Scientific research in Neotropical protected areas: themes and gaps

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Protected areas are often used by scientists to observe natural processes and organisms in habitats that have been minimally influenced by human actions. In contrast to many PA objectives, their effectiveness for promoting and supporting scientific research can be easily quantified in terms of quantity and quality of scientific products (primarily peer-reviewed articles) that are based on research within a PA's boundaries. In addition to their contribution to global scientific knowledge, these research products may support local conservation efforts and contribute to park management, monitoring and governance. Here, we investigate the effectiveness of Neotropical PAs at supporting scientific research based on data from the World Database of Protected Areas (WDPA). Specifically, we randomly selected 102 PAs from each designation from the Latin American and Caribbean region, to give a total of 612 PAs. A total of 444 PAS did not return any results and only 30 were associated with more than 10 publications. Research topics varied widely in the PAs in our dedicated sample, but we found an evident trend to research related to geosciences and paleontology. Conservation and biodiversity were secondary subjects. there seems to be a lack of influence of PAs type and presence of management plan on scientific productivity. On the other hand, we have seen that most areas do not present a management plan, the absence of which makes it more difficult to assess the effectiveness of these areas.

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Abstract

Protected areas are often used by scientists to observe natural processes and organisms in habitats that have been minimally influenced by human actions. In contrast to many PA objectives, their effectiveness for promoting and supporting scientific research can be easily quantified in terms of quantity and quality of scientific products (primarily peer-reviewed articles) that are based on research within a PA's boundaries. In addition to their contribution to global scientific knowledge, these research products may support local conservation efforts and contribute to park management, monitoring and governance. Here, we investigate the effectiveness of Neotropical PAs at supporting scientific research based on data from the World Database of Protected Areas (WDPA). Specifically, we randomly selected 102 PAs from each designation from the Latin American and Caribbean region, to give a total of 612 PAs. A total of 444 PAS did not return any results and only 30 were associated with more than 10 publications. Research topics varied widely in the PAs in our dedicated sample, but we found an evident trend to research related to geosciences and paleontology. Conservation and biodiversity were secondary subjects. there seems to be a lack of influence of PAs type and presence of management plan on scientific productivity. On the other hand, we have seen that most areas do not present a management plan, the absence of which makes it more difficult to assess the effectiveness of these areas.

Keywords: bibliometrics; protected areas; biodiversity; scientific production

Introduction

Protected areas (PAs) currently cover approximately 14% of the world's land masses (Deguignet M. et al., 2014). Their main aim is to conserve nature over time, protecting ecosystems and cultural values (Leverington et al., 2010). In addition to conserving biodiversity, many PAs also aim to promote social and economic benefits, such as tourism (Worboys et al., 2015), and are responsible for attracting nearly 8 billion visitors per year (Balmford et al., 2015). The World Tourism Organization estimates that tourism in protected areas will continue to grow at 3.3% per year until 2030 (Day et al., 2012).

Despite the clear advantages PAs deliver, biodiversity conservation remains a challenge (Brooks et al., 2006; Groombridge and Jenkins, 2002) due to continuing habitat destruction, introduction of exotic species, natural resources for overexploitation, pollution and climate change (Loreau et al., 2006). Conservation is particularly problematic in tropical regions, where both biodiversity and extinction rates are higher (Pimm et al., 2014). In these areas, weak governance and short-term interests prevail, management resources are limited and basic scientific information is often deficient or inexistent (Lele et al., 2010; Oliveira Júnior et al., 2016).

The neotropical region extends from the south of the Mexican desert to the borders of the sub-Antarctic zone in South America (*sensu* (Udvardy and Udvardy, 1975). The biodiversity in this region is remarkable, widely distributed and also highly threatened (Jenkins et al., 2013; Léveque et al., 2008). While conservation policies have been widely enacted throughout the region (Barletta et al., 2010; Ceballos et al., 2009; Pelicice et al., 2017), good governance is rare (Borrini-Feyerabend and Hill, 2015; Lockwood, 2010; Torquebiau and Taylor, 2009), prompting demands for wide-scale reform and innovation (Bennett, 2016; Fletcher et al., 2014; Torquebiau and Taylor, 2009). Although this is a global issue (Bennett and Dearden, 2014; Leverington et al., 2010; McCay and Jones, 2011), it is particularly critical in the biodiverse countries of the Neotropics (Gerhardinger et al., 2011; Oliveira Júnior et al., 2016; Ribeiro et al., 2009).

