.1038/s41893-018-0175-0.

Sugimoto, L., https://www.ecycle.com.br/um-experimento-de-alcance-sem-precedentes-na-amazonia/, 2021 (accessed 23 February 2023).

Ter Steege, H., Pitman, N., Sabatier, D., Castellanos, H., Van der Hout, P., Daly, D.C., Silveira, M., Phillips, O.L., Vasquez, R., Van Andel, T., Duivenvoorden, J., De Oliveira, A.A., Ek, R., Lilwah, R., Thomas, R., Van Essen, J., Baider, C., Maas, P., Mori, S., Terborgh, J., Nunez, P.V., Mogollon, H., Morawetz, W., 2003. A spatial model of tree adiversity and b-density for the Amazon Region. Biodivers. Conserv. 12, 2255–2277.

Trisos, C.H., Auerbach, J., Katti, M., 2021. Decoloniality and anti-oppressive practices for a more ethical ecology. Nat. Ecol. Evol. 5 (9), 1205–1212, http://dx.doi.org/10.1038/s41559-021-01460-w.

Venticinque, E., Forsberg, B., Barthem, R., Petry, P., Hess, L., Mercado, A., Cañas, C., Montoya, M., Durigan, C., Goulding, M., 2016. An explicit GIS-based river basin framework for aquatic ecosystem conservation in the Amazon. Earth Syst. Sci. Data 8 (2), 651–661, http://dx.doi.org/10.5194/essd-8-651-2016.

Vieira, I.C.G., Silva, J.M.C., Toledo, P.M., 2005. Estratégias para evitar a perda de biodiversidade na Amazônia. Estudos Avançados 19 (n. 54), 153–164, http://dx.doi.org/10.1590/S0103-40142005000200009.

Web of Science Group, https://jornal.usp.br/wp-content/uploads/2019/09/ClarivateReport_2013-2018.pdf, 2019 (accessed 10 April 2022).

Weigel, P., 2001. O papel da ciência no futuro da Amazônia: uma questão de estratégia. Parceiras Estratégicas, pp. 12 https://www.cgee.org.br/documents/10195/734063/8.2.2_1890.pdf/6b46abc3-a3ea-4342-8566-351366d772ca?version=1.0.

Zapata-Ríos, G., Andreazzi, C.S., Carnaval, A.C., Rodrigues da Costa Doria, C., Duponchelle, F., Flecker, A., Guayasamin, J.M., Heilpern, S., Jenkins, C.N., Maldonado, C., Meneghelli, D., Miranda, G., Moraes, R.M., Silman, M., Pinheiro de Almeida Silveira, M.A., Tabet, G., Trujillo, F., Ulloa Ulloa, C., Arieira, J., 2021. Chapter 3: Biological diversity and ecological networks in the Amazon. In: Nobre, C., Encalada, A., Anderson, E., Roca Alcazar, F.H., Bustamante, M., Mena, C., Peña-Claros, M., Poveda, G., Rodriguez, J.P., Saleska, S., Trumbore, S., Val, A.L., Villa Nova, L., Abramovay, R., Alencar, A., Rodríguez Alzza, C., Armenteras, D., Artaxo, P., Athayde, S., Barretto Filho, H.T., Barlow, J., Berenguer, E., Bortolotto, F., Costa, F.A., Costa, M.H., Cuvi, N., Fearnside, P.M., Ferreira, J., Flores, B.M., Frieri, S., Gatti, L.V., Guayasamin, J.M., Hecht, S., Hirota, M., Hoorn, C., Josse, C., Lapola, D.M., Larrea, C., Larrea-Alcazar, D.M., Lehm Ardaya, Z., Malhi, Y., Marengo, J.A., Melack, J., Moraes, R.M., Moutinho, P., Murmis, M.R., Neves, E.G., Paez, B., Painter, L., Ramos, A., Rosero-Peña, M.C., Schmink, M., Sist, P., ter Steege, H., Val, P., van der Voort, H., Varese, M., Zapata-Ríos, G. (Eds.), Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. https://www.theamazonwewant.org/spa-reports/.