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Effectiveness and management of terrestrial protected areas: a bibliometric analysis

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ABSTRACT

Effectively managed protected areas (PAs) are an efficient strategy to promote sustainable development and human well-being. The objective of this study was to examine aspects related to the evaluation of PA effectiveness and management, for which a bibliometric analysis was performed by taking as a reference the English language publication made globally from 2013 to 2022 in the Scopus database. Three research trends were found. The first is studies on conservation planning, management, and evaluation, with multiple approaches aimed at developing tools to determine PA effectiveness objectively. The second studies the impacts of human activities on PAs and considers human pressure, the impacts of anthropogenic climate change, and the valuation of ecosystem services, among others. The third studies specific indicators to determine the effectiveness of a specific set of PAs or one in particular. Finally, conservation management was identified as a basic topic that has not been sufficiently developed, so the convenience of developing management and evaluation models for PA management should be evaluated in future research.

Keywords: assessment, conservation area, efficacy.

Eficácia e gestão de áreas terrestres protegidas: uma análise bibliométrica

RESUMO

Áreas protegidas (APs) geridas de forma eficaz são uma estratégia eficiente para promover o desenvolvimento sustentável e o bem-estar da humanidade. O objetivo deste estudo foi examinar aspectos relacionados à avaliação da eficácia e gestão de APs, para o qual foi realizada uma análise bibliométrica tomando como referência as publicações em língua inglesa realizadas globalmente de 2013 a 2022 na base de dados Scopus. Rês tendências de pesquisa foram encontradas. A primeira são os estudos sobre planejamento, gestão e avaliação da conservação, com múltiplas abordagens voltadas para o desenvolvimento de ferramentas que permitam determinar a efetividade das APs de forma objetiva. A segunda estuda os impactos das atividades humanas nas APs e considera a pressão antrópica, os impactos das mudanças climáticas antrópicas, a valoração dos serviços ecossistêmicos, entre outros. A terceira estuda

indicadores de espécies para determinar a eficácia de um conjunto específico de APs ou de uma em particular. Finalmente, a gestão da conservação foi identificada como uma questão básica que não foi suficientemente desenvolvida, portanto, deve-se avaliar a conveniência de desenvolver modelos de gestão e avaliação de AP em pesquisas futuras.

Palavras-chave: área de conservação, avaliação, eficácia.

1. INTRODUCTION

There is broad consensus that protected areas (PAs) are an efficient strategy to promote sustainable development and the well-being of humanity because they contribute to the conservation of biological diversity, regulation of water resources and climate, mitigation of natural hazards, and climate change (Aziz, 2023; Chigonda, 2018; Sweke *et al.*, 2016). PAs are clearly defined, recognized, dedicated, and managed geographic space, through legal or other effective means, to achieve the long-term conservation of nature, its ecosystem services, and associated cultural values (Dudley, 2008). PA management is implicit in the above definition, and its success requires political, economic, and social considerations, as well as the participation of local communities not only at this stage, but also in the previous phases of planning and implementation, and subsequent monitoring. The effectiveness of PAs varies considerably, and these areas are often reported to have negative impacts on the local population, which fuels the debate on the compatibility of environmental and socioeconomic development objectives (Oldekop *et al.*, 2016).

It is recommended that countries document and report their management experiences and conduct PA management effectiveness studies (Woodley *et al.*, 2012). Equitable and effective management of these areas is essential to halt biodiversity loss, but understanding of the relationships between management effectiveness and equity remains weak (Zafra-Calvo and Geldmann, 2020). Most PAs are poorly managed due to resource exploitation by marginal communities and poor government funding, which threatens their management effectiveness (Ayivor *et al.*, 2020). Multiple types of research have been conducted for the development of conservation proposals and various management models for PAs, as well as for the analysis and evaluation of existing models. However, there is no conclusive evidence on the relationship between PA management inputs and conservation results (Geldmann *et al.*, 2013). The causes that generate greater effectiveness in some areas concerning others are not sufficiently known (Shah *et al.*, 2021). Therefore, it is necessary to conduct and document the evaluation of PA effectiveness and management to monitor their conservation status.

The exponential growth of the research literature created the need for new approaches to structure knowledge (Kokol *et al.*, 2021). Bibliometric analysis, introduced by Pritchard in 1969, is a mathematical and statistical approach with great capacity to analyze the literature at the macro and microscopic level in a specific area (Duan *et al.*, 2020). This approach performs a quantitative analysis of bibliographic characteristics to identify patterns that are present in a given field (Kokol *et al.*, 2018). Bibliometric analysis has been widely used to study the productivity of scientific research in various fields of knowledge and has become a popular method for identifying research trends and knowledge gaps, estimating the productivity of institutions, countries, and authors, and identifying cooperative networks (Antoneli *et al.*, 2021; Cavalcanti *et al.*, 2023; He and Wu, 2023). The main objective of bibliometric analysis is not to analyze in depth the studies that are identified but to synthesize general trends and describe the structure of a field of knowledge (Hallinger and Chatpinyakoop, 2019).

Several bibliometric analyses have been conducted in the specific field of PA, such as an analysis for PA effectiveness in general, terrestrial, and marine, but the study focuses on bibliometric figures and does not identify research trends (Martínez-Vega and Rodríguez-

Rodríguez, 2022). Other bibliometric analyses conducted in this field focus on a specific geographic area or topic, such as Antarctic marine PAs (Xiangyun and Guoping, 2021), PA ecotourism (Hasana *et al.*, 2022) and the application of remote sensing in PA monitoring (Duan *et al.*, 2020). Despite this progress, bibliometric analyses are still lacking in the specific field of the effectiveness of terrestrial APs at the global level.

This research aims to examine aspects related to the evaluation of the effectiveness and management of terrestrial PAs, starting from a bibliometric analysis that provides an overview in terms of publications, countries, authors, and sources, The aim is to identify current and emerging research trends, evaluation approaches and factors that negatively affect the effectiveness and management of PAs, as well as the degree of development and impact of the different topics. This will contribute elements for new research on management models and evaluation of the effectiveness of PAs that contribute to the fulfillment of international commitments related to biodiversity conservation. These relevant theoretical and practical aspects are addressed based on the following research questions:

What are the research trends and degrees of relevance and development in PA effectiveness and management evaluation?

What are the approaches with which PA effectiveness and management evaluation has been approached?

What are the research gaps in PA effectiveness and management evaluation?

2. METHODOLOGY

2.1. Data source and search strategy

Initially, a search was conducted in Google Scholar to identify the main descriptors related to the research topic, based on which the search string was designed ("protected areas" OR "conservation areas" OR "priority areas" OR "natural areas" OR "wild areas" OR "natural reserves") AND (management OR governance OR administration OR operation OR strategies) AND (terrestrial) AND (assessment OR evaluation OR effectiveness). For the bibliometric analysis, a quantitative study was performed in the Scopus database taking as reference titles, abstracts, and keywords of English language publications made globally in a range of 10 years, from 2013 to 2022. This period was selected for the manageability of the literature and to consider the impact of Aichi Target 11 (COP, 2010) up to two years after the deadline. Articles, reviews, books, book chapters, and other secondary documents were considered in the search results. Scopus was selected because it is a database with quality content, which also offers direct and simple tools for the analysis and visualization of information (Sweileh *et al.*, 2018). Scopus is one of the largest and most holistic academic databases with advanced search capabilities that reduce the number of irrelevant or duplicate articles. Scopus has been widely used in bibliometric analysis and systematic literature reviews in various fields of knowledge (Melaku *et al.*, 2023; Dash *et al.*, 2022; Steblianskaia *et al.*, 2023; Zyoud and Zyoud, 2021). The use of multiple databases was not considered necessary, since it does not significantly increase the number of documents due to duplication of literature (Harzing and Alakangas, 2016). The Scopus search yielded 274 results on February 4, 2023.