Scientific knowledge related to PAs can be used to support policy, attract funding, and strengthen management and monitoring. However, despite scientific research being an unambiguous objective of several designations, there have been surprisingly few studies quantifying scientific production in PAs and identifying the underlying drivers. In a rare exception, a recent study of PAs in the Amazon region demonstrated that a high proportion of

PAs have no scientific articles based on research within their borders and that, where present, research volume was most strongly associated with a long history of scientific study (Correia et al., 2016).

Here, we aim to provide an overview of the scientific value of neotropical PAs. Specifically, we conduct a bibliometric analysis to answer three questions about neotropical PAs: (1) What are the most researched topics? (2) Do IUCN category and presence of management plan influence scientific production? (3) Are threatened species studied more often than non-threatened species? The final question is designed to assess whether research is specifically meeting conservation needs.

Material and methods

Data on protected areas was obtained from the World Database on Protected Areas (WDPA - www.protectedplanet.net/) organized by United Nations Environmental Program (UNEP) and International Union for Conservation of Nature (IUCN). We downloaded all information available by country for Latin America and Caribbean regions. We retrieved information on PA name, country, IUCN category, management plan, reported area, and status. We then filtered for PAs that had a designated IUCN category. Areas were separated by IUCN category (Ia and Ib were collated due to their similar objectives and low number matches), and 102 PAs in each category (20% of the total) were randomly selected for more detailed analysis (612 PAs in total).

Scientific production in these 612 PAs was estimated through documents returned from Web of Science (WoS) database, from the oldest register up to 2017. Documents were identified using the following search strings: "Name of PA" AND (conserv* OR protect* OR reserv*) AND “name of country”. Books and symposium material were excluded.

Co-word analysis assessed keywords frequency and co-occurrence using software VOSviewer to evaluate the most discussed topics and their relationships. VOSviewer clusters keywords in groups according to the frequency they occur together. For better visualization, only words mentioned more than ten times were used. From keywords and titles, we obtained names of species studied and linked these to information on threat status from the IUCN Red List of

Threatened Species (IUCN, 2017). We also retrieved the number of species registered in the countries researched and their status in the same source.

Finally, a one-way analysis of covariance (ANCOVA) was performed to test the influence of IUCN categories and presence of a management plan on scientific production.

Results

We found 5,529 protected areas registered by IUCN system within the 39 countries that have all their territory inside the neotropical region, including marine areas. Of these, 4,420 (approximately 80%) did not have a management plan registered or available, and 1,782 (about 32%) were not assigned to an IUCN category.

The 612 randomly sampled PAs had 2,967 scientific articles associated with them. However, 444 (72.5%) of these PAs did not return any results and only 30 PAs were associated with more than 10 documents. Most papers have been published in the last 7 years, from 2011 to 2017.

Despite the increase in scientific production, changes in the 10 predominant research areas were discrete. Geosciences, ecology, environmental sciences and paleontology, respectively, have kept the first positions since the 80s. The other seven alternated slightly through years but were always among the most published subjects. The exception is Public, Environmental & Occupational Health, which was one of the few topics retrieved from the 80s (Figure 1).

Our sample incorporated PAs in 29 countries. The greater numerical representation of some nations had no influence over the final quantity of articles in each, as seen in Figure 2. For instance, Brazil detained more PAs sampled, but Argentina held the higher number of published articles. Patagonia (Argentina) detained almost 51% of the scientific production captured by our sample, followed by Martinique (Domenican Republic – 5%), Windsor (Jamaica – 4%), and Correa (Cuba – 3.5%).

Our keyword co-occurence analysis indicates that research performed inside PAs varies broadly, but reveals some trends (Figure 3). Words used more frequently are related to the locations studied (e.g., Patagonia, Argentina, and South America). Other commonly mentioned

words are linked to taxonomic groups, conservation, and geological eras. Research performed in Patagonian regions is frequently related to geological time and taxonomic terms, suggesting prevalence of studies related to paleontology. On the other hand, the cluster containing the term "conservation" has more connection with biodiversity and ecology.

