



Systematic Review of Spatial Planning and Marine Protected Areas: A Brazilian Perspective

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Marine protected areas (MPAs) are essential to human well-being and usually part of spatial planning processes for managing coastal and marine areas. In Brazil, national-level spatial planning processes are still incipient. This article offers a systematic review through a comparative meta-analysis of the literature on MPAs and spatial planning based on the following questions: (I) What topics are investigated in spatial planning in MPAs worldwide? and (II) What are the advances and trends of these topics in Brazilian MPAs? Specific goals of this study are (I) to identify studies on Brazil; and (II) to compare and contrast these with studies performed elsewhere. The PRISMA report was used to select literature, with a focus on three spatial contexts (I) outside Brazil, analyzing studies from other countries; (II) in Brazil; and (III) a case study in Brazil that focuses on a sustainable-use area in northeastern Pará. Studies outside Brazil showed three major groups of themes: (I) planning and tools; (II) stakeholders; and (III) the ecology of non-human species. For the Brazilian context, studies were grouped into five major themes: (I) small-scale fishing practices and conflicts; (II) participation in protected areas; (III) technical aspects of the planning process, (IV) zoning; and (V) mapping. The local case study investigates socio-cultural sustainability and tourism. All identified studies relate to use, but have a greater focus on conservation and, especially abroad, on species and ecosystems. There are few reviews or comparative studies that could help to draw parallels between the different spatial planning settings. We conclude that synthesis work on spatial management strategies worldwide is needed, including the elaboration of frameworks to develop measures to address the widespread lack of data and spatial planning expertise. Collaborative networks of researchers and practitioners are needed for this. The novelty in our study is that it examines MPAs and spatial planning research at three spatial contexts with innovative methodologies to represent the current state of the spatial planning discourse in coastal and marine conservation.

Keywords: fisheries, marine spatial planning (MSP), spatial management, stakeholders, systematic review

INTRODUCTION

A marine protected area¹ (MPA) is a geographical space reserved by law, considered essential to human well-being (Gubbay, 2005) and, especially, to local communities (Bennett and Dearden, 2014). The implementation of MPAs has grown worldwide (Potts et al., 2014; Leenhardt et al., 2015; Tonin, 2018) as a management strategy to conserve resources (Bennett and Dearden, 2014). However, MPAs still need to be better planned (IUCN, 2009). They have an important role in marine spatial planning (MSP) (GEF, 2012) with MSP understood as a public process for organizing the use of marine space, and pursuing social, economic, and ecological benefits (Ehler and Douvère, 2009). The relationship between MPAs and MSP is sometimes described based on geographic level: Marine protected areas represent marine spatial planning at lower levels (or smaller scales²), while MSP usually refers to a higher-level process (Strickland-Munro et al., 2016). MPAs are recognized as an important element of MSP (Ehler and Douvère, 2009). Another cornerstone of MSP is zoning, which, in this study, is considered a management tool in the wider context of MSP (Dudley, 2008; Kenchington and Day, 2011). It focuses on the MSP process within (IUCN, 2012) and outside MPAs. The relationship between MSP, MPA, and zoning is clarified in **Figure 1**.

Thus, MSP is one element of ocean or sea use management, whereas zoning plans and other regulations are one of a set of management actions for implementing MSP (Ehler and Douvère, 2009). Whether zones are highly, moderately, or weakly regulated influences the overall protection level of MPAs (Costa et al., 2016; Horta e Costa et al., 2016). Therefore, zoning applies to the management of MPAs considering their zone classification and the International Union for the Conservation of Nature (IUCN) categories of protected areas (Dudley, 2008). It facilitates the identification of types of resource uses (Domínguez-Tejo et al., 2016), as well as challenges, knowledge gaps, and institutional difficulties in MSP (Katsanevakis et al., 2011). Zoning, MPA networks, and MSP are helpful processes for ecosystem-based, marine spatial management (Katsanevakis et al., 2011). Moreover, diverse stakeholders have emphasized the importance of including MSP as a tool to harmonize different marine uses, including renewable energy generation, aquaculture, and climate change adaptation (Lombard et al., 2019). Still, MSP is incipient worldwide (Abspoel et al., 2019) and studies on MSP and zoning are rarely published in peer-reviewed journals (Domínguez-Tejo et al., 2016), although the number of published studies is growing (Rêgo et al., 2016).

In Brazil, the Blue Amazon represents the country's Exclusive Economic Zone (EEZ) and has an area of 5.7 million km², or approximately half of Brazil's terrestrial area³, which makes it

one of the largest on the planet (Gerhardinger et al., 2018). The implementation of zoning strategies in the Brazilian EEZ is still at an early stage (Gerhardinger et al., 2019), despite existing projects that aim at the management of coastal areas, such as the Orla Project (Casemiro et al., 2018). Brazilian protected areas, inserted in the National System of Conservation Units (Brazil, 2000), are part of an important conservation strategy toward the conservation of myriad coastal and marine ecosystems, including mangroves (Pinheiro et al., 2015). Federal protected areas are divided into two main groups: strictly protected areas (17%) and sustainable use areas (83%) (MMA and ICMBIO, 2018). The goal of strictly protected areas is to preserve nature so that only indirect use, which does not involve consumption, collection, or destruction, is allowed (Brazil, 2000). The sustainable use group aims to reconcile nature conservation and direct use, allowing for the collection and commercial use of natural resources (Brazil, 2000).

One of the categories in the sustainable use group is the extractive reserve. This model pursues the participation of local stakeholders in the management of natural resources (Brazil, 2000; Partelow et al., 2018): members of traditional communities have the role of co-managers (da Silva, 2004). In the case of mangroves, for example, "mangrove civilizations" (Diegues, 1995) practice artisanal fisheries (Diegues, 2008). These are usually the main socio-economic activity in these areas (Fernandes et al., 2018), such as the Amazon macrotidal mangrove coast (Souza Filho, 2005). This coast is one of the longest (Souza Filho, 2005) and most important protected mangrove regions on the planet (Hayashi et al., 2019) and its coastal-estuarine communities depend on the mangrove ecosystem services (Eyzaguirre and Fernandes, 2018; Fernandes et al., 2018).

Despite the importance of ecosystems such as the northern mangroves, policy measures for MSP in Brazil are at an early stage (Gerhardinger et al., 2019), and the development of knowledge creation in this front remains poorly understood. In the implementation arena, the incipency of spatial management in Brazilian MPAs is revealed by the fact that only 19% of these areas have management plans⁴, which usually include the MPAs zoning. Assessing the status of MSP in Brazil can help identify gaps and conservation needs in marine conservation. The development of effective management plans and zoning strategies requires systematic data, which are usually gathered by, or in collaboration with, scientific studies.

With the aim to better understand research in MPAs and spatial management in different spatial contexts⁵, this article offers a systematic review through a meta-analysis of the literature and addresses the following questions: (I) Which

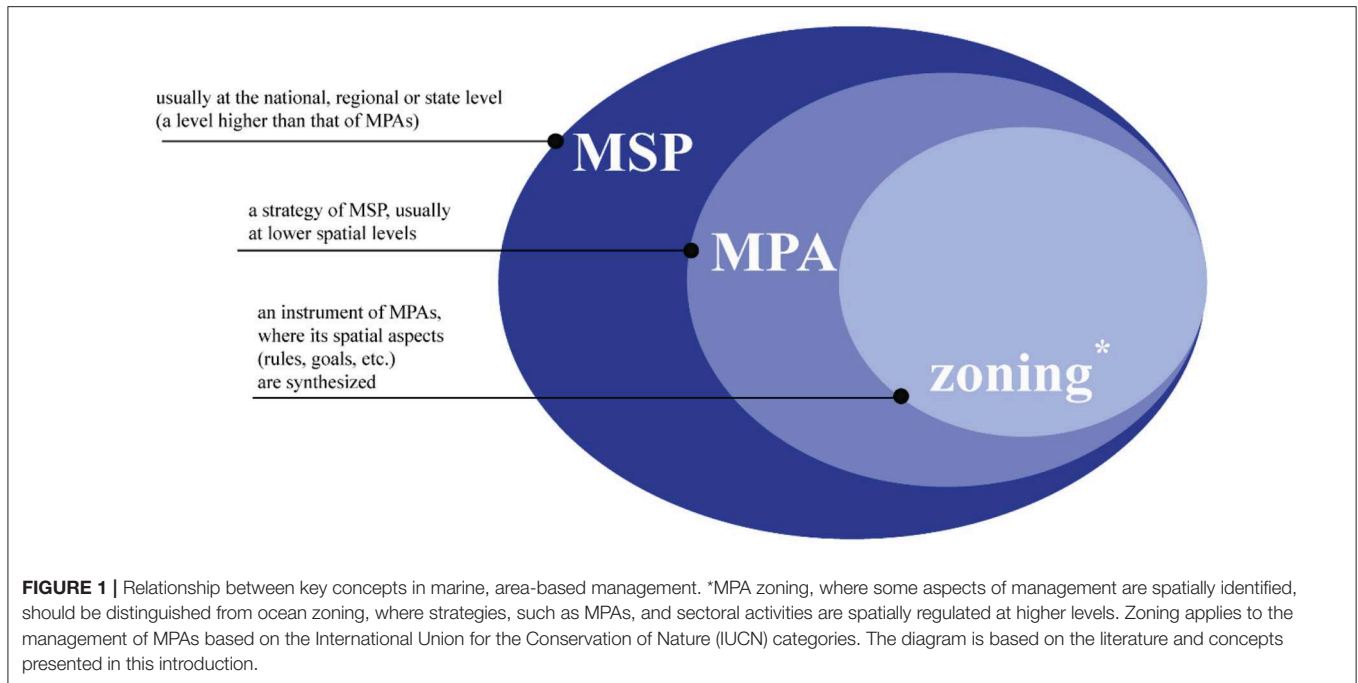
¹Although most literature refers to "marine" protected areas, coastal protected areas are included in this definition.

