Four decades of natural resources research in Brazil: A scientometric analysis

Quatro décadas de pesquisa em recursos naturais no Brasil: Uma análise cienciométrica

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ABSTRACT

Brazil holds vast natural resources reserves, but their depletion can cause serious environmental issues on natural ecosystems and human society, such as desertification, pollution, biodiversity loss, and climate change. In this study, we update the perspectives of natural resources publications by Brazilian scientists. We investigated articles in the Web of Science and Scopus databases published until December 31st 2020 using the key terms "natural resource", and "Brasil" or "Brazil" in the authors' address field. Data were analyzed using Microsoft Excel, Biblioshiny for RStudio, and SigmaPlot. From the first publication in 1977 until 2020, 3,983 articles were published, totalizing 88,530 citations. A total of 5,950 institutions from 78 countries collaborated on publishing in 1,101 journals, with 13,763 signed authors. Conservation and sustainability were the hot topics cited in keyword analyses, while the Amazon Forest was the most studied ecosystem. Brazilian natural resources' research focuses on sustainable development, environmental management politics, and strategies to protect biodiversity and cope with climate change effects.

Keywords: bibliometric; scientific production; Brazilian science; natural richness; sustainability.

RESUMO

O Brasil possui vastas reservas de recursos naturais, mas seu esgotamento pode causar sérios problemas ambientais nos ecossistemas naturais e na sociedade, como desertificação, poluição, perda de biodiversidade e mudanças climáticas. Neste estudo, atualizamos as perspectivas das publicações sobre recursos naturais feitas por cientistas brasileiros. Investigamos, nas bases de dados Web of Science e Scopus, artigos de até 31 de dezembro de 2020 usando os termos-chave "natural resource*" e "Brasil" ou "Brazil" no campo de endereço dos autores. Os dados foram analisados no Microsoft Excel, Biblioshiny para RStudio e SigmaPlot. Desde a primeira publicação em 1977 até 2020, foram publicados 3.983 artigos, totalizando 88.530 citações. O total de 5.950 instituições de 78 países colaboraram na publicação em 1.101 periódicos e assinaram 13.763 autores. Conservação e sustentabilidade foram os principais tópicos citados nas análises de palavras-chave, enquanto a Floresta Amazônica foi o ecossistema mais estudado. A pesquisa brasileira em recursos naturais enfoca o desenvolvimento sustentável, políticas de gestão ambiental e estratégias para proteger a biodiversidade e lidar com os efeitos das mudanças climáticas.

Palavras-chave: bibliometria; produção científica; ciência brasileira; riqueza natural; sustentabilidade.

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Introduction

Scientometric research efficiently analyzes scientific publications, quantitative and qualitative data, measures and delineates current research trends, and guides future studies (Zhong et al., 2016). Mapping scientific production has become a significant scientific research field (Meneghini and Packer, 2010) since Pritchard (1969) proposed and developed it. From the scientific perspective, scientometric and its related terms (bibliometric and informetric) are considered a tool that helps investigators comprehend scientific publications' evolution and how scientific knowledge is created and accumulated from time to time (Dávila, 2012). Since the 1990s, Leta and De Meis (1996) have studied the science structure in Brazil, helping to define research trends, and highlighting the achievements, advances, and problems of national science.

Brazil is known to hold an enormous reserve of natural resources (NR) (Coplin and O'Leary, 1986), which are generally described as any kind of earth's raw material used by humans for their subsistence, to build plenty of useful secondary products, and are also considered as essential elements to maintain ecosystems and wildlife (EPA, 2005). The term NR was first mentioned in the 1970s (Schumacher, 1973) and includes compounds produced through biological, physical, and chemical processes without human interference (Venturi, 2006). Humans can transform NR according to their needs, e.g., the use of petroleum, gas, and coal as fuel, copper for electrical equipment, cotton for clothes, and trees into paper or furniture (EPA, 2005). A more complete definition of the term was written by Venturi (2006), who described that any natural element in demand by men, directly or indirectly, to satisfy physical, biological, social, economic, and cultural needs in a given space and time can be considered a NR.