We identified 258 species among the article titles and keywords, predominantly animals distributed across 24 taxonomic classes. Mammalia, Aves, and Insecta were the most studied animal groups while plants were represented by 18 classes, mostly Magnoliopsida (Figure 4).

According to IUCN Red List (2017), there are 6,668 terrestrial species that are classified as vulnerable, endangered or critically endangered, with Ecuador (2,387), Brazil (998), Colombia (853), and Peru (700) having the most endangered species in the Neotropics. However, within the PA articles, 25% of species were classified as "least concern" and 56% had not been assessed by IUCN, while 1 to 5% of species received other classifications (Figure 5).

Our ANOVA suggested no influence of IUCN category or presence of MP on scientific production ($p>0.05$).

Discussion

One of our main findings is that a very low number of PAs in the Neotropics have scientific production related to them, and even those that do are unlikely to be associated with 10 or more published articles. Considering the importance of tropical and subtropical diversity for conservation, at the least this indicates that the research value of the majority of PAs is not being effectively explored. However, it is important to underline that our metric of research production does not capture all forms of research, and that many PAs may generate other types of research products within the grey literature, such as post-graduate theses and ONG/government technical reports. Although it might be possible to find more data about these sites in technical reports, for example, this kind of publication often lacks detailed methodological information that is essential for researchers. Furthermore, some peer-reviewed literature may not have been captured by our search strings because not all articles will mention the name of the protected area in the abstract, title or keywords. Nevertheless, our data should represent an unbiased sample of

internationally visible scientific material for each PA in our database, which is crucial for exchange of information inside the global scientific community.

Research topics varied widely in the PAs in our dedicated sample. Possible reasons for such assortment is the diversity of environmental conditions in Neotropical region, which ranges from world's most arid desert (Atacama, in Chile and Peru) to the largest rainforest (Amazon, in Brazil and other nine surrounding countries) (Morrone, 2014). Therefore, highly diverse fauna and flora also means high diverse demand for information. Still, both research areas quantification and keyword analysis indicate the strength of geosciences and paleontology, possibly due to the big weight of Patagonia in our sample. Ignoring this influence, the secondary cluster reveals focus on conservation related research, which use terms such as "biodiversity", "endangered species", and "climate change".

The absence of terms as "assessment", "evaluation" or "management" in the analysis is noteworthy if we acknowledge the importance of constant evaluation of PAs as well as for ensuring that conservations goals are being reached (Pomeroy et al., 2005). On the other hand, concern for local biodiversity is reinforced by the efforts presented to research species that have not been not assessed by IUCN. As aforementioned, this region holds high diversity (Condon et al., 2008; Costa et al., 2000; Mullen et al., 2011), consequently, a wide range of taxonomic groups were mentioned in the sampled peer reviewed publications. The dominant presence of Mammalia as the most studied group inside PAs is likely to be an effect of popularity and commodity. This group is a common subject of study due to abundance, geographical range, attractiveness and charisma (Brooke et al., 2014). All this attention is also important to help increasing popular awareness, and even to raise funds for conservation (Lunney and Moon, 2012).

Finally, there seems to be a lack of influence of PAs type and presence of management plan on scientific productivity. PAs in categories Ia, Ib, and II are often reference for scientific research and monitoring (Deguignet M. et al., 2014), so they are more likely to be associated to NGOs, universities or other research institutions (Götmark et al., 2015) and, consequently, more research production associated to them. However, the low fit of our model suggests that these two variables alone are weak predictors as research drivers.

Conclusion

Our study identifies a trend to little quantity of peer-reviewed material available to most of Neotropical region PAs. Also, despite the clear concern of local research for conservation, the existence of management plans was alarmingly low, with the majority of PAs having no accessible plan. We urge to have global efforts to preserve ecosystems and biodiversity, but it requires accessible data, as well as full implementation protected areas and their management plans. Interesting area for future research would be testing drivers for research inside PAs and whether this association promotes or improves conservation.

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321

Figure 1

Quantity of articles published about the most frequent research areas between 1984 and 2017.