²We adopt the definition of scale as the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon (Gibson et al., 2000), while levels represent the points on a certain scale (Cash et al., 2006; Glaser and Glaeser, 2014). "Level," as defined here, is often found in the literature as "scale," especially in terms such as "small-scale."

³https://www.mar.mil.br/hotsites/amazonia_azul/

⁴<https://www.mma.gov.br/areas-protetidas/cadastro-nacional-de-ucs>

⁵We adopt the term "spatial context" in the sense of geographic, concrete space. We aim to investigate research on MSP and MPAs, and not directly policy-making on these topics. For this reason, we are not interested in institutions related to decision-making. We also purposely avoid the term "level" (as explained above in another footnote) because we do not aim to distinguish research done at the national, state, or municipal level. We are rather interested in the geographic spaces included in each study, whether related to coastal-marine spaces outside or in Brazil, or whether specifically in our study case site.



topics studied relating to spatial planning in MPAs have been investigated worldwide? and (II) What are the advances and trends in these topics regarding MPAs in Brazil, both considering the whole country and a case study? and (III) How do studies performed worldwide (outside Brazil) compare to those performed in Brazil? This last question aims to assess how a single country has been developing research in MPAs and spatial management and how this research differs from other countries. This helps identify common topics, successes, and challenges in spatial planning inside and outside Brazil, while also pinpointing aspects that are specific for the Brazilian context and that could dialogue with the experience of other countries with the goal to promote mutual learning and the exchange of experience.

MATERIALS AND METHODS

Spatial Contexts

Studies were categorized according to three spatial contexts (or the geographic areas analyzed): (I) outside Brazil, (II) in Brazil, and (III) in a case study MPA in north Brazil, the Caeté-Taperaçu marine extractive reserve, located in the coastal Bragantian northeastern region of Pará (Mendes, 2005; IBGE, 2010; **Figure 2**). The mangrove areas in the Amazonian mangrove belt are a Ramsar Site (RAMSAR, 2018). They represent at least 57% of the mangrove coverage in Brazil, with an area of about 7,591 km² (Souza Filho, 2005). They have high biodiversity (Abdala et al., 2012) and are one of the largest continuous extensions of mangroves on the planet (Souza Filho, 2005). Caeté-Taperaçu is one of the few marine extractive reserves in the marine biome that has a zoning plan and where local research contributed to formulate the management plan (Abdala et al., 2012). This marine extractive reserve therefore

offers a good case study to investigate the literature on spatial planning inside Brazil.

Literature Selection Criteria

In May 2018, the Web of Science (WoS) database (Clarivate Analytics, 2017) was used to search for studies outside and inside Brazil and the Brazilian Digital Library of Theses and Dissertations (BDTD) was searched to obtain more studies on Brazil. In these databases the following combined terms were searched: (I) {"protected area*" AND "(coastal OR marine)"}, OR MPA} AND {"spatial management" OR "spatial planning"} and (II) {"protected area*" AND "(coastal OR marine)"}, OR {"MPA" OR "conservation unit*"⁶} AND {"spatial management" OR "spatial planning"} AND Brazil}.

Criteria were adopted to filter studies that focused on the search terms (**Table 1**). The titles and abstracts of the retrieved articles were screened based on these criteria. The English language was selected for its broad usage in scientific publications (Drubin and Kellogg, 2012), both outside and inside Brazil. Portuguese was selected to increase the number of studies found, due to the amount of literature produced in the Portuguese language (Barata et al., 2014). Title, abstract, and keywords sections of studies in Portuguese were translated into English by the first author in order to obtain results in the English language.

Some words were analyzed as terms while others, as individual words. The words "marine protected area," for instance, when occurring together, were analyzed as a term. When combined with other words, e.g., "marine habitats" and "study area," these words were analyzed separately. On the other hand,

⁶We used the term "conservation unit" because it is the literal translation into English of "unidade de conservação," which is the term most frequently used in Portuguese for "protected area."

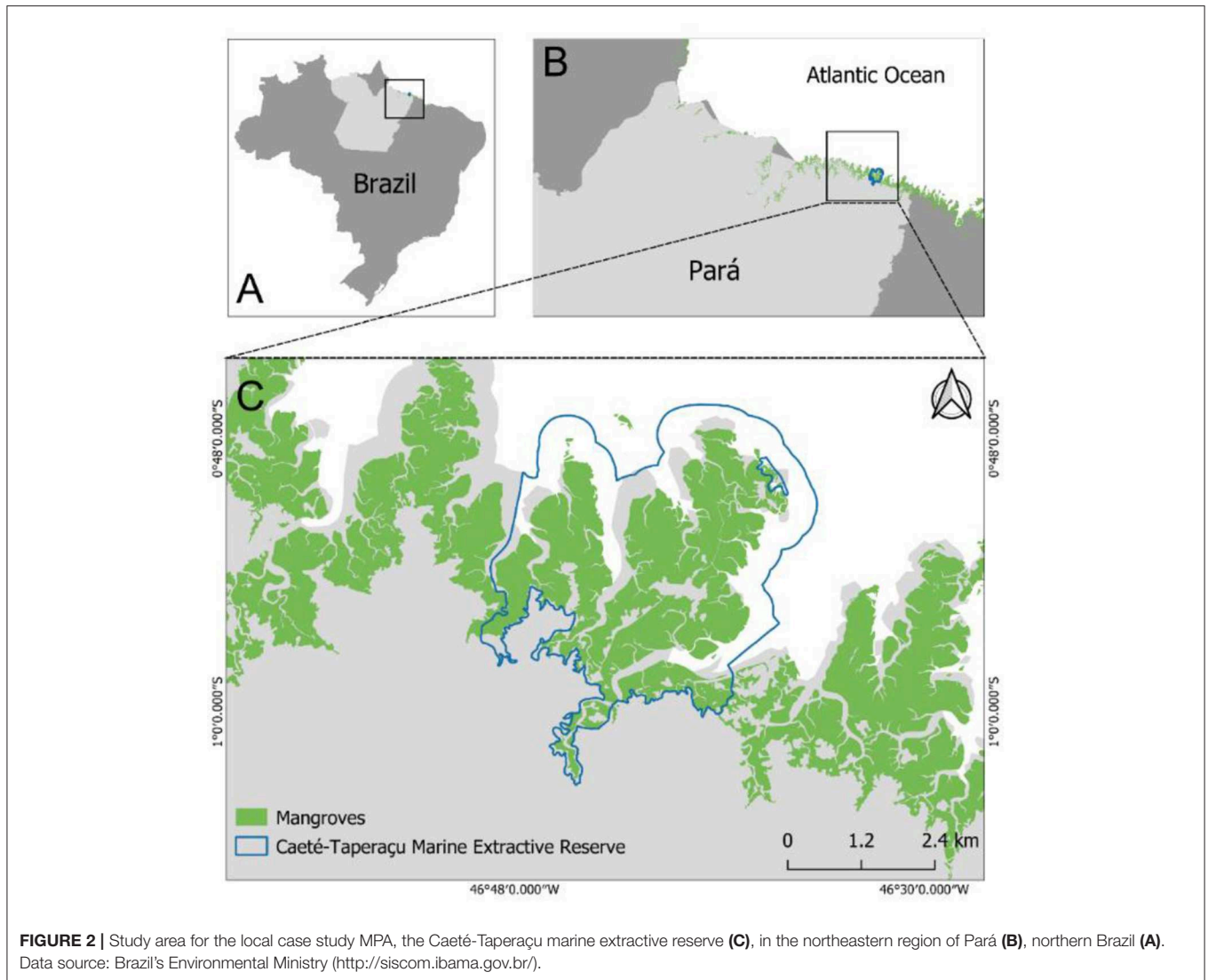


FIGURE 2 | Study area for the local case study MPA, the Caeté-Taperaçu marine extractive reserve (C), in the northeastern region of Pará (B), northern Brazil (A). Data source: Brazil’s Environmental Ministry (<http://siscom.ibama.gov.br/>).