A review of the title, abstract, and keywords and, when necessary, the full text was made for each of the 274 publications identified, to exclude those considered irrelevant to the topic of study. Papers related to marine PAs (n=47) and those focused exclusively on freshwater ecosystems (n=10) were excluded. In addition, documents that, although related to the evaluation of common PA characteristics, were not limited to this type of area (n=41) were discarded. In this last group, one duplicate document was detected (n=1). However, evaluation documents of other types of areas were included when they had among their objectives the selection of PA (Blackman *et al.*, 2014; Koskikala *et al.*, 2020). Publications related to Other Effective Area-based Conservation Measures (OECM) were also included (Donald *et al.*,

2019). After the selection, 175 documents resulted in the bibliometric analysis.

2.2. Bibliometric analysis

The search results in the Scopus database were exported in BibTeX file format to feed the next phase of the analysis in Bibliometrix, a powerful open-source tool developed by Aria and Cuccurullo to perform detailed literature analysis following the scientific mapping workflow. Bibliometrix programming in R facilitates integration with other statistical and graphical packages. Bibliometrix allows importing bibliographic data from different databases, including Scopus, and building networks for co-word analysis, co-citation, and scientific collaboration (Aria and Cuccurullo, 2017). Bibliometrix allows for performing statistical calculations and creating high-quality graphs for quantitative research in scientometrics and bibliometrics (Moreira *et al.*, 2022).

For the performance analysis, the evolution of publications was determined based on annual scientific production, the most important journals, and authors according to the number of publications, citations, and impact indexes, and the most influential articles according to the number of citations. In the scientific mapping, the thematic map of keywords was drawn to determine the degree of relevance and development of the different research topics, and the map of the historical evolution of citations among the most relevant articles. The thematic map was used to identify important and well-developed topics that have driven the progress of the research field, well-developed topics that have not had a high impact, and basic topics that have not been sufficiently developed. Collaborative production makes it possible to evaluate the level of research of countries and authors concerning the topic being developed (Mamatzakis, 2007). In addition, it facilitates the search for innovative solutions and stimulates learning and development in countries with less research experience (Shasha *et al.*, 2020).

In a complementary way, VOSviewer, a powerful free-to-use software developed by Van Eck and Waltman (Van Eck and Waltman, 2010), was used. VOSviewer allows the construction and visualization of bibliometric networks through a mapping to identify research progress and knowledge systems (Zhang *et al.*, 2022). These networks can consider individual publications, authors, or journals, and are constructed based on bibliographic linkage and the number of citations and co-citations. VOSviewer is useful for constructing large bibliometric maps that can be easily interpreted (Aria and Cuccurullo, 2017). VOSviewer identifies important terms in a set of scientific publications using text mining and creates the coexistence networks of these terms using the mapping technique called visualization of similarities (VoS) (Van Eck and Waltman, 2014). Scientific mapping can be visualized by showing the association between terms, grouping related terms, identifying keywords used together, or visualizing bibliometric or citation networks, among other ways (Kokol *et al.*, 2018).

VOSviewer was fed with the search results in the Scopus database exported in CSV (Comma Separated Values) file format. This tool was used to analyze the most important countries according to the number of publications and citations. Likewise, the keyword co-occurrence analysis map was drawn to analyze the hot topics in the evaluation of PA effectiveness and management and the co-authorship analysis map of the most influential authors. Keyword co-occurrence allows inferring the direction of research for a given field based on the presence of two or more comparable keywords (Shahbaz *et al.*, 2021). A bibliometric keyword mapping was used to perform the content analysis by identifying research trends, themes, and subcategories according to the synthetic knowledge synthesis (Kokol *et al.*, 2022). To identify interesting future research topics, VOSviewer was also used to induce the scientific landscape for the periods 2013 - 2017 and 2018 - 2022. New research topics were identified with the terms appearing in the second period, but not in the first period. Also, change of research context with the terms appearing in both periods, but in different fields or co-occurrences. Finally, change in the popularity of research topics with the terms appearing in

both periods, but more frequently in the second (Kokol *et al.*, 2018).

3. RESULTS AND DISCUSSION

3.1. Performance analysis

In this section, a performance analysis of publications is carried out using bibliometric indicators obtained in Bibliometrix, such as the number of publications, number of citations, H-index, and other indicators based on the number of publications and citations, to determine the evolution of publications and the most influential journals, disciplines, articles, authors, and countries in the field of PA effectiveness evaluation and management.

3.1.1. Evolution of the publications

The annual production of publications has a general upward trend with an annual growth rate of 14.1% from 2013 to 2022. Specifically, from 2013 to 2016 the number of publications presented fluctuations from one year to another without a generalized increase in production. From 2017 to 2022 the annual production of publications had a significant increase over the previous period. This increase shows an increase in global interest in issues related to PA effectiveness assessment, probably stimulated by the adoption in 2015 of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (United Nations, 2015), in particular SDG 15 aimed at sustainably managing forests and halting biodiversity loss. Another aspect that probably influenced the increase in the production of publications is Aichi Target 11, which established that by 2020 the PA system globally should be effectively managed (COP, 2010), which may have increased interest in assessing the status of compliance with the target, before and after the deadline. These results are in line with other studies indicating that the steady growth of articles published in the last decade is likely due to the adoption of international biodiversity and sustainability targets in the first half of the decade 2010-2020 (Gao *et al.*, 2023; Martínez-Vega and Rodríguez-Rodríguez, 2022).

3.1.2. Analysis of major journals

There were 175 papers published in 91 sources in the field of PA effectiveness and management evaluation during the period 2013 to 2022, which shows a high degree of dispersion, because 64 sources have published only one paper. The ranking of journals is based on the total number of publications and total citations as the first and second criteria respectively, which are important indicators to measure journals in a research field (Yang *et al.*, 2021). Biological Conservation is the most prolific journal with 13 publications and an outstanding number of 916 citations, followed by Biodiversity and Conservation with 10 publications and 100 citations. Conservation Biology and Conservation Letters with 9 and 8 publications, respectively, have a considerable number of citations, higher than those of the journal in ranking 2, which may indicate that they have published some important articles in the research field.

The H-index has become an important criterion for evaluating the impact of journals (Yang *et al.*, 2021). Biological Conservation also leads this indicator with a value of 10, followed by Conservation Letters and Conservation Biology with 8 and 7 respectively, showing that articles published in these journals play a key role in the study of PA effectiveness and management. Analysis of the growth of the five most productive sources over time yielded some interesting results. Conservation Letters started its publications in 2017 and had a rapid impact on the research field according to the number of citations and H-index of the journal. Global Ecology and Conservation also positioned itself in a relatively brief period, as it started its publications in 2019 and is ranked 5 of the most productive journals. The thematic classification of the five journals with the highest H-index indicates that the fields of Environmental Sciences and Agricultural and Biological Sciences have received the most attention, specifically in the areas

of nature conservation and ecology. The analysis of search results performed directly in Scopus found that Environmental Sciences and Agricultural and Biological Sciences concentrate most of the production, followed by Social Sciences, which could be related to the fact that the local population can exert multiple pressures on the ecosystem services provided by PAs (Arroyo-Quiroz *et al.*, 2017; Egarter *et al.*, 2021; Schirpke *et al.*, 2017) or, on the other hand, that the public can simply accept or reject PAs (Zorondo-Rodríguez *et al.*, 2019).