Each line and marker represents one of the most researched areas.

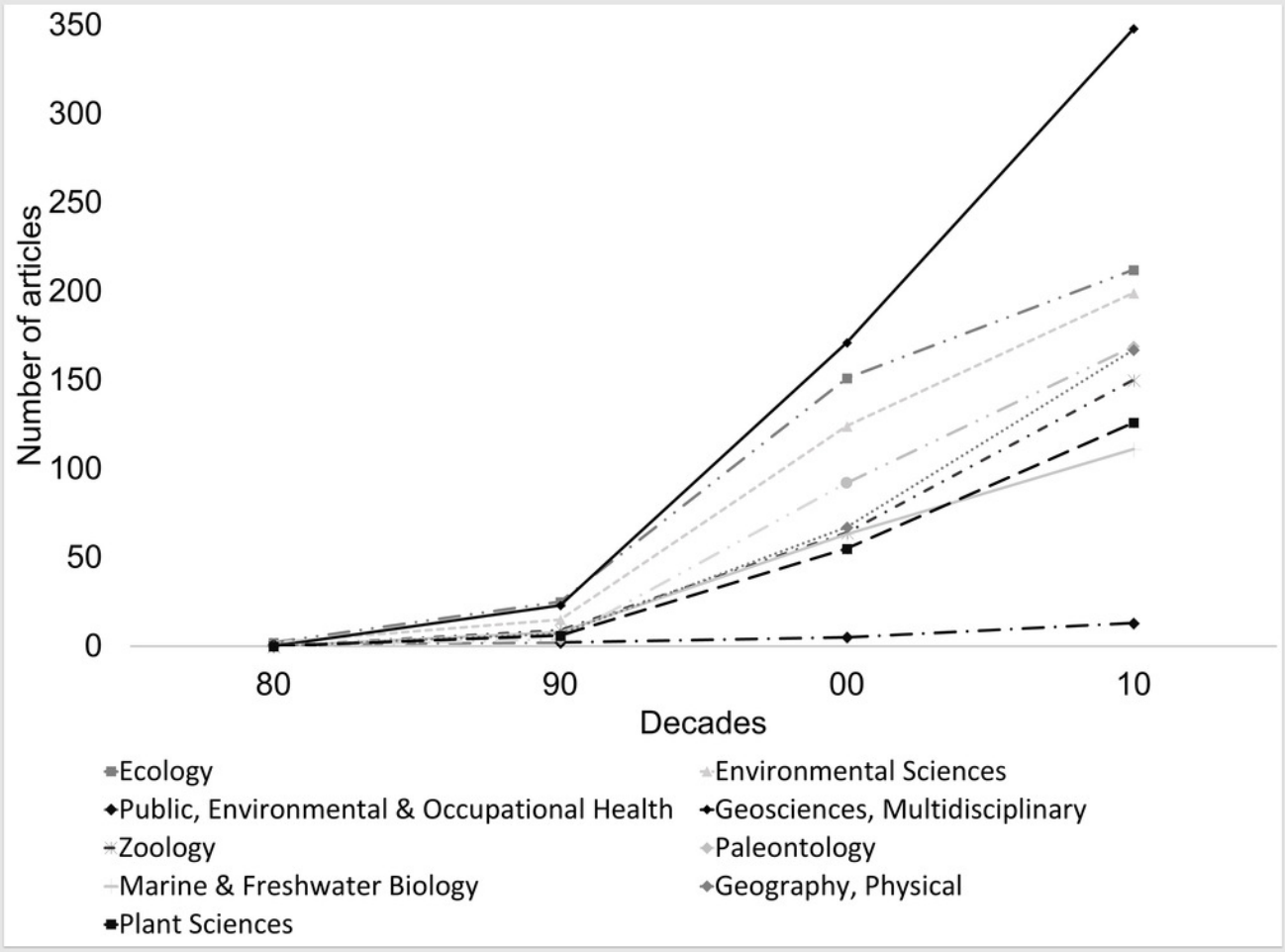

Figure 2

Relationship between the percentage of PAs sampled in each country and percentage of articles each country had in relation to the total.

Bars represent the countries, the line represents the articles.