TABLE 1 | Inclusion and exclusion criteria used to select the studies for the analyses.

Inclusion criteria	Exclusion criteria
The study presents a spatial planning case study, where analyses were conducted for policy-making, even if some further adjustments would have to be made or if more data had to be added to the analyses	The study gathers data to be later inserted in spatial analyses, without having done at least some analyses (e.g., identification or prioritization of biodiversity hotspots)
English or Portuguese languages	The study presents new methodology or software for spatial planning and/or management without relating it to real-life case studies, such as theoretical or generic discussions

words such as “spatial” and “management” were analyzed as separate units, because of their independent meaning and possibility to be combined with other words, forming units with

different meanings, such as “spatial planning,” “protected area management,” and “management plan.”

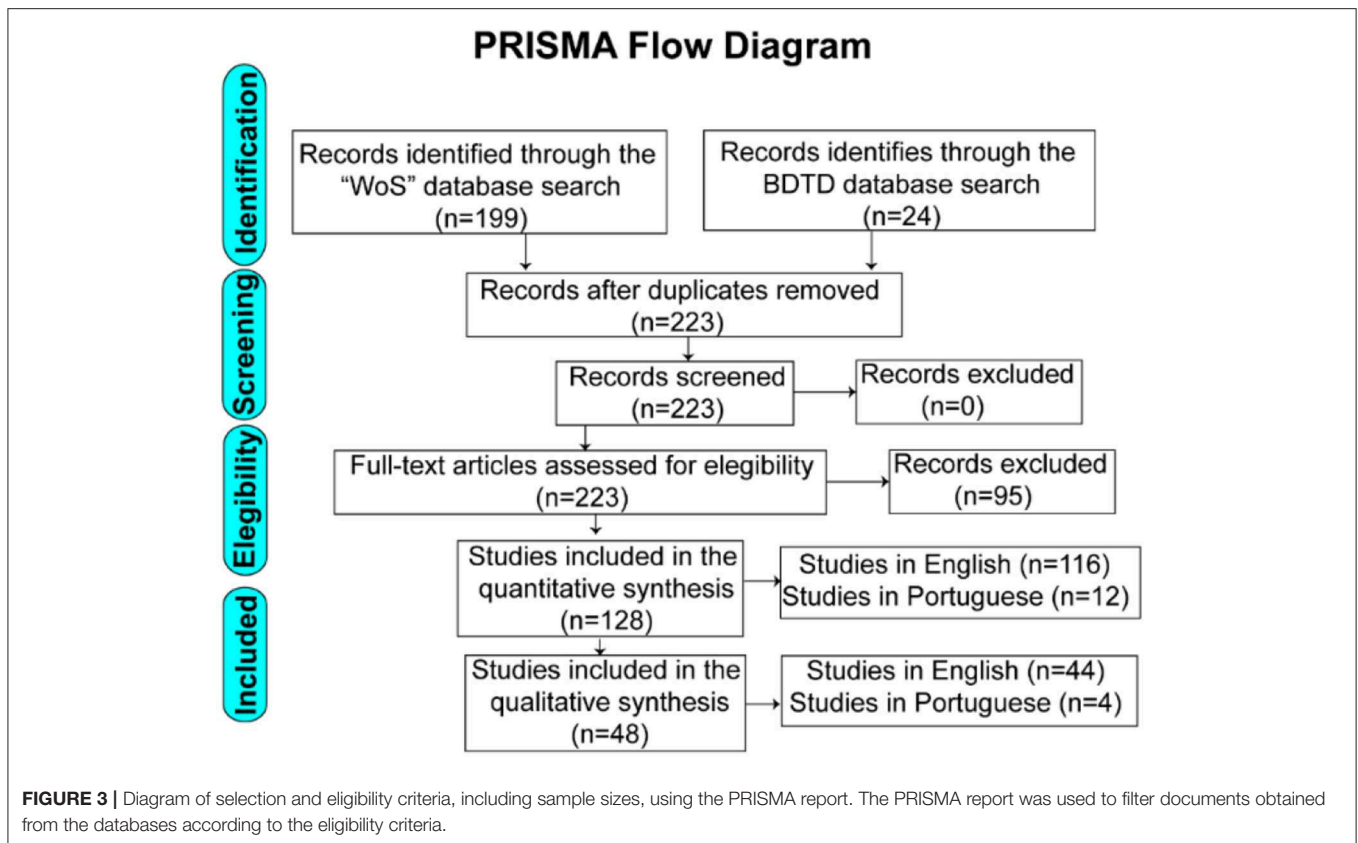
Analyses

Overview of all Analyses Performed

The systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guide (Moher et al., 2009; **Figure 3**). The qualitative and quantitative analyses were conducted after the systematization of the studies with the PRISMA report.

Quantitative Analyses

The textual content or *corpus* of title, abstract, and keywords sections of the selected studies was structured after the collection and compilation of all the documents. The frequency of certain key terms in the studies and similarity among these words were analyzed (Abric and Vergès, 1994; Abric, 2003). Lexicometry is a method to measure word frequency in a text (Torruella and Capsada, 2013). A semantic lexicometry analysis was performed



(Wasserman and Faust, 1994; Leydesdorff and Welbers, 2011) based on the co-occurrence of words and their interrelationship of coexistence with the nodes represented in the similarity chart (Fronzetti, 2018). Proximity or connectivity is based on distance metrics (Wasserman and Faust, 1994) depending on the frequency and inter-relationship between nodes (Fronzetti, 2018). The results presented are related to the most frequent terms in each analysis, but do not necessarily exhaust all possible relationships that could be derived from the datasets.

Word clouds

Title, abstract, and keywords sections of the studies were also jointly subjected to the word cloud analysis using MAXQDA version 2018.2. Word cloud is the processing of qualitative data that are grouped and organized graphically according to word or expression frequency (Heimerl et al., 2014). Word clouds can serve as a starting point for a more in-depth analysis. Terms shown in the word clouds have a minimum frequency of three hits. Words used in the search were eliminated from the word clouds generated.

Similarity analysis

A similarity analysis shows the spring force⁷ and the frequency between the words through the classification of the three sections

⁷Spring force is used in network social theory to measure the distance between objects in a text. In this study, the distance between words/terms shows the relationship of meaning in the discourse.

analyzed (titles, abstracts, and keywords). The textual content was evaluated using the discursive occurrences related to similarities and interlinks between the words or terms (Alexandridis et al., 2018). We used the method of graphs (Fruchterman and Reingold, 1991), based on Eades' algorithm (Eades, 1984) and on the spring forces (Kobourov, 2012) to indicate how close or far apart terms are (Fruchterman and Reingold, 1991), how interrelated words are in the discourse (Alexandridis et al., 2018), and the salient themes of each class. Classes are connected to each other by a frequency number that shows the similarity between the words and identifies the discourse structure of the studies analyzed. This similarity analysis is related to the descending hierarchical analysis that we introduce below.

Descending hierarchical analysis

We used the Descending Hierarchical Analysis (DHA) to classify terms in descending order by lexical category (Reinert, 1990). The hierarchical dendrogram is based on the Euclidean distance between words in the text (Fruchterman and Reingold, 1991). It also evaluates the degree of association between the classes of each word (Ratinaud and Marchand, 2012). Since only one document was found for the local case study, this document was incorporated into the Brazilian context for this specific analysis. Three important parameters for interpretation were used: (I) similarity, which refers to the concurrence between the words that are similar; (II) proximity, which indicates the distance between the words (Fruchterman and Reingold, 1991); and (III)

frequency, which explains the interrelation between the words in all documents (Ratinaud, 2009; Alexandridis et al., 2018).