3.1.3. Analysis of Significant Publications

Papers with a high number of citations are considered authoritative and high-quality bibliographic resources (Yang *et al.*, 2021). The most cited paper is "Effectiveness of terrestrial protected areas in reducing habitat loss and population declines", written by Geldmann *et al.* published in "Biological Conservation" in 2013 and cited 539 times. This paper does a systematic literature review to determine the effectiveness of PAs based on habitat cover and species populations (Geldmann *et al.*, 2013) and has become an important reference for research on PA effectiveness. The second paper in the ranking is "Global priority areas for ecosystem restoration", written by Strassburg *et al.* and published in 2020, so it is the most recent in the list and additionally has the highest number of citations per year (65.00), which indicates that it achieved a rapid impact in the research field. In this paper the authors develop and apply a multi-criteria optimization approach to identify priority areas for restoration in all terrestrial biomes, also estimating their benefits and costs (Strassburg *et al.*, 2020). The third most cited publication is "A global-level assessment of the effectiveness of protected areas at resisting anthropogenic pressures" in which data were collected from 12315 PAs in 152 countries to determine their capacity to reduce human pressure according to socioeconomic and management circumstances (Geldmann *et al.*, 2019). This paper was published in 2019, so it also gained rapid recognition with 42.20 citations per year. On the other hand, four of the top 10 most cited papers, including the first in the ranking, were published from 2013 to 2016, which was identified as a period of lower output in Section 3.1.1. However, these papers have taken a longer time for queries and citations and have laid the foundation for subsequent research on PA effectiveness and management.

3.1.4. Analysis of major authors

A total of 914 authors participated in the 175 publications identified in this study. The average number of coauthors per paper is 6.43 and 8 authors of single-author papers were found. The top five authors in the ranking have an extensive level of collaboration among them, as evidenced by multiple co-authorships, which has allowed their research to receive wide attention from the academic community. Geldmann is the author with the highest number of published papers (6), the highest number of citations (1133), and an H-index of 5 indicating that almost all his publications have achieved some degree of relevance in the field of protected area effectiveness and management. This author is a professor at the University of Copenhagen and focuses his research on assessing in a holistic approach how resources, management, governance, and socioeconomic context influence PA effectiveness. In addition to the two topics mentioned in the previous section related to PA effectiveness in reducing habitat and species population loss (Geldmann *et al.*, 2013) and resisting anthropogenic pressures (Geldmann *et al.*, 2019; 2014), Geldmann has assessed the impact of PAs on vegetation extent and condition (Sharma *et al.*, 2020), management capacity and ecological outcomes in PAs (Geldmann *et al.*, 2018), and threats to PAs (Schulze *et al.*, 2018). In second place in the ranking is Burgess with 5 publications, an H-index equal to 5, and almost the same number of citations as Geldmann, which is explained by the fact that he has published his five papers co-authored with this author (Geldmann *et al.*, 2013; 2014; 2018; 2019; Schulze *et al.*, 2018). Three of these papers are also co-authored by Hockings (Geldmann *et al.*, 2013; 2018; Schulze *et al.*, 2018),

third in the ranking, which ratifies the prominent level of collaboration between these authors. In another prominent paper, Hockings assessed the state of knowledge on the drivers of biological outcomes within PA, focusing on those that can be addressed at the local scale, to identify those that enable more successful outcomes and those that impede success (Barnes *et al.*, 2017). Coad and Craigie, ranked fourth and fifth, complete along with the three previous authors the core group of authors in the field of PA effectiveness evaluation and management research.

3.1.5. Analysis of major countries

Seventy-nine countries have produced publications related to PA effectiveness and management, 30 of which have published a single document. The United States tops the list with 54 papers. This country has a long tradition in nature protection and was a pioneer in declaring the world's first national park in 1872, Yellowstone National Park. In addition, it has an extensive network of scientific cooperation that has allowed it to publish many papers co-authored with authors from other countries. In the second and third place in the ranking are the United Kingdom and Australia with 42 and 38 publications respectively, numbers far higher than those of the other countries in the ranking, which shows that these two countries have played an outstanding role in the evaluation of PA effectiveness and management. A special case is Denmark, which with 6 publications is outside the ranking of the 10 most productive countries. However, it has 1144 citations, i.e., 190.7 citations per paper, a value well above the other countries, which is explained by the fact that it is the country of affiliation of Geldmann, the most important author identified in Section 3.1.4 In another study, the United States, United Kingdom, and Australia were the top contributors to publications on AP management in China and India, excluding the countries of origin themselves (Gao *et al.*, 2023).

3.2. Scientific mapping

In this section, a scientific mapping of the literature on the evaluation of PA effectiveness and management is conducted to complement the performance analysis. Keyword co-occurrence analysis is used to analyze the hot topics in the field of study, which is complemented by analyses of the social and intellectual structures.

3.2.1. Analysis of burning issues in the evaluation of PA effectiveness and management

Keywords represent the highly summarized content of a paper, whereby keyword frequency analysis allows the revealing of critical points in a field of research. VOSviewer presents clear clustering and readability for numerous documents and various keyword categories (Van Eck and Waltman, 2010). In this study, VOSviewer was used to create a keyword co-occurrence analysis map to analyze the hot topics in the evaluation of PA effectiveness and management, for which a minimum of 5 occurrences were considered, considering the words declared by the author and those defined in the source indexes, resulting in a total of 82 keywords as shown in Figure 1. The size of the circle represents the number of occurrences of the keyword, the thickness of the line between two circle nodes indicates the number of co-occurrences of the two keywords, and circles of the same color represent the same clustering attribute by a higher co-occurrence of this group of keywords. By the synthetic knowledge synthesis (Kokol *et al.*, 2022), the following themes, codes, and subcategories are presented in Table 1. The content analysis revealed three predominant themes, which are analyzed as follows.