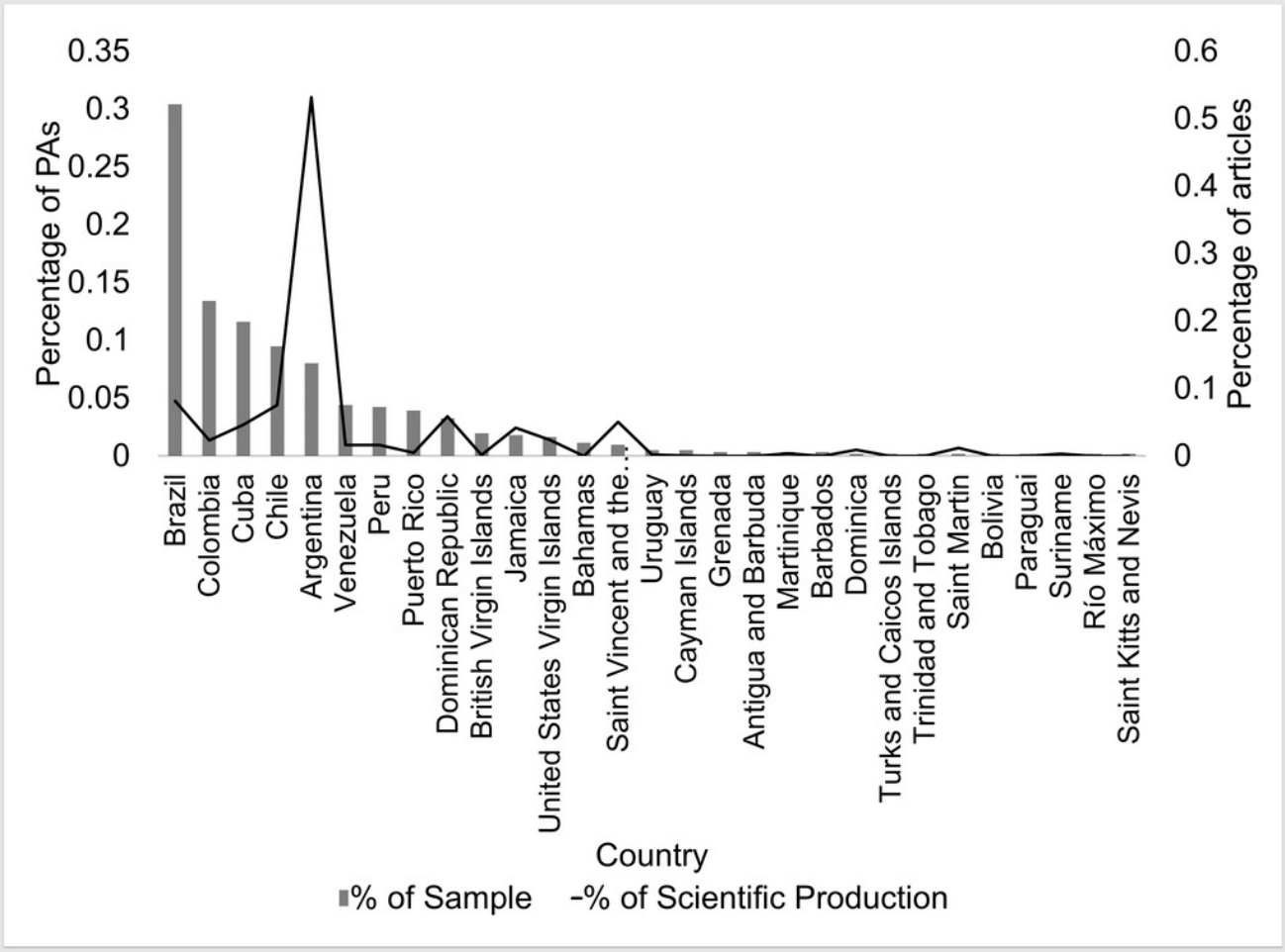

Figure 3

Keyword network analysis of articles related to the protected areas sample.

The size of nodes reflects the number of papers that used that keyword, whereas density and proximity of connecting lines indicates number of co-occurrences.