The distance between the classes was analyzed using the DHA and a dendrogram chart, where the percentage indicates how many words/terms belong to each class. The words were analyzed using the chi-square (χ^2) statistics according to the analysis done within Iramuteq. To clarify this in the Results section, we included a few examples with the statistical results. The other statistics for the words in each class can be found in **Data Sheet 2**.

Frequency of topics through lexical search

The frequency of topics was established through a lexical search allowed for a more thorough analysis of the all the documents using the “advanced lexical search” tool in MAXQDA. More on MAXQDA is explained in section Software Used.

Specific topics approached in each study were identified, including the referenced bibliography. The qualitative categorization was based on the search terms, according to hits (number of times the search term was found) and to the number of documents where these search terms were found. Search terms relate to frequent topics in the literature on MSP and MPAs. A list of search terms was created based on the authors’ familiarity with the literature on these two topics.

Software Used

Two software packages were used for the analyses: MAXQDA and Iramuteq (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*) (Table 2). These tools were used to represent the structure of discourse on spatial planning studies in order to map the studies and their scientific cognitive structure through the landscape of bibliometric cartography (van Raan, 1996). The analyses were selected from each package based on the availability of each analysis and the easiness of interpretation of the visualized results.

MAXQDA is a license-based tool that uses the coding of data as a starting point for qualitative and mixed-methods analyses (Oliveira et al., 2016). Iramuteq is an open-access, qualitative analysis tool which is not based on the codification of texts but rather analyzes segments of the texts through tests such as the descending hierarchical classification, the similarity analysis, and word clouds (Souza et al., 2018). It offers different ways of statistically analyzing qualitative data (Ramos et al., 2019), since

it is developed in the Python language and uses functionalities provided by the statistical software R (Souza et al., 2018).

The textual *corpus* was analyzed through coded segments of the documents using MAXQDA. An analysis of the frequency of the codes used in relation to the contexts was produced, as well as a lexical search on study topics (section Word clouds). MAXQDA was also used to code studies selected for the content analysis into thematic categories (section Similarity analysis).

Additionally, Iramuteq was used to analyze the textual *corpus* derived from the publications (Ratinaud, 2009). This tool produces a statistical map of a textual *corpus* from the frequency of words or lexicometry analyses based on chi-square statistics (Ratinaud, 2009). The titles, abstracts, and keywords sections of the studies were analyzed in the Iramuteq for each of the spatial contexts considered. Table 2 shows the analysis performed by database search and spatial contexts, highlighting the software used for each analysis.

Although some databases have interesting analytical tools such as the tree maps and bar charts on WoS, the programs we used here have a wider range of descriptive and inferential statistical tools to analyze qualitative data. MAXQDA, for example, is considered user-friendly, while Iramuteq is intuitive (Oliveira et al., 2016). The word cloud analysis, for instance, a way of presenting the frequency of the words in the documents, was carried out with MAXQDA due to its more appealing presentation of the results.

RESULTS

Quantitative Analyses

General Characteristics

Initially, the search yielded one, 28, and 190 studies for the local case study, for studies in, and outside Brazil, respectively. After applying inclusion and exclusion criteria, a total of 111 studies done outside Brazil, 16 in Brazil, and one for the local case study remained to be analyzed, with publication years ranging from 2003 to 2017 (Table 3).

Word Frequency Clouds

The frequency of the words in the title, abstract, and keywords of each study was analyzed (see **Data Sheet 1**). Studies outside Brazil (Figure 4A) most frequently contain the word “conservation,” “species,” “fisheries,” and “fishing.” In the titles

TABLE 2 | Overview of the analyses performed, with the systematization of documents according to the search database and the type of analysis for each spatial context (international, national, and local).

Search terms	Search database	Number of studies	Analysis	Software	Spatial context(s) analyzed	
(1) and (2)	WoS and BDTD	128	Quantitative analyses	Term frequency (word clouds) DHA and similarity analysis Lexical search of key topics	MAXQDA Iramuteq MAXQDA	Outside and in Brazil, plus the local case study
(1) and (2)	WoS and BDTD	48	Qualitative analysis	–	–	Outside and inside Brazil, without the case study

WoS, *Web of Science*; BDTD, *Biblioteca Digital Brasileira de Teses e Dissertações*.

TABLE 3 | Studies selected.

	Local	In Brazil	Outside Brazil	Total
Number of studies after exclusions				
WoS	0	5	111	116
BTD	1	11	0	12
Total	1	16	111	128

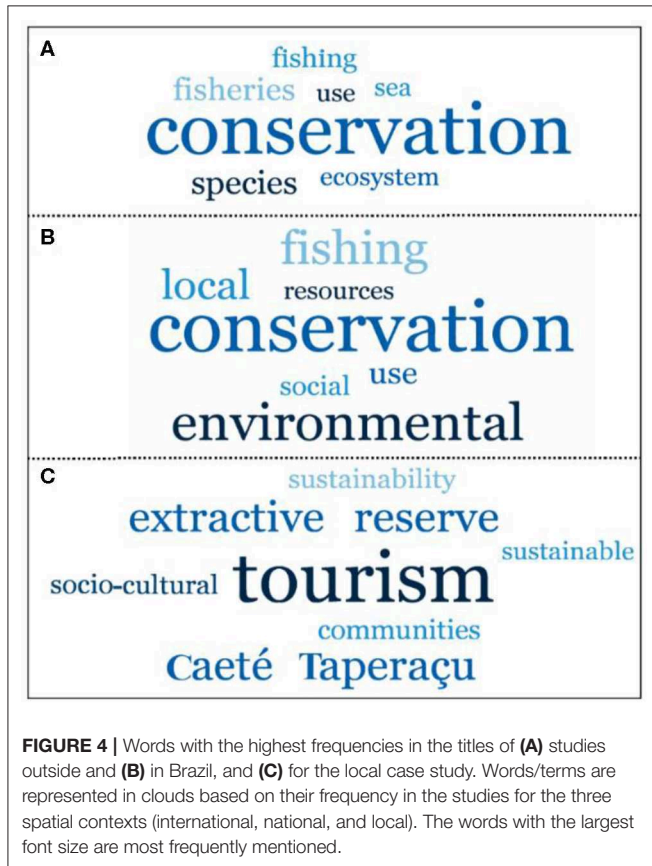


FIGURE 4 | Words with the highest frequencies in the titles of (A) studies outside and (B) in Brazil, and (C) for the local case study. Words/terms are represented in clouds based on their frequency in the studies for the three spatial contexts (international, national, and local). The words with the largest font size are most frequently mentioned.

of the Brazilian studies (Figure 4B), the terms most frequently mentioned are “conservation,” “environmental,” “fishing,” “local,” and “use.” The local study (Figure 4C) has among its most frequently mentioned terms “tourism,” “extractive reserve,” and “Caeté-Taperaçú,” which are all terms directly related to the protected area that is the research site for this specific study. Some words observed with greater frequency (larger size) are similar for studies outside and in Brazil, such as “conservation” and “fishing,” while the local case study leans toward “sustainability” and “sustainable.”

Similarity Analysis

Five classes compose the words for studies outside Brazil (Figure 5), where the most frequent words are “plan,” “management,” and “conservation.” The term “marine protected area” should be read as one single word, while “spatial” and “management” are two different words that have a relationship to

one another. On the one hand, “marine protected area” is related to “stakeholder,” “process,” “plan,” and “network.” On the other hand, “management” is related to the “spatial,” and “ecosystem.” This group (yellow) is related to the red group, i.e., the studies on spatial management relate to the benefits of the fishery activity. The distance values between the words, based on frequency, can be found in Data Sheet 2.

Five classes compose the words of the studies in Brazil (Figure 6). These studies discuss more frequently “conservation,” “management,” and “environmental.” The words “social” and “participation” (yellow group) have a greater proximity value with “conservation” of “biodiversity” in Brazil. On the other hand, the most frequent word in the lilac class, “management,” is related to “relationship,” while “conflict” is related to “area” and “zone” in the red class. “Brazil” is connected, in a direct way, to “biodiversity,” and in an indirect way, to “participation” and “social.”