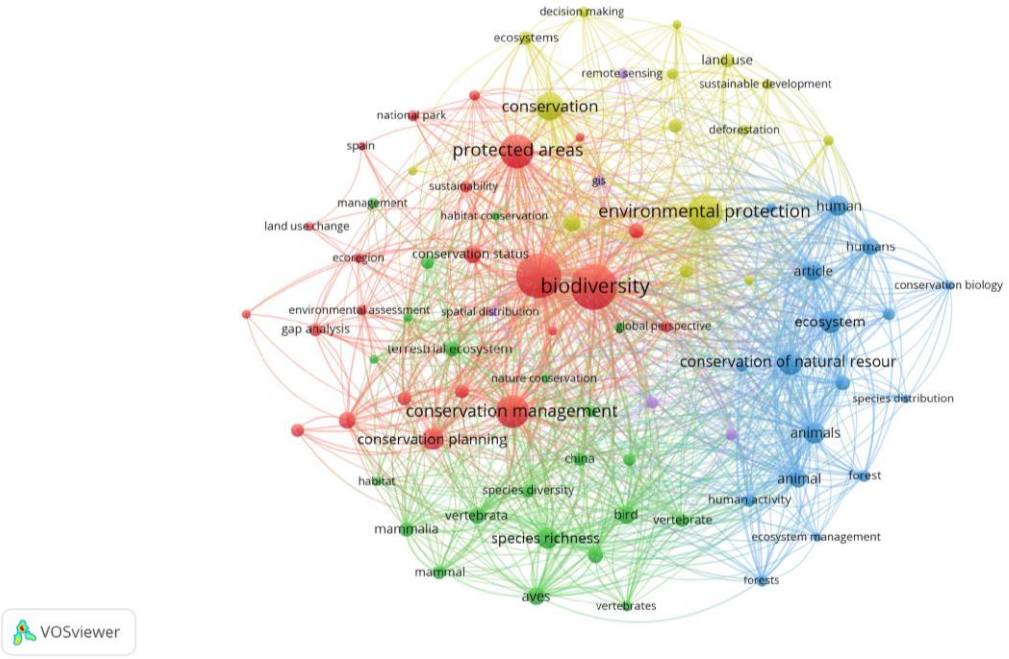

Figure 1. keyword co-occurrence analysis map.

Table 1. Research topics in effectiveness and management of terrestrial PAs.

Theme	Color	More frequent codes	Prevailing sub-categories
Conservation planning, management, and assessment	Red	Conservation management (45), Conservation planning (22), Prioritization (14), Biodiversity conservation (11), Assessment method (10), Vulnerability (10), Gap analysis (9), Global perspective (7), Aichi targets (6)	Representation of biodiversity, Gaps in conservation objectives, Assessment of growth, resilience to degradation and reduction, Monitoring with remote sensing and Geographic Information Systems (GIS), Quality of governance, Effectiveness of management, Effectiveness of conservation plans management, Evaluation of Aichi Target 11
Impacts of human activities on Pas	Blue and yellow	Environmental protection (52), Conservation of natural resources (27), Human (33), Nonhuman (11), Ecosystem service (17), Forest (15), Human activity (9), Land use (11), Environmental monitoring (7), Conservation biology (5), Environmental impact assessment (6), Environmental management (10), Environmental policy (5), Ecosystem management (5), Sustainable development (6)	Assessment of human pressure according to management category and Human Development Index (HDI), Vegetation condition and forest cover loss, Vulnerability to climate change, Integration of ecosystem services in management
Species richness	Green	Bird (31), Vertebrate (19), Terrestrial ecosystem (12), Mammal (21), Connectivity (9), Species diversity (9), Species conservation (8)	Threatened species or subspecies, ecosystem health indicator species

Conservation planning, management, and assessment: The main keywords are "conservation management", "conservation planning", "environmental assessment", "prioritization", "conservation status", "gap analysis", "Aichi targets", etc. Multiple approaches have been considered to assess PAs, including gap analysis to determine biodiversity representation and gaps in conservation targets, assessment of growth, resilience to degradation, and reduction and effectiveness of various PA systems considering the connectivity between them. Remote sensing and Geographic Information Systems (GIS) have also been used to monitor PA dynamics. On the other hand, effective long-term conservation cannot always be ensured by a protection regime or effective management, as is often assumed, so the goal of assessing PAs should be oriented more towards overall long-term effectiveness rather than management effectiveness (Rodríguez-Rodríguez and Martínez-Vega, 2012). However, PA management is a component that must necessarily be addressed and has been considered in several studies, so a conceptual framework was developed linking the mechanisms by which conservation outcomes are affected by the quality of governance (Eklund and Cabeza, 2017), species population trends were used with data derived from the Management Effectiveness Tracking Tool (METT) database to examine biodiversity outcomes (Geldmann *et al.*, 2018), and the existence and effectiveness of management plans were also assessed using the PA Management Effectiveness (PAME) methodology recommended by the International Union for Conservation of Nature (IUCN) (Petit *et al.*, 2018). Finally, Aichi Target 11 states that at least 17% of the Earth's land area should be protected and effectively managed by 2020 (COP, 2010). Publications related to the keywords "Aichi targets" intensified from 2018 onwards, which is explained by the interest in assessing compliance with the Target due to the approaching deadline. The effectiveness of this compliance has been questioned by several studies, and it is inferred that overall progress towards meeting the target may have been overestimated, considering that indicators should not only focus on the quantity but also the quality of PAs. As a conclusion, although PAs have increased in number and extent globally in recent years, biodiversity indicators have not improved, and many habitats and species are in danger of extinction. The effectiveness of PAs has often been overestimated and there can be no assurance that these areas can conserve nature, ecosystem services, and the cultural values they are mandated to protect in the long term. Therefore, studies on conservation planning, management, and evaluation are becoming increasingly relevant to develop tools to determine PA effectiveness objectively. Its importance lies in the fact that effective planning and management of PAs are essential to address biodiversity loss, which could facilitate the development of new conservation approaches and tools that contribute to the achievement of international targets, such as the Aichi Target and the UN Sustainable Development Goals.

Impact of human activities on Pas: The most important keywords are "environmental protection", "conservation of natural resources", "ecosystem", "climate change", "human activity", "anthropogenic effect", "ecosystem services", "land use", "forest", "deforestation", etc. In general, human pressure on PAs has increased to varying degrees according to their location and management category. Cases of pressure reduction were correlated with high Human Development Index (HDI) values of the country (Geldmann *et al.*, 2014; 2019) and in contrast, another study associated fewer threats on PAs with lower HDI (Schulze *et al.*, 2018). Strict management policies led to higher forest protection, higher species diversity, and lower impacts related to hunting and wildlife consumption, thus it is hypothesized that management effectiveness is higher in PAs with strict regulations. The keyword "forest" is an emerging research trend according to the analysis in VOSviewer, and in this field, the impact of PAs on vegetation extent and condition, gaps in vegetation protection, and forest cover loss have been evaluated, clarifying that not all of it is a product of human activities. Anthropogenic climate change threatens the lasting effectiveness of PAs in conserving biodiversity and providing ecosystem services, which is why it has become an important research trend. It has assessed

how climatic conditions within PAs are expected to change, potential hotspots of climate change impact, vulnerability to climate change by combining hazard and resilience indicators, PA characteristics that are linked to climate change resilience, and changes in the effectiveness of a PA system under different climate change scenarios. The analysis conducted in VOSviewer also identified the keyword "ecosystem services" as an emerging research trend, as PAs play a fundamental role in the provision of these services, which are indispensable for the survival of human life. As a final comment, human activities are frequent in many PAs because these areas can be seen as a profitable scenario for the development of economic activities. When anthropogenic activities are significant, they can destroy the habitat necessary for the survival of threatened species. Therefore, it is necessary to evaluate the conflicts between these activities and biodiversity conservation to develop strategies aimed at achieving satisfactory results. Although biodiversity conservation is the main function of PAs, the evaluation of conflicts with human activities will make it possible to identify ways of balancing it with the sustainable development of local populations, contributing to the preservation of essential ecosystem services and preventing PAs from becoming conflict zones. This would increase support for PAs by the local community and society in general and would lead to greater legitimacy and compliance with regulations and laws. It could also contribute to the development of solutions and mitigation strategies.