Following the previous definition, NR have been exploited by humanity through centuries, improving the development of civilizations. More than economic values, NR also have ethical and ecosystemic importance, guaranteeing the maintenance of all living organisms (Dulley, 2004). However, NR depletion due to over-extraction, manufacturing, consumption, and waste disposal generates environmental impacts in both terrestrial and aquatic environments, such as desertification, water and air pollution, species extinction, climate change, and natural disasters (Jie et al., 2023). The direct result of such impacts on NR are a severe loss of biodiversity and ecosystems services (Ceballos et al., 2020)

Due to its relevance, it is essential to investigate and understand the role of NR in our society and in natural environments. This bibliometric analysis provides an updated perspective of natural resources publications by Brazilian scientists. We searched for answers to the questions:

- Q1: How many articles about NR were published by scientists linked to Brazilian institutions until 2020?
- Q2: Which articles about NR are the most cited?
- Q3: What are the main countries producing work on this subject? Did Brazilian authors collaborate with national and foreign researchers?
- Q4: What languages are the articles written and published in?
- Q5: Which institutions are focused on this research field? Which regions in Brazil are they from?
- Q6: What are the most prolific journals in the scope analyzed?
- Q7: What are the research trends depicted by authors' keywords?

Natural resources have been the study object of bibliometric research under different perspectives (Fernandez et al., 2012; Olawumi and Chan, 2018; Ortigueira-Sánchez and Risco-Martínez, 2023). Ho ever, to our knowledge, this is the first bibliometric study that focuses specifically on NR publications by Brazilian authors. The article was structured to describe and discuss the publication and citation numbers, author and institution collaborations, the rank of the most prolific journals, and the trends in the analysis of the keywords.

Methods

The search for documents was performed on the Web of Science (WoS) and Scopus databases. We searched for publications using the term "natural resource*" in titles, keywords, and abstracts, then "Brasil *OR* Brazil" in the authors' address field. The research term was chosen due to its broad meaning, not limiting our search by only one NR, e.g., water, soil, air, or biomass. The temporal gap was settled between the first publication in each database and December 31st, 2020. "Article" as defined by WoS and Scopus was the only analyzed document type. The data downloaded was recorded and contained all article information as provided by each database. They were analyzed using Microsoft Office Excel™ (Version 2016), Biblioshiny (Aria and Cuccurullo, 2017) for RStudio 2021.09.0 Build 351 (R Core Team, 2022) and SigmaPlot 12.0 (Systat Software Inc., 2011). The only screening step adopted was removing the duplicate articles.

Results

Publication outputs, languages, and countries

A total of 1,527 articles were found on the WoS database and 3,606 on Scopus. Articles from both databases were added together and 1,150 duplicates were removed. We then analyzed the publication and citation dynamics, languages, authors, institutions, and keywords from the 3,983 remaining articles. The first publication using the term NR was from 1977. Until 2020 an exponential growth was observed in the number of articles (Figure 1).

Since the beginning of the 21st century, there has been an increase in the scientific production of Brazilian Natural Resources

(BNR). Analyzing each decade since the first publication in 1977, the number of articles published doubled every ten years until 1990. From 1991 to 2000, we observed an increment of 78 articles, a 10-fold publication growth. This pattern continued between 2001 and 2010, when 739 articles were published, with a subsequent 326% increase between 2011 and 2020. The citation progress of BNR publications is also depicted in Figure 1. Citations fluctuated over time, reaching the peak in 2016, when 441 citations were registered.

The ten most cited BNR articles are listed in Table 1, and they are responsible for almost 14,000 citations, while all articles found were cited 88,530 times. An amount of 862 (21.6%) articles were not cited yet. Six of the ten most cited articles were published in *Science*, evidencing the dominance of this journal with regard to publications on BNR.
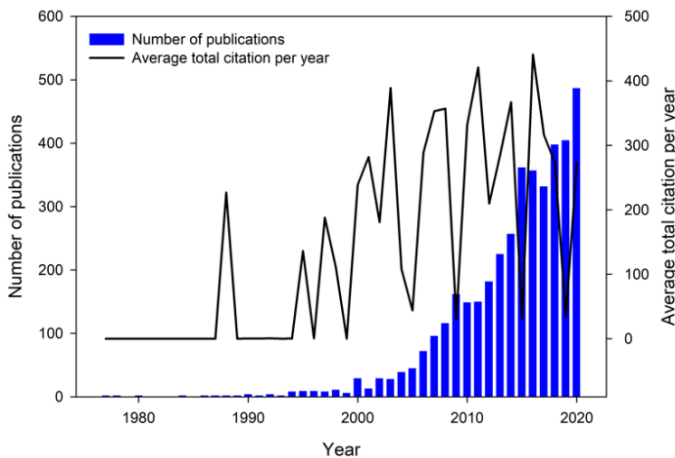
Figure 1 – Number of publications and citations concerning natural resources in Brazil.