Brazilian studies also bring the term “conflict” in combination with “fish” and zone. “Management” and “plan” relate to “local” and “knowledge,” while also including, but apparently with smaller frequency, “social” and “participation.”

Unlike the other two contexts, the analysis of similarity of the one relevant study on the local case study presents only three classes (Figure 7). The structure of the discourse in this study presents the word “tourism” (green group) as most frequently occurring and also as related to “extractive reserve” (blue group). “Caeté-Taperaçú” is an “extractive reserve.”

Descending Hierarchical Analysis (DHA)

For studies outside Brazil (Figure 8A), three classes were identified, the Brazilian studies (including the local case study) (Figure 8B) present five classes.

The words in class 1 (44%) are closest to those in class 2 (16.6%), and these two classes are significantly different from class 3 (39.4%) The results of the statistical analyses can be found in Data Sheet 2. The red and green classes, e.g., “management” ($\chi^2 = 47.28$, $p = 0.0001$), “conservation,” “plan,” “initiatives” ($\chi^2 = 105.2$, $p = 0.0001$), and “stakeholder” refer to the management dimension of spatial planning research. The blue class, e.g., “fish,” “population,” “species,” “abundance,” and “model,” refers to the biological and ecological dimensions of the spatial planning research on MPAs.

Studies in Brazil form different classes of terms and words (Figure 8B). The green class, e.g., “practice,” “alternative,” and “fisherman” are closest to red class, e.g., “conflict,” “fisher,” and “actor.” The brown class, e.g., “protect” and “participation” are closest to blue class, e.g., “project.” The lilac class contains words such as “legal,” “development,” and “GIS”⁸.

All the classes are interrelated in varying degrees, for example, classes 3 and 1, which relate to social dimensions. Classes 2 and 4 are closely related to one another and also relate to management, while class 5 relates to the zoning, for example, by using GIS tools to establish zones.

⁸Geographic Information System (GIS).

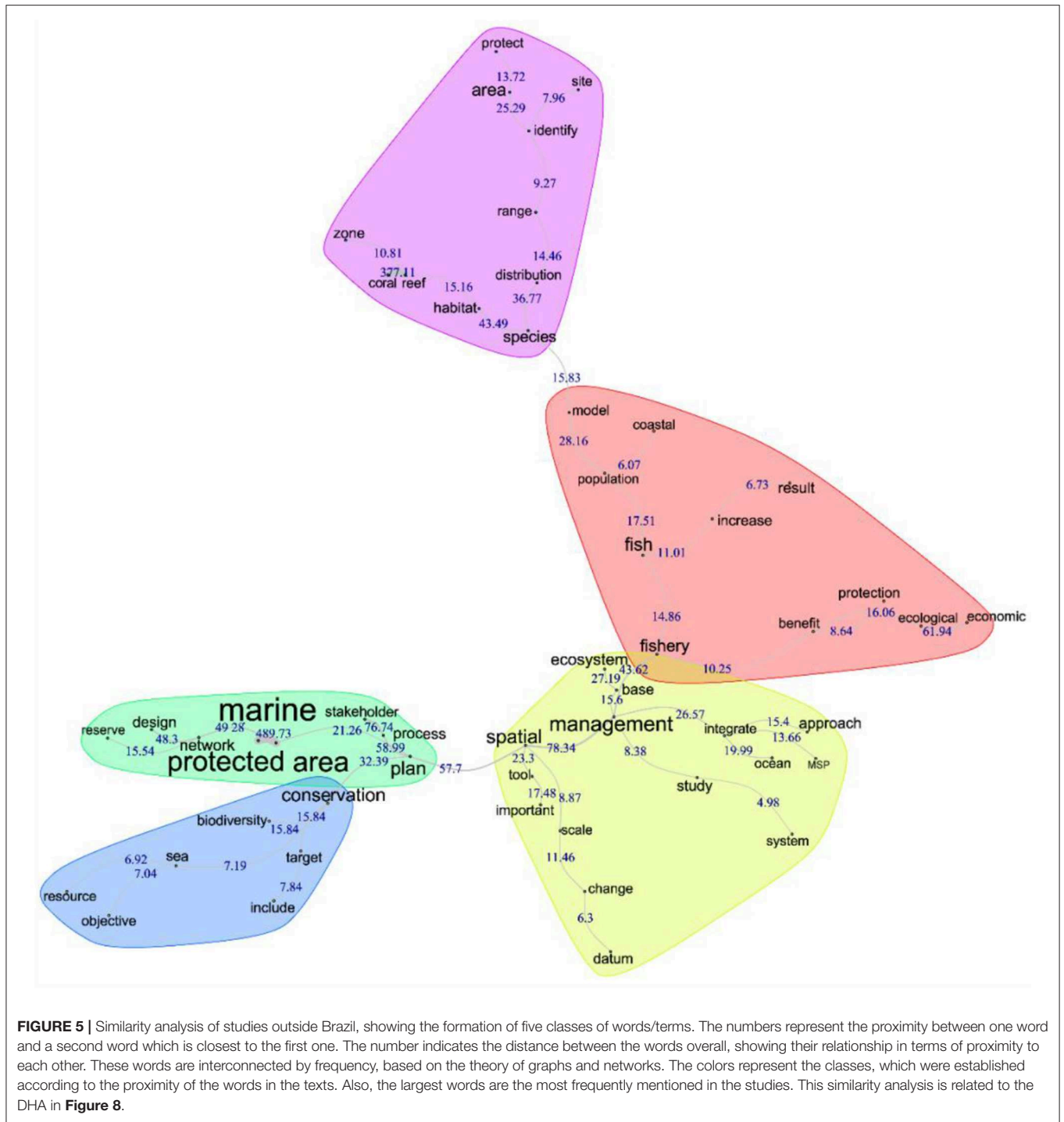


FIGURE 5 | Similarity analysis of studies outside Brazil, showing the formation of five classes of words/terms. The numbers represent the proximity between one word and a second word which is closest to the first one. The number indicates the distance between the words overall, showing their relationship in terms of proximity to each other. These words are interconnected by frequency, based on the theory of graphs and networks. The colors represent the classes, which were established according to the proximity of the words in the texts. Also, the largest words are the most frequently mentioned in the studies. This similarity analysis is related to the DHA in **Figure 8**.

Frequency of Topics Through Lexical Search

The lexical search identified the terms related to fisheries as the most frequent ones for studies both outside (7,382 hits in 111 studies searched, or an average of ~66 hits/study) and in Brazil (5,877 hits in 16 studies searched, or an average of ~367 hits/study), as well as for the local case study (110 hits for

one study searched). Other high frequency terms can be found in **Table 4**.

Furthermore, the lexical search identified missing research topics (**Table 5**). Further details on the results for this analysis can be found in **Data Sheet 3**.