Species richness: The most representative keywords are "species richness", "endangered species", "species conservation", "vertebrata", "mammal", "bird", etc. Different specific groups of species and subspecies have been used with different overlapping designations such as threatened species or subspecies, ecosystem health indicator species, wildlife species, tetrapods, vertebrates, mammals, birds, flora, fauna, fungi, and some specific subspecies. However, for South Asia, it was reported that almost 70% of PA biodiversity assessments focused on the distribution of organisms, and only 9% conducted conservation assessments or devised strategies to manage PAs (Chowdhury *et al.*, 2022). Although these keywords appear less frequently than those in the two previous categories, species indicators are an important trend in determining the effectiveness of a specific set of PAs or a particular one, to determine the degree to which these areas provide suitable habitat for species or how these species are represented in PAs. These indicators make it possible to evaluate whether conservation measures are effective, to focus conservation efforts on the most critical sites, and to guide ecological restoration planning. These results could also facilitate decision-making in land-use planning and natural resource management within the PAs.

The analysis of the consecutive periods 2013 - 2017 and 2018 - 2022 allowed identifying some differences that indicate the change in research focus shown in Table 2. The first column shows the terms present in the second period, but not in the first, which represent the most current topics that could be used to guide future research in the effectiveness and management of APs. The second column shows terms present in both periods, but in different contexts, which are shown in the third column. For example, climate change shifted its focus from species richness in the first period to human activity, forest, land use, and sustainable development in the second period. The fourth column shows terms present in both periods, but that increased in popularity in the second period, which could also be used to guide new research. A systematic literature review on PA management conducted in specific geographic regions found some similar results. The forest ecosystem was the focus of studies in China, while in India research focused on wildlife management, climate change, ecosystem services, and the relationship between environmental protection and people. Natural resource conservation and endangered species were common in both countries (Gao *et al.*, 2023).

As a complement to the keyword co-occurrence analysis performed in VOSviewer, Figure 2 shows the thematic map produced by Bibliometrix. The horizontal axis is labeled "centrality" and is a measure of the degree of relevance of the topic and its strength of connection with other

topics in the research field. The vertical axis is called "density" and is a measure of the degree of development of the topic and its strength of connection with keywords of the same topic. "Environmental protection", "conservation of natural resources" and "ecosystem" show a high degree of centrality and density indicating that they are important and well-developed topics that have driven the progress of the research field. "Gap analysis" and "buffer zone" are well-developed topics, but with minimal impact, which can be explained by the fact that the former has a high specificity, and the latter is a peripheral topic in the field of PA effectiveness and management. “Conservation management” has a high degree of centrality, which indicates that it is a basic topic for the research field, but it has not been sufficiently developed. Therefore, the convenience of developing PA management and management evaluation models should be evaluated in future research, considering that global goals establish that new and existing areas should be managed effectively.

Table 2. Interesting research directions and themes in the effectiveness and management of PAs.

	Change of Research Context		
New Research Topics in 2018 - 2022	**Topic**	**Change of Context**	**Increased Topic Popularity in 2018 - 2022**
Endangered species, Forest, Human activity, Vulnerability, Prioritization, Ecosystem service, Global perspective, Sustainable development, Anthropogenic effect, Land use, Decision making, Remote sensing, Gap analysis, Aichi targets	Species richness	Bird → Vertebrate, Mammal	Species richness, Animal, Vertebrate, Mammal, Human, Nonhuman, Climate change
	Human	Species richness → Forest, Land use, Sustainable development	
	Climate change	Species richness → Human activity, Forest, Land use, Sustainable development	

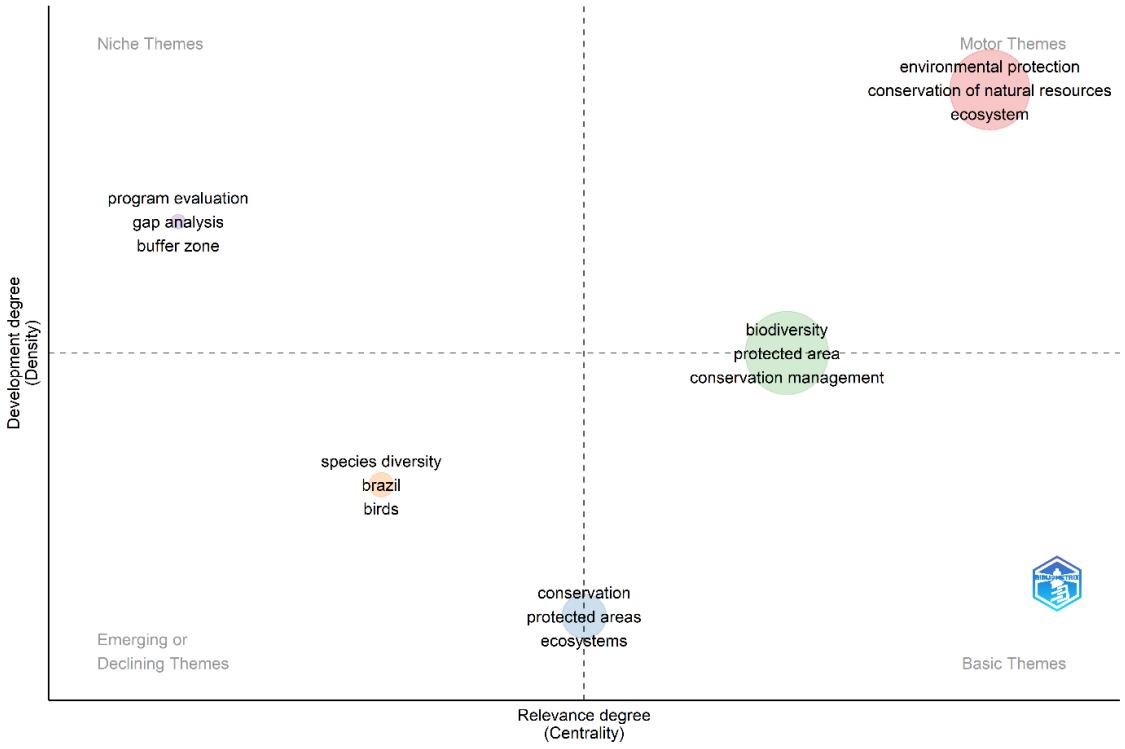

Figure 2. Thematic map of keywords.

3.2.2. Collaboration between authors and countries

Collaboration among researchers for the publication of articles on a given topic is a measure of the degree of maturity of the discipline, and results in an increase in the quality and quantity of scientific production (Pestana *et al.*, 2019). For the analysis of the collaboration between the most influential authors, VOSviewer was used to create the co-authorship analysis map in Figure 3, which shows the largest set of authors who have published a minimum of three papers and have collaborated with other authors. It should be clarified that 28 authors have published a minimum of three papers and the largest set of authors who relate to others is 14, which does not mean that the authors not shown in the map do not collaborate with others, but that they do not collaborate with the 14 most influential authors. The size of the circle represents the number of publications of the author, the thickness of the line between two circle nodes indicates the number of co-authorships of the two authors, and circles of the same color represent the same clustering attribute by higher co-authorship in this group of authors. Figure 3 is consistent with the analysis performed in Section 3.1.4, as the closest collaborative relationships are between Geldmann, Hockings, Burgess, Coad, and Craigie, who led the ranking of the most influential authors. Three other authors in this ranking, Balmford, Butchart, and Adams, have significant collaborative relationships in the group of the 14 most influential authors.