Analyzing the articles' titles, the highlighted topics were the Amazon Forest, the Atlantic Forest, croplands, diversity, deforestation, vertebrates, marine mammals, and climate change. A profound analysis of the research trend topics can be seen in "keywords".

Among the most cited articles, USA and UK journals prevailed, ranking seven and three articles, respectively. Hence, the dominant language in BNR publications was English (72.9% or 2,903 articles), followed by Portuguese (24.6% or 979 articles), Spanish (1.9% or 75 articles), French (0.3%), and German (0.02%). The collaboration map of BNR publications is illustrated in Figure 2. The thicker the red line among countries, the stronger their collaboration. Brazilian collaboration in NR research has spread around the world, except for Eastern Europe, the west and north of Asia. Brazil has collaborated with 78 countries, and the USA was the most cooperative (265 articles) followed by the United Kingdom (UK, 115 articles), France (79), Spain (66), and Germany (62). In America, Brazil also published with Canadian, Mexican, Argentinian, Colombian, and Uruguayan researchers. Other countries that contributed to only one article totalized 25.

Authors and institutions

The 3,983 articles found were signed by 13,763 different authors, of which 235 were single authors, responsible for publishing 263 articles. Most of the articles were published in co-authorship with an average of 5.5 authors per article, confirming the co-authorship trend in BNR publications. Considering single (SCP) and multiple country publications (MCP) based on the corresponding author, Brazilian authors were prevalent as the corresponding authors. Brazil was the country that presented the highest number of authors in SCP and MCP, which shows that the articles were published mostly by national researchers or

Table 1 – Ten most cited articles about natural resources in Brazil.

	Title	Journal	Journal Country	Year	Citations
1	Extinction risk from climate change	Science	USA	2004	4,694
2	CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms	Software: Practice and Experience	UK	2011	3,194
3	Effectiveness of the global protected area network in representing species diversity	Nature	UK	2004	950
4	The Status of the World's Land and Marine Mammals: Diversity, Threat, and Knowledge	Science	USA	2008	948
5	The Impact of Conservation on the Status of the World's Vertebrates	Science	USA	2010	887
6	Stability Predicts Genetic Diversity in the Brazilian Atlantic Forest Hotspot	Science	USA	2009	711
7	Selective Logging in the Brazilian Amazon	Science	USA	2005	681
8	Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon	Proceedings of the National Academy of Sciences	USA	2006	647
9	Annual fluxes of carbon from deforestation and regrowth in the Brazilian Amazon	Nature	UK	2000	567
10	Cracking Brazil's Forest Code	Science	USA	2014	553
	Total				13,832

foreign authors residing in Brazil. American researchers were the most collaborative with Brazilian scientists followed by researchers from European countries, with British scientists being important partners.

A total of 5,950 institutions were identified, representing all the geopolitical regions of Brazil. The most productive institutions are listed in Table 2. Institutions from the southeast of Brazil occupied half of the first ten positions, while the most productive international university listed was Florida University (12th position, 56 publications). On average, 3.8 institutions collaborated on each article. National collaboration was higher than partnerships with international institutions, a phenomenon that was observed especially between 1990 and 2000 (Sidone, Haddad and Mena-Chalco, 2016).

Considering the cooperation network between the most productive institutions, we observed that institutions from the same geographical region are most likely to collaborate with each other than with those from different regions. Southeastern universities such as USP, UFRJ, and UFMG presented intense collaboration. The same is true for the partnership between UnB and UFG, both form the center-west region. Because of the geographical proximity, UnB and UFMG also showed strong cooperation on NR publications.