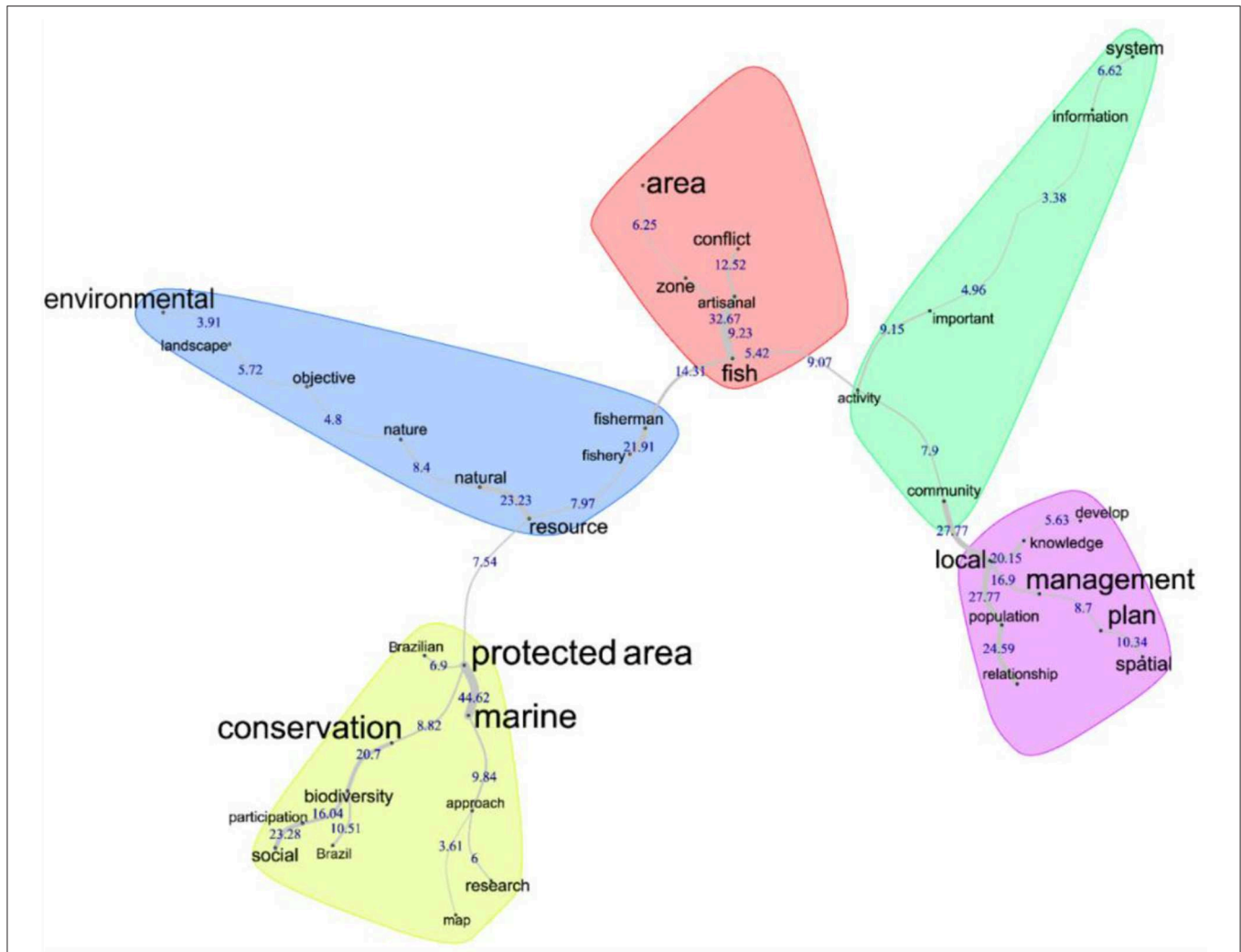


FIGURE 6 | Similarity analysis of studies in Brazil (local case study excluded). The numbers represent the proximity, expressed as the distance between the words based on frequency and similarity. The largest words are the most frequently mentioned. These words are interconnected by frequency, based on the theory of graphs and networks. The colors represent the classes, which were established according to the proximity of the words in the texts. This similarity analysis is related to the DHA in **Figure 8**.

DISCUSSION

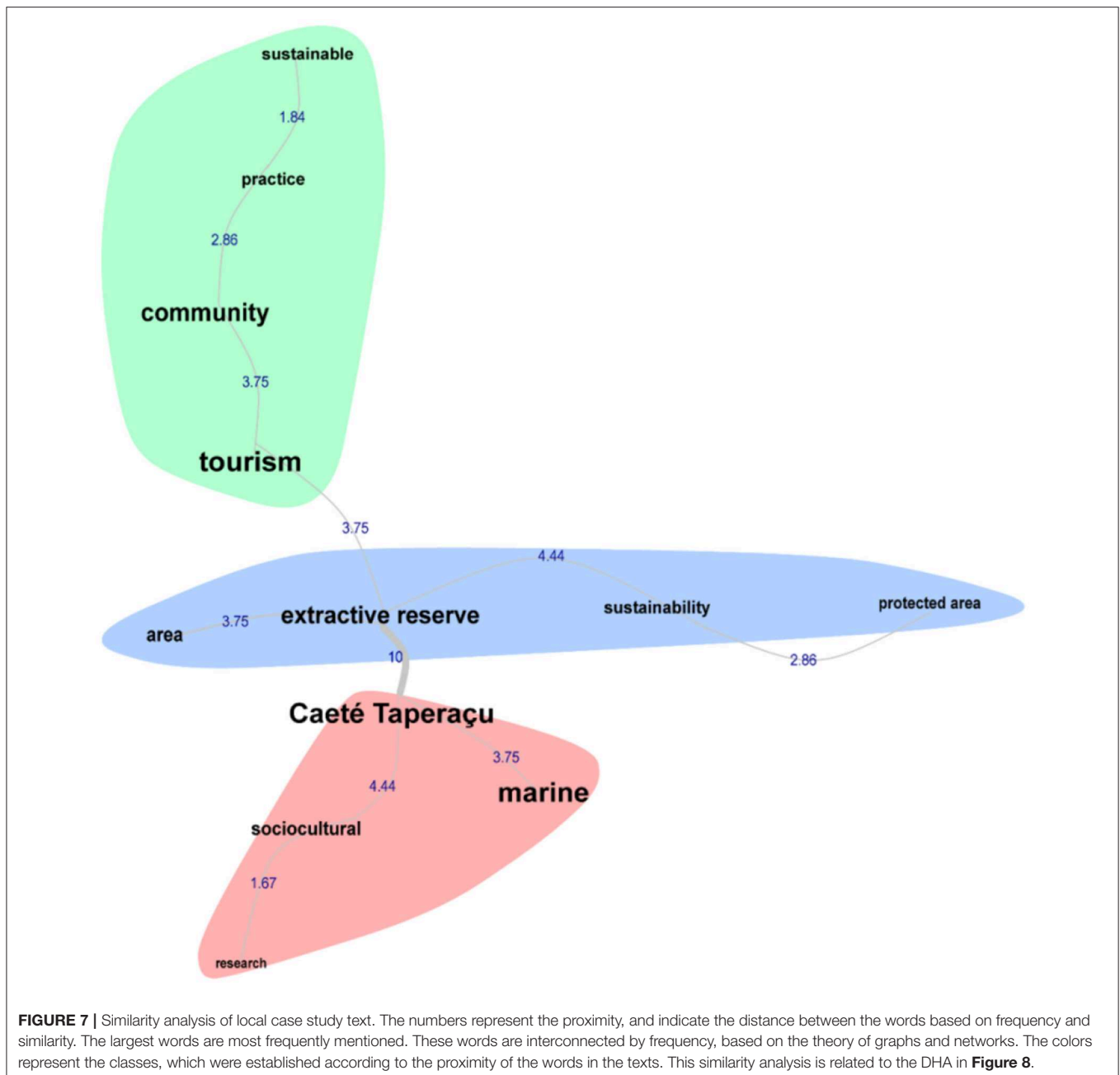
This systematic review identifies studies on spatial planning in MPAs and, specifically, compares and contrasts studies performed outside and in Brazil. We identified studies related to spatial management in different spatial contexts and provide a combination of systematic review and meta-analysis, with a qualitative and quantitative approach (Impellizzeri and Bizzini, 2012). A list of all titles can be found in **Data Sheet 2**, as well as the context of each study, the database where it was found, and its original language.

The Context Outside Brazil

The relationship between ecological and socioeconomic aspects is evidenced by the connection of spatial planning to fishing.

Research on MPAs involves aspects of networks, planning, design, and stakeholders. Spatial management in general, not necessarily linked to protected areas, relates to issues of scale, tools, and approaches, and, as expected, to MSP. Species and habitats are related to distribution and range, probably due to the importance of their distribution for MSP and zone in general, with a focus on coral reefs. The term “conservation” is usually linked to biodiversity.

Some studies focus on spatial prioritization. One study introduces a framework for spatial prioritization as an alternative to conservation planning tools (Teh et al., 2013). This study specifically mentions zoning strategies, such as the implementation of no-take zones (Mangubhai et al., 2015; Martín et al., 2015). Other studies rely on prioritization software. One of them uses Marxan to build a new zoning plan for



the current MPAs in the Canary Islands and highlights the need for a rezoning of these areas (Martín et al., 2015). Marzan is an algorithm designed to help decision-makers find solutions to conservation planning problems (Ball et al., 2009). Marzan also assisted the distribution of biodiversity, for example, defining zones of fish conservation as an important tool for spatial planning success of MPAs (Haupt et al., 2017). Another study uses Marzone with socioeconomic criteria and concludes that the final zoning plans recognize community use and governance of resources, maximize equity and access to traditional fishing grounds, and better support long-term food security and livelihoods of local communities (Mangubhai et al.,

2015). Marzone is a prioritization tool in the Marzan family. It allows for geographic areas to be assigned to specific zones, each with its own set of actions, objectives and constraints (Ball et al., 2009). Besides algorithms such as Marzan and Marzone, spatial modeling can also be used as a planning tool (Pillans et al., 2014).