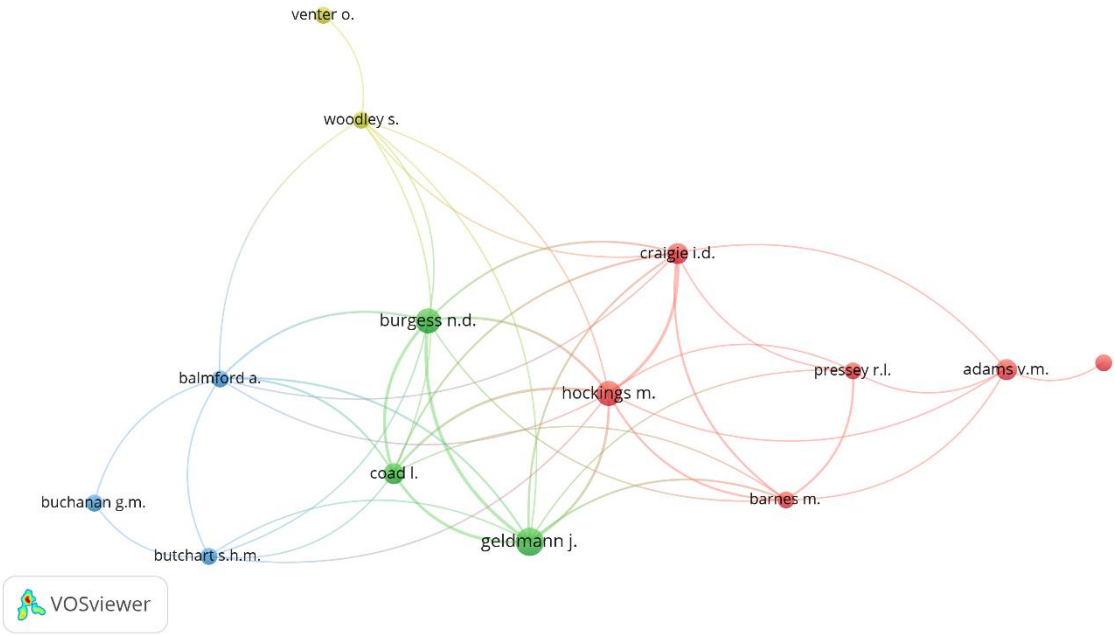

Figure 3. Co-authorship analysis map for the largest set of authors connected to others.

The analysis of cross-country collaboration carried out in Bibliometrix shows the development of an extensive international co-authorship network that confirms that the degree of maturity of the discipline is high. Australia and the United Kingdom have the highest frequency of collaboration with 17 links. The United States has the highest frequency of collaboration, with 158 links to 57 different countries.

3.2.3. Direct citation analysis

Analysis of the historical network of direct citations of the most influential publications makes it possible to understand how research trends in a scientific discipline have developed and evolved, and to identify the influence of a publication or an author in the field of knowledge. (Sharma and Mishra, 2021). The analysis was performed using historiography analyzing the historical network of direct citations of the 20 most influential papers. Three papers, that have

the global focus as a common feature, led to the most important research branches. First, the paper by Geldmann published in 2018, performs a global analysis of management capacity and ecological outcomes in PAs (Geldmann *et al.*, 2018). Second, the paper by Schulze, also published in 2018, presents a comprehensive assessment of threats to PAs based on information from 1961 PAs in 149 countries, assessed by PA managers and local stakeholders (Schulze *et al.*, 2018). Third, the paper published by Saura in 2017, assesses the connectivity of PA networks in all terrestrial ecoregions of the world (Saura *et al.*, 2017).

4. CONCLUSIONS

Based on the documents extracted from the Scopus database, the Bibliometrix software was used and VOSviewer as a complementary tool to perform the bibliometric analysis on PA effectiveness and management. In the 10 years of study (2013 - 2022), 175 publications were found and an increasing trend showed an increase in the global interest in topics related to the evaluation of PA effectiveness and management. This increased interest could be stimulated by the adoption in 2015 of the 2030 Agenda for Sustainable Development and in particular, Sustainable Development Goal 15 aimed at sustainably managing forests and halting biodiversity loss and, on the other hand, Aichi Target 11, which established that by 2020 the PA system globally should be effectively managed. The basic bibliometric analysis shows that the United States, the United Kingdom, and Australia have the largest number of publications in the field of study and an important network of collaboration with other countries. At the journal level, Biological Conservation and Biodiversity and Conservation stand out in terms of number of publications and impact indicators.

The special bibliometric analysis identified the hot topics in PA effectiveness and management evaluation, and three research trends were found. The first is related to studies on conservation planning, management, and evaluation, with multiple approaches aimed at developing tools to determine PA effectiveness objectively. These studies are motivated by the fact that, in general, biodiversity indicators have not improved, and numerous habitats and species are in danger of extinction, despite the increase in the number and extent of PAs globally in recent years. It is concluded that overall progress in meeting conservation targets related to the amount of effectively protected and managed land area may have been overestimated. The second trend studies the impacts of human activities on PAs. In general, human pressure has increased to varying degrees according to the location and management category of the PA. It is hypothesized that management effectiveness, in terms of biodiversity conservation, is greater in PAs with strict regulations. However, this could lead to a lower acceptance of the areas by local communities, mainly in countries with low HDI, which poses a great challenge if these regulations are not accompanied by the creation of alternative sources of livelihood. Other important lines of research in this trend are the evaluation of the impacts of anthropogenic climate change on PAs and the valuation of ecosystem services provided by PAs. The third trend has a lesser impact than the previous two and studies species indicators to determine the effectiveness of a specific set of PAs or one in particular, to determine the degree to which these areas provide suitable habitat for species or how these species are represented in PAs.

Although several documented experiences show how the quality of governance affects conservation results and biodiversity, according to the analysis of the degree of relevance and development of the different research topics related to PA effectiveness and management, conservation management is a basic topic that has not been sufficiently developed. Therefore, the convenience of developing PA management and management evaluation models in future research should be assessed, considering that global goals establish that new and existing areas should be managed effectively.

The results of this study can be used by researchers to design projects that align with the areas that require the most attention. PA managers can obtain information to identify the most

effective approaches to management and evaluation. It could also guide policy and strategy formulation by policymakers and help improve programs and projects of conservation organizations. More generally, this study is useful to have a comprehensive view of the state of PA effectiveness and management evaluation that allows an understanding of its past development and future research trends, which may inspire diverse perspectives to find new methods to objectively evaluate PA effectiveness and management. Finally, the limitations of this study are related to the document exclusion criteria in terms of type, language, and year of publication. Although using multiple databases was not considered necessary because it does not significantly increase the number of documents due to duplication of literature, using Scopus as the only data source could also be considered a limitation. Future studies could consider expanding the number of publications to obtain more complete findings.