Journals

The articles were published in 1,101 journals. The journals that published only one article totalized 613 or 55.6%, while 18.7% of the articles were published by the ten most prolific journals (Table 3).
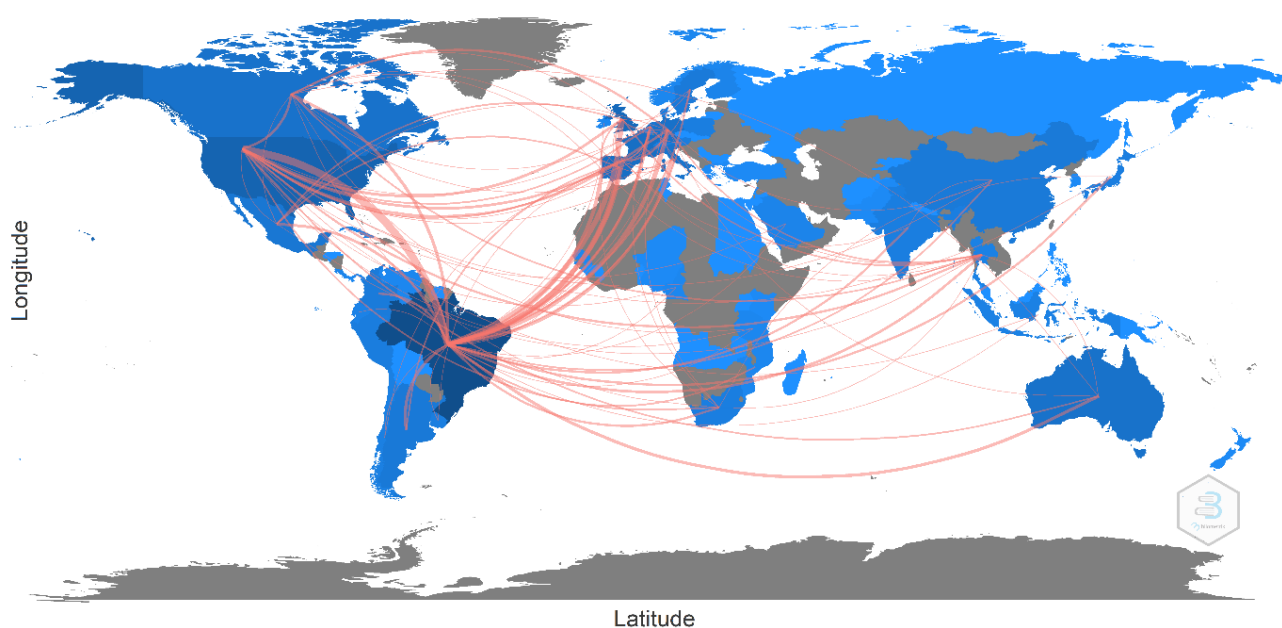

Figure 2 – Collaboration map of research on Brazilian natural resources.

Table 2 – Ten most productive institutions with regard to publications on Brazilian natural resources.

	Institution (Initials)	n	Region
1	University of São Paulo (USP)	456	Southeast
2	Federal University of Minas Gerais (UFMG)	109	Southeast
3	University of Brasília (UnB)	87	Center-West
4	Federal University of Rio Grande do Sul (UFRS)	82	South
5	Federal University of Rio de Janeiro (UFRJ)	81	Southeast
6	Federal University of Pará (UFPA)	80	North
7	Federal University of Viçosa (UFV)	71	Southeast
8	Federal University of Goiás (UFG)	70	Center-West
9	Federal University of Pernambuco (UFPE)	66	Northeast
10	State University of Campinas (UNICAMP)	62	Southeast
	Other (5,940)	13,773	

Brazilian's most productive journals occupied the 2nd, 5th, 6th, and 10th positions, followed by three-tenths of British sources (3rd, 4th, and 7th), and two-tenths of North American journals (1st and 9th). Considering the number of Brazilian journals in the top ten ranks, we observed that Brazilian scientists in Environmental Science still publish in Brazilian journals, evidencing the adequacy of Brazilian sources to international scientific requirements and standards.