Spatial modeling of seabirds also serves to represent areas of intensive use and is applied to identify solutions for MSP and spatial management of MPAs (Perrow et al., 2015). Conservation of pelagic biodiversity, for example, needs innovative methods to reach conservation targets related to marine planning, such as modeling of data in a temporal context (Grantham et al., 2011). Such modeling should integrate supporting processing

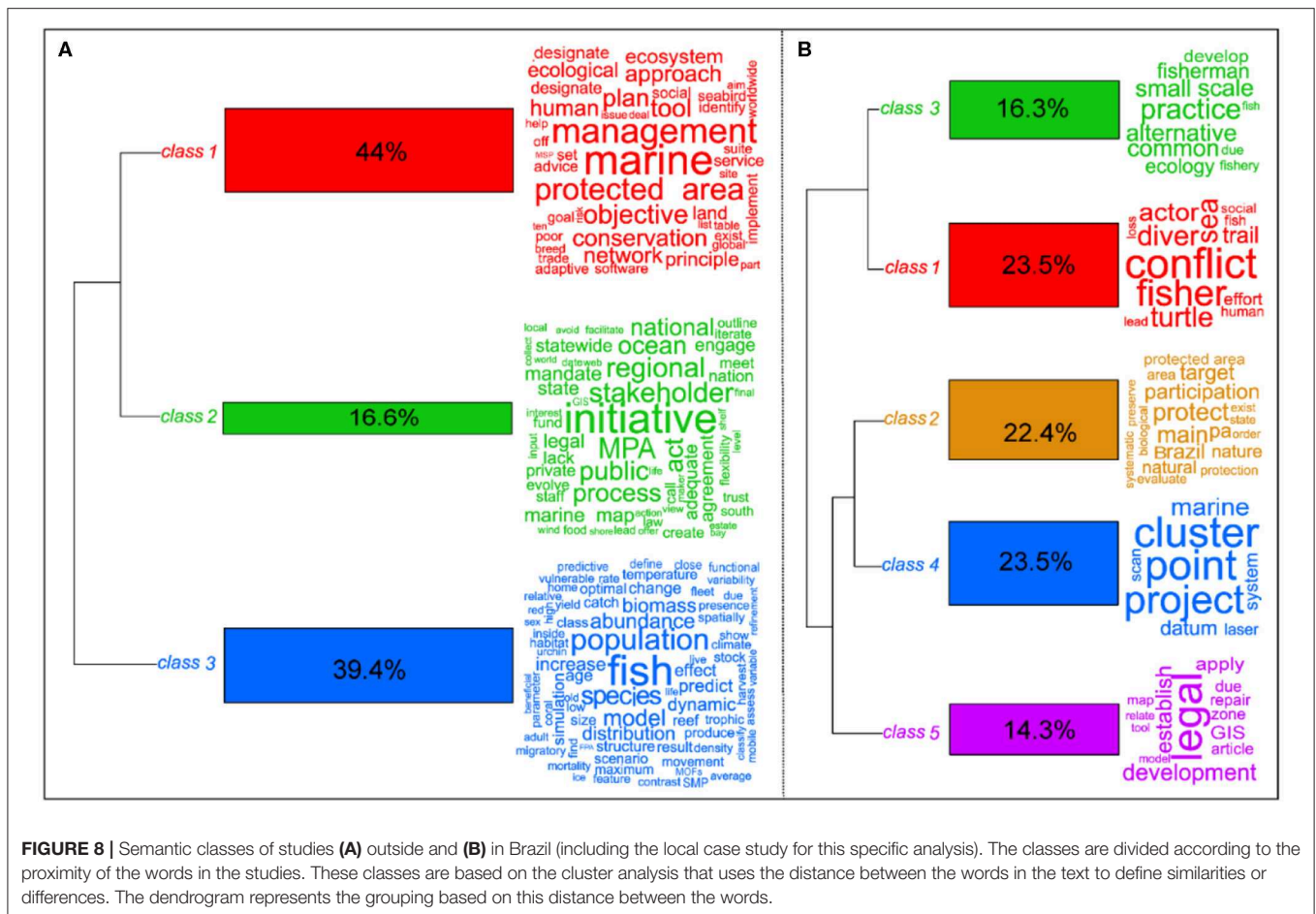


FIGURE 8 | Semantic classes of studies **(A)** outside and **(B)** in Brazil (including the local case study for this specific analysis). The classes are divided according to the proximity of the words in the studies. These classes are based on the cluster analysis that uses the distance between the words in the text to define similarities or differences. The dendrogram represents the grouping based on this distance between the words.

such as links to nearby systems and their elements (Guidetti et al., 2013). The spatial-temporal modeling of corals showed the areas with the highest conservation priority to be included in MPA planning (Makino et al., 2014). Spatial planning is also a topic in studies on historical modeling with climatic projections in space-time scenarios to identifying the changes and disturbances of an MPA (Levy and Ban, 2013). The changes and vulnerability of the exclusive economic zone through spatial analysis are also important to the decision making in risk management (Katsanevakis et al., 2011). Therefore, MPA management includes modeling studies that identify the resilience of ecosystems to climate change by identifying the priority and exclusion zones for spatial planning in the future (Davies et al., 2016). Connectivity strategies for seabird conservation indicate that MPAs are valuable tools for conservation and that spatial protection should be included in the complexity of such systems (Yorio, 2009).

As the results show that research on MPAs outside Brazil emphasizes aspects of MPA stakeholder participation and design. The coastal and marine zone planning process should apply diversified initiative strategies such as stakeholder inclusion to achieve MPA management objectives (Fox et al., 2013) and spatial modeling which includes expert opinion successfully allows the identification of areas for conservation (Wedding et al., 2013).

To do this, it is necessary to include the contributions of the stakeholders in the MPAs by analyzing the conflicts among the different sectors and their interests (Lieberknecht and Jones, 2016). For example, a study addresses the evaluation of stakeholder policies and stakeholder views and concerns to verify the MPAs management effectiveness and establish MPA networks (Lu et al., 2014). In another study, a conflict analysis was carried out and the spatial modeling in the MPAs helped the implementation of MPAs (Pecceu et al., 2016). The effectiveness of protected areas can be boosted by a creating a network which has population representation as a design principle (Ban et al., 2014).

Some studies specifically focus on zoning. On the one hand, MPA zoning requires integrating socio-economic and cultural factors to obtain support from communities during implementation. On the other hand, spatial prediction models include zoning studies of biodiversity distribution to represent areas of high conservation need (Schmiing et al., 2014) and to identify areas of conservation priority for interconnected land-sea planning (Klein et al., 2012). In addition, multi-criteria spatial analysis is used to define areas and minimum and maximum sustainability through the socioeconomic evaluation of activities such as fish farming in the MPA (Dapueto et al., 2015). Bio-economic models are used to verify the spatial management

TABLE 4 | Percentage of documents that contain each groups of search terms, according to the lexical analysis for the three spatial contexts, for the top 5 search terms regarding the number of hits (appearances) for each group of search terms, considering all contexts together.

Group rank	Search terms	# of hits	International context	National context	Local context
1	"fishery" "fisheries" "fishing" "pesca" "pesqueir" "pescaria"	13,369	7,382	5,877	110
2	"protected area" "área* protegida*" "unidade* de conserva*"	3,408	2,123	1,232	53
3	"zon"	2,908	2,072	817	19
4	"rede de unidades" "rede de áreas" network" "redes de unidades" "redes de áreas"	1,964	1,924	37	3
5	"biodiversity" "biodiversidade"	1,856	2,072	817	22

The search term groups include words in English and their counterparts in Portuguese.

TABLE 5 | Percentage of documents that contain each group of search terms, according to the lexical analysis for the three spatial contexts for the bottom 5 search terms regarding the number of hits (appearances) for the each group of search terms, considering all contexts together.

Group rank	Search terms	# of hits	International context	National context	Local context
46	"blue growth" "blue economy" "economia azul" "crescimento azul"	55	55	0	0
47	"human dimension" "dimensões humanas" "dimensão humana"	45	41	4	0
48	"limited-take" "partial-take" "uso parcial" "uso limitado" "uso restrito"	25	23	1	1
49	"social-ecological system" "sistema* sócio-ecológico"	14	11	3	0
50	"social* network analysis" "análise* sócio-ecológica*" "análise* sócioecológica"	1	0	1	0

The search term groups include words in English and their equivalents in Portuguese.

according to the distribution of the fishing (Rassweiler et al., 2012). Thus, spatial modeling is employed to indicate zones of exposure to natural phenomena and the zones of greatest impact in the MPAs, in order to increase the resilience and adaptation of these protected areas (Maynard et al., 2016). Finally, the identification of zones, for example, recreation and tourism, can influence the fulfillment of conservation objectives of the MPA and guide the decision-making process (Rees et al., 2010).