5. REFERENCES

ANTONELI, V. *et al.* Stemflow and throughfall in agricultural crops: a synthesis. **Revista Ambiente & Água**, v. 16, n. 1, p. 1, 2021. https://doi.org/10.4136/ambi-agua.2528

ARIA, M.; CUCCURULLO, C. bibliometrix: An R-tool for comprehensive science mapping analysis. **Journal of Informetrics**, v. 11, n. 4, p. 959–975, 2017. https://doi.org/10.1016/j.joi.2017.08.007

ARROYO-QUIROZ, I. *et al.* Local Perspectives on Conflicts with Wildlife and Their Management in the Sierra Gorda Biosphere Reserve, Mexico. **Journal of Ethnobiology**, v. 37, n. 4, p. 719–742, 2017. https://doi.org/10.2993/0278-0771-37.4.719

AYIVOR, J. S. *et al.* Evaluation of management effectiveness of protected areas in the Volta Basin, Ghana: perspectives on the methodology for evaluation, protected area financing and community participation. **Journal of Environmental Policy & Planning**, v. 22, n. 2, p. 239–255, 2020. https://doi.org/10.1080/1523908X.2019.1705153

AZIZ, T. Terrestrial protected areas: Understanding the spatial variation of potential and realized ecosystem services. **Journal of Environmental Management**, v. 326, p. 116803, 2023. https://doi.org/10.1016/j.jenvman.2022.116803

BARNES, M. D. *et al.* Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas. **Annals of the New York Academy of Sciences**, v. 1399, n. 1, p. 42–60, 2017. https://doi.org/10.1111/nyas.13154

BLACKMAN, A. *et al.* **Biodiversity Conservation in Latin America and the Caribbean**. Routledge, 2014.

CAVALCANTI, I. L. R.; LEITE, V. D.; OLIVEIRA, R. A. DE. Bibliometric analysis on the applicability of anaerobic digestion in organic solid waste. **Revista Ambiente & Água**, v. 18, p. 1–13, 2023. https://doi.org/10.4136/ambi-agua.2891

CHIGONDA, T. More than Just Story Telling: A Review of Biodiversity Conservation and Utilisation from Precolonial to Postcolonial Zimbabwe. **Scientifica**, v. 2018, p. 1–11, 2018. https://doi.org/10.1155/2018/6214318

CHOWDHURY, S. *et al.* Protected areas in South Asia: Status and prospects. **Science of The Total Environment**, v. 811, p. 152316, 2022. https://doi.org/10.1016/j.scitotenv.2021.152316

CONVENTION ON BIOLOICAL DIVERSITY. **COP 10 Decision X/2 Strategic Plan for Biodiversity 2011–2020**. 2010. Available at: https://www.cbd.int/decision/cop/?id=12268. Access: Dec. 2023.

DASH, M. K. *et al.* ICT for sustainability and socio-economic development in fishery: a bibliometric analysis and future research agenda. **Environment, Development and Sustainability**, v. 25, 2022. https://doi.org/10.1007/s10668-022-02131-x

DONALD, P. F. *et al.* The prevalence, characteristics and effectiveness of Aichi Target 11′s "other effective area-based conservation measures" (OECMs) in Key Biodiversity Areas. **Conservation Letters**, v. 12, n. 5, 2019. https://doi.org/10.1111/conl.12659

DUAN, P.; WANG, Y.; YIN, P. Remote Sensing Applications in Monitoring of Protected Areas: A Bibliometric Analysis. **Remote Sensing**, v. 12, n. 5, p. 772, 2020. https://doi.org/10.3390/rs12050772

DUDLEY, N. (Ed.) **Guidelines for applying protected area management categories**. Gland: IUCN, 2008.

EGARTER VIGL, L. *et al.* A multi-pressure analysis of ecosystem services for conservation planning in the Alps. **Ecosystem Services**, v. 47, p. 101230, 2021. https://doi.org/10.1016/j.ecoser.2020.101230

EKLUND, J.; CABEZA, M. Quality of governance and effectiveness of protected areas: crucial concepts for conservation planning. **Annals of the New York Academy of Sciences**, v. 1399, n. 1, p. 27–41, 2017. https://doi.org/10.1111/nyas.13284

GAO, W. *et al.* Conservation and Management of Protected Areas in China and India: A Literature Review (1990–2021). **Climate**, v. 11, n. 1, p. 22, 2023. https://doi.org/10.3390/cli11010022

GELDMANN, J. *et al.* Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. **Biological Conservation**, v. 161, p. 230–238, 2013. https://doi.org/10.1016/j.biocon.2013.02.018

GELDMANN, J. *et al.* A global analysis of management capacity and ecological outcomes in terrestrial protected areas. **Conservation Letters**, v. 11, n. 3, 2018. https://doi.org/10.1111/conl.12434

GELDMANN, J. *et al.* A global-level assessment of the effectiveness of protected areas at resisting anthropogenic pressures. **Proceedings of the National Academy of Sciences**, v. 116, n. 46, p. 23209–23215, 2019. https://doi.org/10.1073/pnas.1908221116

GELDMANN, J.; JOPPA, L. N.; BURGESS, N. D. Mapping Change in Human Pressure Globally on Land and within Protected Areas. **Conservation Biology**, v. 28, n. 6, p. 1604–1616, 2014. https://doi.org/10.1111/cobi.12332

HALLINGER, P.; CHATPINYAKOOP, C. A Bibliometric Review of Research on Higher Education for Sustainable Development, 1998–2018. **Sustainability**, v. 11, n. 8, p. 2401, 2019. https://doi.org/10.3390/su11082401

HARZING, A.-W.; ALAKANGAS, S. Google Scholar, Scopus and the Web of Science: a longitudinal and cross-disciplinary comparison. **Scientometrics**, v. 106, n. 2, p. 787–804, 2016. https://doi.org/10.1007/s11192-015-1798-9

HASANA, U.; SWAIN, S. K.; GEORGE, B. A bibliometric analysis of ecotourism: A safeguard strategy in protected areas. **Regional Sustainability**, v. 3, n. 1, p. 27–40, 2022. https://doi.org/10.1016/j.regsus.2022.03.001

HE, J.; WU, W. Comprehensive landscape and future perspectives of long noncoding RNAs (lncRNAs) in colorectal cancer (CRC): Based on a bibliometric analysis. **Non-coding RNA Research**, v. 8, n. 1, p. 33–52, 2023. https://doi.org/10.1016/j.ncrna.2022.10.001

KOKOL, P.; BLAŽUN VOŠNER, H.; ZAVRŠNIK, J. Application of bibliometrics in medicine: a historical bibliometrics analysis. **Health Information & Libraries Journal**, v. 38, n. 2, p. 125–138, 2021. https://doi.org/10.1111/hir.12295

KOKOL, P.; KOKOL, M.; ZAGORANSKI, S. Machine learning on small size samples: A synthetic knowledge synthesis. **Science Progress**, v. 105, n. 1, p. 003685042110297, 2022. https://doi.org/10.1177/00368504211029777

KOKOL, P.; ZAVRŠNIK, J.; VOŠNER, H. B. Bibliographic-Based Identification of Hot Future Research Topics: An Opportunity for Hospital Librarianship. **Journal of Hospital Librarianship**, v. 18, n. 4, p. 315–322, 2018. https://doi.org/10.1080/15323269.2018.1509193

KOSKIKALA, J.; KUKKONEN, M.; KÄYHKÖ, N. Mapping Natural Forest Remnants with Multi-Source and Multi-Temporal Remote Sensing Data for More Informed Management of Global Biodiversity Hotspots. **Remote Sensing**, v. 12, n. 9, p. 1429, 2020. https://doi.org/10.3390/rs12091429

MAMATZAKIS, E. C. EU infrastructure investment and productivity in Greek manufacturing. **Journal of Policy Modeling**, v. 29, n. 2, p. 335–344, 2007. https://doi.org/10.1016/j.jpolmod.2006.12.002