The scientific production of Brazilian scientists on NR grew in the early 2000s, and both the *Brazilian Journal of Biology* and the *Brazilian Journal of Soil Science* were pioneers in publishing articles on this subject. *Plos One* and *Conservation Biology* started to publish articles on BNR in 2010 or later. In general, NR topics increased in number of publications, and remain a hot topic research area in national and international journals, since all the sources are still publishing on the subject.
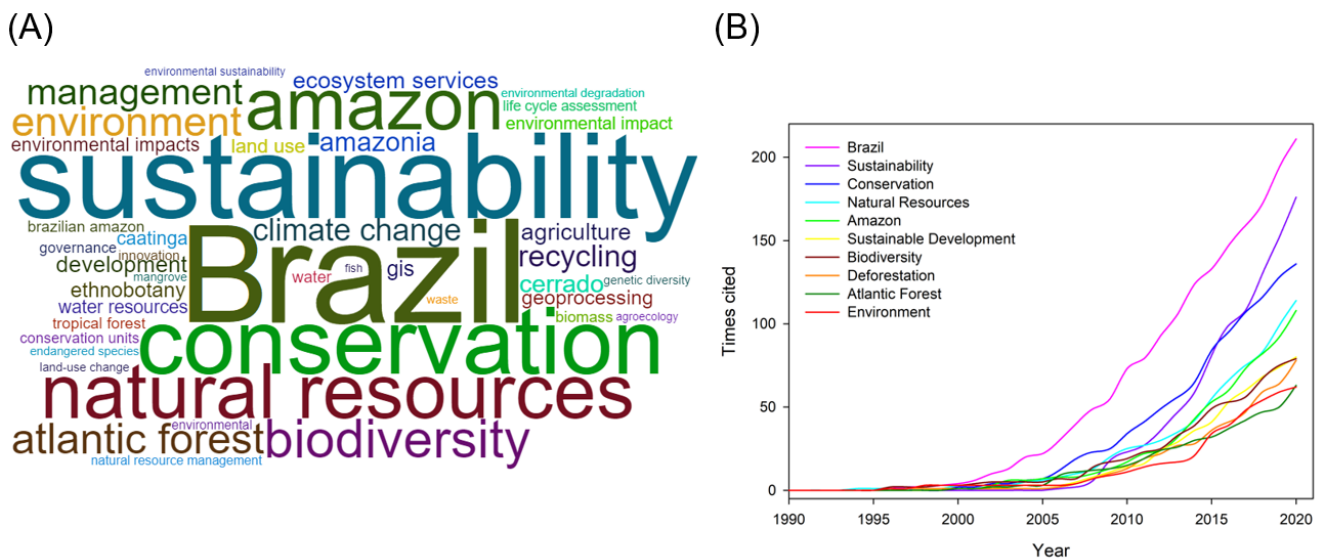
Keywords

A total of 8,981 authors' keywords were analyzed and the 50 most cited are depicted in Figure 3A. Excluding "natural resources" and "Brazil", the two search terms used in this investigation, the words "sustainability" and "conservation" occurred as the most cited topics, being cited 177 and 138 times, respectively. Considering the term "sustainable development", sustainability-related terms were cited in 258 articles. The Amazon (related terms as Amazonia, Brazilian Amazon, and Amazon Forest) and the Atlantic Forest ranked 5th (171 mentions) and 9th (63 citations), respectively, representing the two most cited Brazilian biomes.

The rising trend of the ten most cited keywords since 1990 is shown in Figure 3B. Differently from what has been observed in journals' publications, the increase in NR keywords started in the late 2000s.

Table 3 – Ten most prolific journals on Brazilian natural resources.

	Source	Nº	Country	IF	h-Index
1	Plos One	208	USA	2.74	332
2	Brazilian Journal of Biology	104	Brazil	1.27	53
3	Conservation Biology	66	UK	5.40	222
4	Journal of Ethnobiology and Ethnomedicine	59	UK	2.26	69
5	Brazilian Journal of Soil Science	55	Brazil	1.20	51
6	Development and Environment	52	Brazil	-	3
7	Journal of Cleaner Production	52	UK	7.24	200
8	Espacios	51	Venezuela	-	17
9	Journal of Environmental Management	50	USA	5.64	179
10	Proceedings of Brazilian Academy of Science	49	Brazil	1.28	58
	Other (1091)	3,237			

Number of published articles, country of origin; IF: impact fator; h-index from the top ten most prolific journals on Brazilian natural resources.