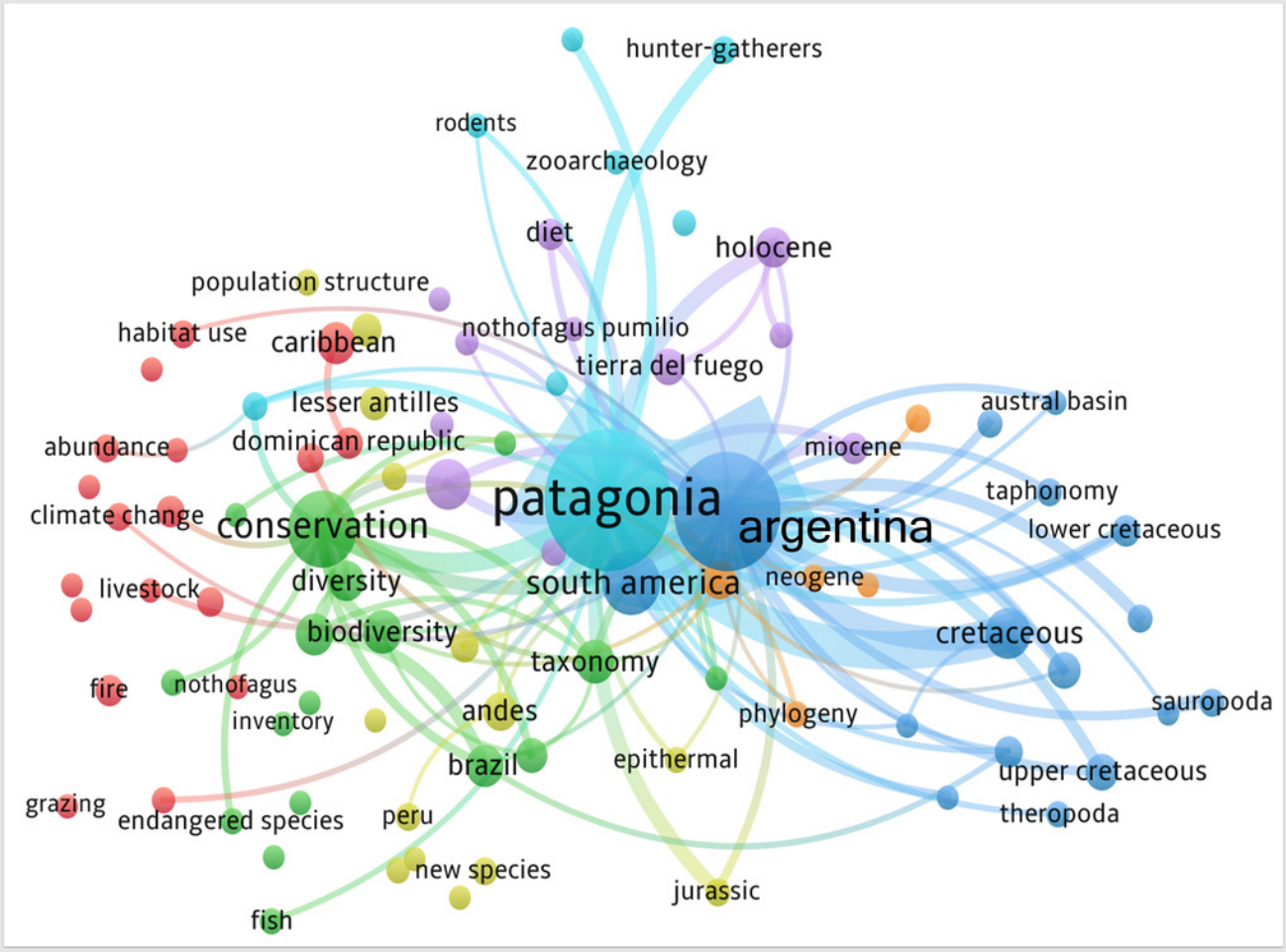

Figure 4

Quantity of articles that mentioned at least one of the five more mentioned taxonomic classes for kingdoms Plantae and Animalia.

Grey bars preserent classes of kingdom Plantae, black bars for Animalia.