A small number of studies have a transnational approach to the MSP discussion and draw relevant conclusions about MSP processes (Kemp et al., 2012; Jones et al., 2016). For example, objectives of spatial management are often very general and poorly defined (Kemp et al., 2012) and MSP is often focused on achieving specific sectorial objectives (Jones et al., 2016). In framing management objectives, many agencies have considered a relatively low spatial level, associated with individual MPAs and adjacent areas (Kemp et al., 2012). MSP processes tend to be complex, fragmented and emergent on an *ad hoc* basis, rather than cyclical, adaptive, and prescribed on an *a priori* basis (Jones et al., 2016). Assessment should, however, begin at the time of initial planning for the spatial management (Kemp et al., 2012).

The Brazilian Context

The similarity analyses show that, in Brazil, "social" and "participation" are closely related to "conservation" and "biodiversity." This is not found in studies outside Brazil. Two studies approach the topic of stakeholder participation (Prestrelo and Vianna, 2016; Ribeiro, 2017), including possible conflicts that emerge in the context of a protected area (Martins, 2012; de Andrade and Soares, 2017). This highlights the importance attributed to local knowledge for the management plan of protected areas. MPAs in Brazil strongly relate to conservation and biodiversity. It also shows that research in Brazil gives some

degree of emphasis to sustainable use of resources. The theme "participation" is a frequent one probably because of a political atmosphere that was favorable to, and reflected demands for, an increased social participation of myriad political actors in coastal governance and management during the progressive governments in Brazil from 2003 to 2015 (Glaser et al., in press).

Fisheries emerge as a research topic for both Brazil and other countries, possibly due to an increasing concern to include fisheries in spatial planning processes. Social and territorial changes related to a protected area are also considered in one of the Brazilian studies analyzed (Martins, 2012). To develop a feasible MSP process, use and user conflicts need to be carefully identified, considering all the relevant legislation and the fact that the participation of fishers is crucial for its maintenance and improvement (Prestrelo and Vianna, 2016; Glaser et al., in press).

A couple of studies make concrete recommendations for the zoning of protected areas (Pereira, 2016; Ribeiro, 2017), including proposing zoning strategies according to environmental susceptibility (Araujo, 2008). Compliance with regulations of existing zoning plans (Prestrelo and Vianna, 2016), as well as with general regulations of an MPA (de Andrade and Soares, 2017), are also analyzed. Perceptions of users regarding the implementation and compliance of MPA zoning is reported in a peer-reviewed study that was published immediately after our search in the databases (Glaser et al., 2018). The perceptions on the zoning scheme in this MPA highlight issues of inequity in terms of user access to certain zones that could be caused by spatial management. This study points to a possible rezoning of the MPA that could consider the perceptions gathered and corrected issues identified.

Various other topics are addressed in the studies analyzed, including the mapping of abiotic factors to provide subsidies for zoning (Pereira, 2016), and the proposal of a new approach to

including climate change into the planning of protected areas through a gap analysis of marine protected areas (Magris et al., 2015). One study assesses issues in protected area management (Gerhardinger et al., 2011), while other studies include fisheries management (Costa et al., 2016; Prestrelo and Vianna, 2016) and fish biology (Costa et al., 2016).

Local Case Study

The local case study approaches the topics of socio-cultural sustainability and tourism in the Caeté-Taperaçu marine extractive reserve (Freitas, 2013). This study was the only one found in the searched databases. This study addresses the application of tourism on Ajuruteua beach, which is in the buffer zone of the Caeté-Taperaçu marine extractive reserve (Abdala et al., 2012). The management plan is a tool of great importance for the inclusion of tourism in this protected area, comprising the support of other stakeholders starting from the formulation of policies to guarantee the participation of the communities (Freitas, 2013). The study also highlights that the study area, a marine extractive reserve, has an important sociocultural dimension. This is expected since management programs in marine extractive reserves are directed at resource sustainability, environmental protection, knowledge, participatory management, and operation of the reserve (Abdala et al., 2012).

In contrast to the national and global contexts, the case study paper does not mention the connection between fishing and spatial planning. It rather emphasizes sustainable use and communities and focuses on the relationship between tourism and the local communities.

Spatial Planning and Management: Comparing the Different Contexts

In Brazil, only two studies recommend zoning in protected areas. While MSP in Brazil is still incipient, we suspect that there are many non-peer-reviewed studies on this topic that are not published in peer-reviewed journals. Such studies in the gray literature were not captured in this study, but will be further analyzed in an upcoming paper. This makes the spatial planning experiences in Brazil less visible to academia and is probably what caused the low number of publications for our local study case. Studies outside and in Brazil deal with “use,” but have a greater focus on “conservation,” and especially abroad, on “species” and “ecosystems.” There are few reviews or comparative studies (26 and 8% of the studies outside and in Brazil, respectively). Such studies would help to draw parallels between the different settings where spatial planning is being evaluated or taking place. This work could be undertaken by one or several collaborative network(s) of researchers and practitioners.

In mangrove ecosystems, for instance, studies on MSP are still incipient, although zoning studies on MPAs, in general, are growing around the world (Rêgo et al., 2016). Brazil is somewhat ahead of the international field: 34 and 50% of the analyzed studies have a focus on spatial management, outside and in Brazil, respectively. Among the studies that deal with the topic of zoning inside a given protected area 23% are outside and in Brazil 31% inside Brazil.

We found only one study for our local MPA related to MSP and management, although the Amazonian coastal area is considered the most protected mangrove region on the planet (Hayashi et al., 2019). This is unexpected, given the high number of studies in the region of this MPA and the fact that it is one of the few MPAs that has a zoning plan. For example, one study is related to the co-management and institutional resilience to assess the adaptations of social-political changes in a MPA (Partelow et al., 2018). Our findings underline that zoning in Brazil is still in its early stages, especially in the blue economy-related marine zoning (Gerhardinger et al., 2019).

Limitations

The absence and presence of publications on spatial planning were affected by the language of search. That is, the Portuguese language was a key factor in the search for studies in Brazil, while English influenced the search for studies both in and outside Brazil. The English language could have overrepresented the number of studies and made others invisible (Mongeon and Paul-Hus, 2016). Although the growth of publications in Brazil has been evident since 2002, Brazilian publications still have little presence abroad due to the language barrier (Barata et al., 2018). Authors in research areas such as the social sciences and humanities publish mainly in Portuguese, although in some areas it is disregarded as a language of knowledge dissemination (Solovova et al., 2018). Similarly, the keywords could have directed the search to find studies on spatial management and protected areas in the contexts studied, but not studies related to planning effectiveness.

CONCLUSIONS

There are few reviews or comparative studies, especially regarding zoning within protected areas, which can help to draw parallels between the different local, national and international settings where spatial planning is being evaluated or taking place. Areas of research on spatial planning are highlighted. When related to MPA research, a strong influence of fisheries is detected. This study used three spatial contexts to assess the status of MSP worldwide and relate it to Brazil. The novelty about this study is the comparison with the reality in Brazil, where “conservation is not on the forefront of spatial planning alone, but rather accompanied by related social aspects, such as “participation” and “user perceptions.”

The methods applied in this study can be replicated elsewhere in order to verify the state of MSP in different countries and they are not necessarily restricted to the coastal and marine realm. The integration of the analyses shown here is an innovative way to present data in a systematic review and can be used to compare and contrast a given issue for different spatial and institutional levels and contexts. This gap could be addressed through a collaborative network of researchers and practitioners.

DATA AVAILABILITY STATEMENT

No datasets were generated or analyzed for this study.

AUTHOR CONTRIBUTIONS

RB conceptualized the research, searched and compiled the studies analyzed, performed the MAXQDA analyses, and wrote the manuscript. IE searched and compiled the studies analyzed, performed the Iramuteq analyses, and wrote the manuscript. RSLB helped design the study, restructure the analyses and presentation of results, and discuss the results. MG helped restructure the manuscript and discuss the results. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2020.00499/full#supplementary-material>

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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