MARTÍNEZ-VEGA, J.; RODRÍGUEZ-RODRÍGUEZ, D. Protected Area Effectiveness in the Scientific Literature: A Decade-Long Bibliometric Analysis. **Land**, v. 11, n. 6, p. 924, 2022. https://doi.org/10.3390/land11060924

MELAKU, A.; IVARS, J. P.; SAHLE, M. The state-of-the-art and future research directions on sacred forests and ecosystem services. **Environmental Management**, v. 71, n. 6, p. 1255–1268, 2023. https://doi.org/10.1007/s00267-023-01790-4

MOREIRA, M. N. B. *et al.* Reducing meat consumption: Insights from a bibliometric analysis and future scopes. **Future Foods**, v. 5, p. 100120, 2022. https://doi.org/10.1016/j.fufo.2022.100120

OLDEKOP, J. A. *et al.* A global assessment of the social and conservation outcomes of protected areas. **Conservation Biology**, v. 30, n. 1, p. 133–141, 2016. https://doi.org/10.1111/cobi.12568

PESTANA, M. H.; SÁNCHEZ, A. V.; MOUTINHO, L. The network science approach in determining the intellectual structure, emerging trends and future research opportunities – An application to senior tourism research. **Tourism Management Perspectives**, v. 31, p. 370–382, 2019. https://doi.org/10.1016/j.tmp.2019.07.006

PETIT, I. J. *et al.* Protected areas in Chile: are we managing them? **Revista Chilena de Historia Natural**, v. 91, n. 1, p. 1, 2018. http://dx.doi.org/10.1186/s40693-018-0071-z

RODRÍGUEZ-RODRÍGUEZ, D.; MARTÍNEZ-VEGA, J. Proposal of a system for the integrated and comparative assessment of protected areas. **Ecological Indicators**, v. 23, p. 566–572, 2012. https://doi.org/10.1016/j.ecolind.2012.05.009

SAURA, S. *et al.* Protected areas in the world's ecoregions: How well connected are they? **Ecological Indicators**, v. 76, p. 144–158, 2017. https://doi.org/10.1016/j.ecolind.2016.12.047

SCHIRPKE, U. *et al.* Supporting the Management of Ecosystem Services in Protected Areas: Trade-Offs Between Effort and Accuracy in Evaluation. **Journal of Environmental Assessment Policy and Management**, v. 19, n. 02, p. 1750007, 2017. https://doi.org/10.1142/S1464333217500077

SCHULZE, K. *et al.* An assessment of threats to terrestrial protected areas. **Conservation Letters**, v. 11, n. 3, 2018. https://doi.org/10.1111/conl.12435

SHAH, P. *et al.* What determines the effectiveness of national protected area networks? **Environmental Research Letters**, v. 16, n. 7, p. 074017, 2021. https://dx.doi.org/10.1088/1748-9326/ac05ed

SHAHBAZ, M. *et al.* A bibliometric analysis and systematic literature review of tourism-environmental degradation nexus. **Environmental Science and Pollution Research**, v. 28, n. 41, p. 58241–58257, 2021. https://doi.org/10.1007/s11356-021-14798-2

SHARMA, R. *et al.* The impact of terrestrial protected areas on vegetation extent and condition: a systematic review protocol. **Environmental Evidence**, v. 9, n. 1, p. 8, 2020. https://doi.org/10.1186/s13750-020-00191-y

SHARMA, R.; MISHRA, D. K. An analysis of thematic structure of research trends in occupational health and safety concerning safety culture and environmental management. **Journal of Cleaner Production**, v. 281, p. 125346, 2021. https://doi.org/10.1016/j.jclepro.2020.125346

SHASHA, Z. T. *et al.* Past, current, and future perspectives on eco-tourism: A bibliometric review between 2001 and 2018. **Environmental Science and Pollution Research**, v. 27, n. 19, p. 23514–23528, 2020. https://doi.org/10.1007/s11356-022-19404-7

STEBLIANSKAIA, E. *et al.* Environmental-social-governance concept bibliometric analysis and systematic literature review: Do investors becoming more environmentally conscious? **Environmental and Sustainability Indicators**, v. 17, p. 100218, 2023. https://doi.org/10.1016/j.indic.2022.100218

STRASSBURG, B. B. N. *et al.* Global priority areas for ecosystem restoration. **Nature**, v. 586, n. 7831, p. 724–729, 2020. https://doi.org/10.1038/s41586-020-2784-9

SWEILEH, W. M. *et al.* Bibliometric analysis of global migration health research in peer-reviewed literature (2000–2016). **BMC Public Health**, v. 18, n. 1, p. 777, 2018. https://doi.org/10.1186/s12889-018-5689-x

SWEKE, E. A. *et al.* Comparing the Performance of Protected and Unprotected Areas in Conserving Freshwater Fish Abundance and Biodiversity in Lake Tanganyika, Tanzania. **International Journal of Ecology**, v. 2016, p. 1–7, 2016. https://doi.org/10.1155/2016/7139689

UNITED NATIONS. **United Nations Transforming Our World**: The 2030 Agenda for Sustainable Development. New York: Division for Sustainable Development Goals, 2015.

VAN ECK, N. J.; WALTMAN, L. Software survey: VOSviewer, a computer program for bibliometric mapping. **Scientometrics**, v. 84, n. 2, p. 523–538, 2010. https://doi.org/10.1007/s11192-009-0146-3

VAN ECK, N. J.; WALTMAN, L. Visualizing bibliometric networks. *In*: DING, Y.; ROUSSEAU, R.; WOLFRAM, D. **Measuring scholarly impact**: methods and practice. Springer, 2014. p. 285–320. https://doi.org/10.1007/978-3-319-10377-8_13

WOODLEY, S. *et al.* Meeting Aichi Target 11: what does success look like for protected area systems. **Parks**, v. 18, n. 1, p. 23–36, 2012.

XIANGYUN, W.; GUOPING, Z. Bibliometric analysis of Antarctic marine protected area research. **Chinese Journal of Polar Research**, v. 33, n. 1, p. 88, 2021. https://doi.org/10.%2013679/j.jdyj.20200023

YANG, Q. *et al.* Resilient City: A Bibliometric Analysis and Visualization. **Discrete Dynamics in Nature and Society**, v. 2021, p. 1–17, 2021. https://doi.org/10.1155/2021/5558497

ZAFRA-CALVO, N.; GELDMANN, J. Protected areas to deliver biodiversity need management effectiveness and equity. **Global Ecology and Conservation**, v. 22, p. e01026, 2020. https://doi.org/10.1016/j.gecco.2020.e01026

ZHANG, J. *et al.* Research progress and knowledge system of world heritage tourism: a bibliometric analysis. **Heritage Science**, v. 10, n. 1, p. 42, 2022. https://doi.org/10.1186/s40494-022-00654-0

ZORONDO-RODRÍGUEZ, F. *et al.* Why would new protected areas be accepted or rejected by the public?: Lessons from an ex-ante evaluation of the new Patagonia Park Network in Chile. **Land Use Policy**, v. 89, p. 104248, 2019. https://doi.org/10.1016/j.landusepol.2019.104248

ZYOUD, S. H.; ZYOUD, A. H. Coronavirus disease-19 in environmental fields: a bibliometric and visualization mapping analysis. **Environment, Development and Sustainability**, v. 23, n. 6, p. 8895–8923, 2021. https://doi.org/10.1007/s10668-020-01004-5