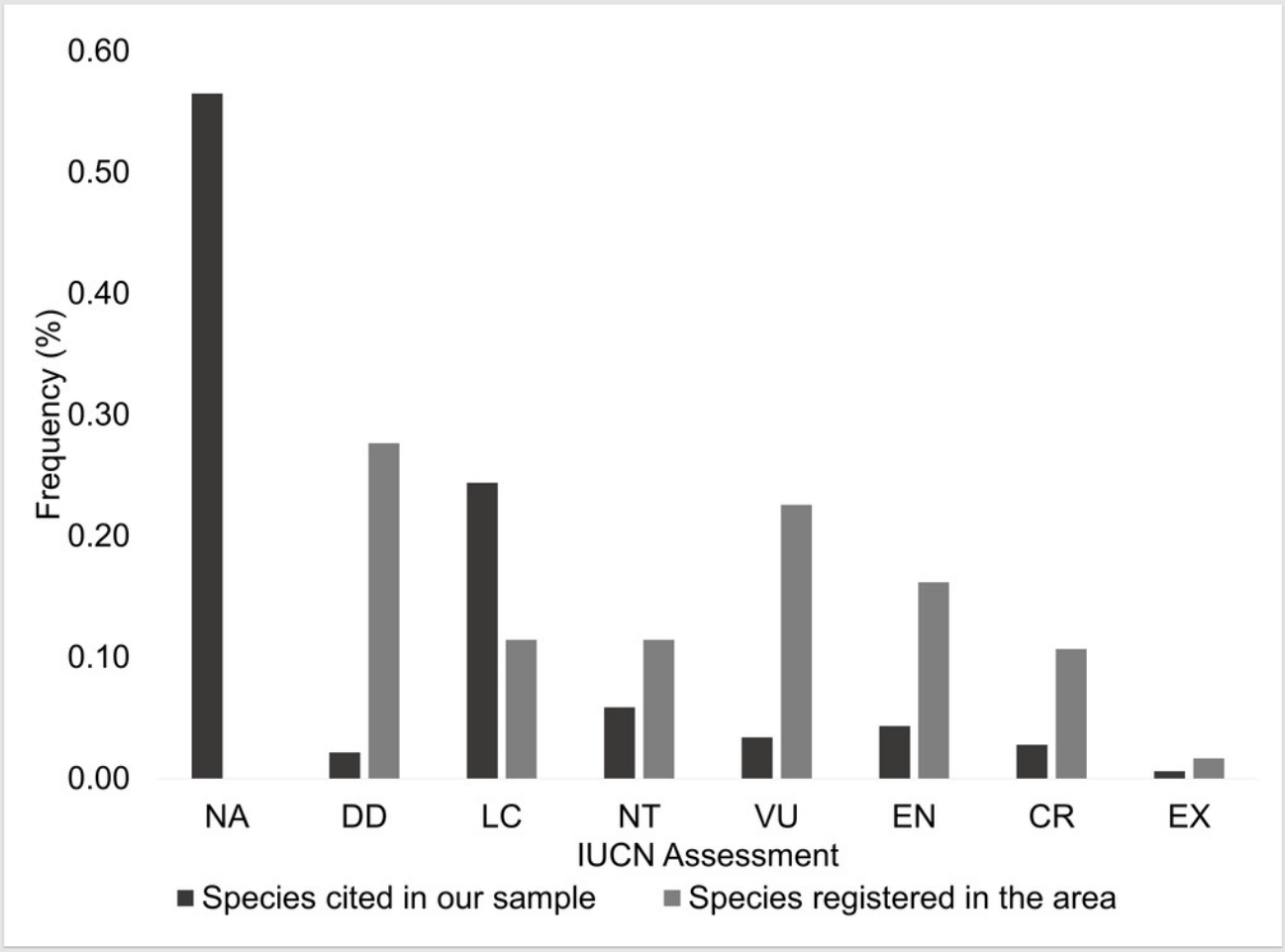

Figure 5

Percentage representation of status of all species registered in IUCN Red List present in Neotropical region and species mentioned in the sampled articles.

NA = Not Assessed, DD = Data Deficient, LC = Least Concern, NT = Nearly Threatened, VU = Vulnerable