(A)

(B)

Figure 3 – Fifty most-cited author keywords (A). Keywords prevalence over the decades (B).

Conservation and sustainability were the topics that increased the most over time, especially in 2011–2020, surpassing one hundred citations each. Lower growth was observed in the Atlantic Forest biome, while sustainable development, biodiversity, and deforestation were topics that raised the number of citations and gained attention in the last decade.

Besides conservation, other hot topics in NR research were the Brazilian biomes. The word Amazon was cited 148 times and occurred as the most-cited biome. Brazilian Amazon is also seen in Table 1, with the 7th, 8th, and 9th most cited articles focusing on this continental biome. The Atlantic Forest was cited 63 times, also mentioned in the 6th most cited article. Cerrado, also called the Brazilian savanna, is one of the world's *hotspots* (Myers et al., 2000), mentioned 37 times, ranking in the 18th position of the most cited keywords. Lastly, the Caatinga biome was cited 28 times and ranked as the 20th most cited topic.

In summary, keywords analysis showed that sustainability is a significant strategy to guarantee the conservation of BNR. Biome preservation plays an important role, since biomes control ecosystemic services that influence biotic and abiotic systems. Also, it was illustrated that environmental impacts such as deforestation can lead to climate change, affect biodiversity, and cause the extinction of endangered species in tropical forests. On the other hand, natural resources management and governance, land-use changes, agroecology, recycling, and the creation of conservation units are means to ensure the sustainability of natural resources, locally and globally.

Discussion

Since the first mention of NR in Brazilian articles in 1977, the number of publications on this topic has regularly increased. The Brazilian contribution to world publications on the theme increased from 0.1 to 1.1% in three decades (1967–2000) (Leite et al., 2011). This pattern is probably related to the government's financial support for Research and Development (R&D) made in the 1990s and 2000s (Chiarini et al., 2020), as well as the increase in master and doctorate research programs (Glänzel, Leta and Thijs, 2006).

Brazil has upgraded its relevance on the science rank, also surpassing the global average on article citations (Grácio and De Oliveira, 2014). Global environmental concerns may have contributed to foster interest in NR, as they are responsible to support modern human life and economic development (Zhong et al., 2016). In 1992, Brazil has gained the world's attention during the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro (known as Rio92), when a couple of conferences highlighted the importance of natural resources conservation, rational exploitation, and the climate changes caused by their depletion (Rhodes, 2016). In 2012, the Rio +20 conference warned against the overexploitation of natural resources for the mitigation of global warming effects (Loyola, 2014).

Our findings highlight that Brazilian scientific production tends to internationalization. The publication of studies on Brazilian NR in for-

eign journals is important given the world's eyes are focused on Brazil for the conservation of its natural resources. Even though three-quarters of the total articles on BNR were published in English, one quarter was still published in Portuguese. This observation can be discussed in different aspects. The first suggestion is that articles in Portuguese were published in the past when English was not completely understood by Brazilian scientists. The second goes back to the use of the mother tongue to disseminate research results (Gonzalez-Brambila et al., 2016) as a resistance to knowledge homogenization (Rossoni, 2018). The third is related to the "publish or perish" logic (Alcadipani, 2017), which explains the rise in the number of publications in English, driving scientists and researchers to learn English or be excluded from the high-impact publishers.

Differently from the exponential increase observed in the number of publications, citations fluctuated through the years and were not constant or linear. Even with the rise in the number of publications in different science fields, Brazilian scientific works are still little cited by foreign researchers (Alcadipani, 2017). A good alternative to increase citation numbers and spread research results across borders is collaborating with international authors and institutions (Diniz, 2017). Our results demonstrated that the articles that relied on global collaboration had a higher number of citations than those for which only national researchers were credited.

Since 1980, Brazilians' international collaboration in science has increased, bringing Brazil to lead publication and citation ranks in Latin America (Glänzel, Leta and Thijs, 2006; Mattos and Job, 2008). International collaboration in Brazil is mainly represented by partnerships with European countries, but also with North, Central, and South American researchers/scientists (Leta and Chaimovich, 2002). Intense collaboration with the USA and Europe originated from R&D alliances between these countries (King, 2004). Similarly, but on a higher scale, China (the 15th most collaborative country in our results) experienced an increase in the world's total publications (Cobo et al., 2015), when R&D investments raised (Chiarini et al., 2020).

An average of 20% of Brazilian scientific production is generated in the southeast institutions, especially from the state of São Paulo (Sidone et al., 2016). On the other hand, in our results, the most productive institutions were heterogeneously distributed across Brazil, indicating that NR is a relevant topic in the entire country. Likewise, lack of international institutions in the top ten ranking cannot be considered a collaboration gap in Brazilian science, since the national research groups cooperate to the rise in the national scientific production and its worldwide propagation by publishing in international journals.

We observed, as well, that regional collaboration reinforced the continental dimension of Brazil, evidencing infrastructure gaps in the scientific development of each region (Chiarini et al., 2014). Othe wise, some institutions from different geopolitical regions also established solid partnerships, such as the so-called "Brazilian Quartet" (*Quarteto*

Brasileiro) (Chiarini et al., 2014), composed of universities from the states of São Paulo, Rio de Janeiro, and Minas Gerais in the southeast, and Rio Grande do Sul in the south of Brazil. Another example is the partnership between UnB in the center-west and UFMG, which is located in the southeast.

Industrialization and globalization not only changed language patterns but also influenced science. Glänzel, Leta and Thijs (2006) observed that, in the past, Brazilian scientists preferably used to publish in domestic and/or Latin-American journals. However, our results illustrated the preference of Brazilian scientists to publish in international journals. High-impact factor journals, such as Plos One, Conservation Biology, and Journal of Environmental Management were predominant in BNR publications. This can be a strategy to improve communication between the scientists and decision-makers. As known, it is an important and necessary connection to overtake science gaps and reach the goals of enhancing human knowledge (Scarano, 2007).

Multidisciplinary and ecological trends were observed in BNR publications, in which the keywords "sustainability" and "conservation" were the most cited terms. Both are emergent subjects connected to social and economic policies to prevent depletion of the earth's natural resources (Olawumi and Chan, 2018). The sustainable exploitation of NR may guarantee their long-term conservation, allowing them to be used by future generations. Such perception and advances in scientific production are fundamental since Brazil holds the most diversified number of species in the world, and environmental degradation rates have rapidly increased (Scarano and Oliveira, 2005; Carvalho et al., 2021).

The conservation of natural resources is essential to society, as much as to the maintenance of ecosystem services and the biomass balance. This is a discussion that goes beyond (non)-governmental financial politics and must be focused on the depletion of NR and their management (Santilli, 2005). However, lack of tailored information between scientists and decision-makers is still a barrier to overcome to match the expectations of both sides (Briley et al., 2015; Hofmann et al., 2023). In this sense, publishing in international journals can be a strategy and an opportunity for local knowledge of Brazil's biodiversity and the speed with which it has been destroyed to play a larger role in problem-solving (Briley et al., 2015).

It is impossible to discuss Brazilian NR and not mention the Amazon Forest, since 69% of its territory is in Brazil (Ferreira, Venticinque and Almeida, 2005). The Amazon holds 30% of the total tropical forests, being home to one-third of the world's total biodiversity, accumulating 350 tons of biomass per hectare. The Brazilian Amazon Forest also attracts world interest because it plays a relevant role in the mechanical, thermodynamic, and chemical balance of atmospheric events on a global scale (Ribeiro, 2014). On the other hand, little has been done to protect this forest, given that deforestation in the Amazon has

increased in 2013–2022 (Coelho-Junior et al., 2022) after one decade of preservation before 2012 (Loyola, 2014; Silva-Junior et al., 2021).

The Atlantic Forest was the second most cited Brazilian biome. It is considered the most degraded Brazilian vegetation, with only 7.6% (Morellato and Haddad, 2000) to 16% of its original area remaining (Rosa et al., 2021). In the past two decades, due to the urgent need for species conservation, the forest's restoration reached around 28% of its initial size (Rosa et al., 2021). Going along with the Atlantic Forest, the Brazilian Cerrado ranked as the third most cited biome. Covering about 24% of the Brazilian territory (Pinheiro and Monteiro, 2010), only 40% of its original vegetation remains, while less than a quarter of it is enclosed in conservation units (Parente et al., 2020). The Brazilian savanna has been enormously threatened by the expansion of soybean, cotton, corn, and cattle (Lahsen, Bustamante and Dalla-Nora, 2016), being called "Brazil's barn".

Retrieving Table 1 and the keywords, climate change is among the most explored topics. Because of weather changes, species' extinction is a risk to consider, since many species are already endangered. It is estimated that 1 to 29% of the species will be extinct while the environment is uncontrollably exploited (Thomas et al., 2004). A other negative impact of climate change is biomass loss in the natural ecosystems, affecting biodiversity, energy balance, and the matter flow (Emmett-Duffy, Godwin and Cardinale, 2017).

Agriculture expansion, land use, and agroecology converge to the emergency of natural resource management and governance directed to the protection of NR. Both involve regulatory measures to face and reduce the consequences of climate change through collaborative work and partnerships between the government, the scientific community, and society (Lockwood et al., 2010). Lahsen, Bustamante and Dalla-Nora (2016) explain that NR are life-supporting not only for the fauna, flora, and fungi (FF&F) (Kuhar et al., 2018), but also for human beings and for agriculture's viability. Moreover, they spotted that high deforestation rates have migrated from the Amazon to the Cerrado.

Despite the strong connection between water and the Amazon, Brazil's Cerrado holds 70% of the country's water reservoirs, which goes to eight of the 12 main hydrographic basins. On the other hand, 80% of this amount is directed to agriculture (Lahsen, Bustamante and Dalla-Nora, 2016). However, monoculture expansion for exportation has endangered the growing Brazilian population's food supply. In Brazil, Protected Areas (PA) are characterized as Strictly Protected Areas (SPA) and Protected Areas of Sustainable Use (PASU). SPA comprise 69% of the Cerrado area, while in the Amazon and Atlantic Forest, PASU occupy 51 and 74% of the biome (Raylands and Brandon, 2005). However, in the Amazon, only 20% of the PA can be deforested, while in the Cerrado the same area needs to be preserved (Lahsen, Bustamante and Dalla-Nora, 2016).

Therefore, conservation of the biodiversity of biomes was one of the central topics of BNR research and still needs to be devel-

oped and studied in future research. On the other hand, land use and water resources were not the most relevant themes but were also highly discussed in the articles. NR management was part of a long-time debate and continues in the scene through sustainability and environmental management subjects. Finally, the central topic of BNR research was the deforestation of the Amazon Forest, especially for agriculture expansion, which can be diminished by sustainable development politics and management focused on environmental education.

Conclusions

In this investigation, we evaluated 3,983 articles published by Brazilian authors in the Web of Science and Scopus databases related to NR. Our conclusions, reached by answering each research question, are listed below:

- The number of publications increased from 1977 to 2020, with 88,530 citations.
- Most cited articles are focused on the Amazon Forest and its conservation.

- The United States and the United Kingdom collaborate the most with Brazilian scientists. In Brazil, researchers from the southeast region are more likely to collaborate with them.
- English is the most published language.
- A total of 13,763 authors and 5,950 institutions published about NR, of which the University of São Paulo is the most prolific institution.
- The top journals hosting natural resources articles are mainly from Brazil, the United States, and the United Kingdom.
- Sustainability and conservation are hot topics in NR publications.

NR research conducted by Brazilian scientists is continuously evolving and embracing Brazilian biomes such as the Amazon, Atlantic Forest, Cerrado, and Caatinga, all threatened by intense exploitation over the centuries. It has also contributed to the spread of emerging topics, such as conservation, preservation, protection, and the sustainable exploitation of NR. Finally, we consider that environmental management and sustainable development are keys to reducing the environmental impacts of natural resource depletion and biodiversity loss on climate change.

Contribution of authors

Lobo-Moreira. A.B.: conceptualization, data curation, formal analysis, investigation, methodology, project administration, software, supervision, writing – original draft, writing – review & editing. Silva, A.G.: data curation, writing – original draft. Carvalho, R.A.: conceptualization, investigation, methodology, project administration, supervision, writing – review & editing. Caramori, S.S.: conceptualization, investigation, methodology, project administration, supervision, writing – review & editing.

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