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Identifying opportunities for improving the coherence of global agreements for species conservation

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Abstract

The current global biodiversity governance system is failing to adequately protect species and halt extinctions. This raises concerns that a lack of coherence among conventions has hindered their effective implementation. We assessed the possibility for improved convention coherence by identifying overlaps among four major international biodiversity conventions; Conservation of Wetlands of International Importance especially as a Waterfowl Habitat (Ramsar), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), and Convention on Biological Diversity (CBD). We applied topic modeling to convention texts to identify overlaps in treaty implementation and purpose. We assessed overlap among species listed under CITES and CMS, and threatened species, which are targeted by CBD's Aichi Target 12. We found that convention texts shared similar articles on their implementation, but differed in articles relating to their purpose. We identified 137 threatened species that are also migratory and threatened by unsustainable international trade. The geographic distribution of species common to two or more conventions showed a concentration in parts of Asia. Our analysis suggests that implementation mechanisms are already well aligned to support increased cooperation across conventions, and that cooperation would provide complementarity rather than result in redundancies. We demonstrate that it is possible to identify where co-operation could have a disproportionately positive impact on alleviating the complex of pressures affecting species.

KEYWORDS
Aichi biodiversity targets, international conservation policy, IUCN red list, multilateral environmental agreements, species conservation, Target 12, threatened species, topic modeling

1 | INTRODUCTION

Since the 1960s, global biodiversity has faced extensive losses due to anthropogenic drivers (Baakman, 2011). The current extinction rate is up to 1,000 times greater than the background rate (Pimm et al., 2014) and almost one-fifth of extant vertebrate species are threatened with extinction (Hoffmann et al., 2010) suggesting that a million species may be at risk of disappearing (IPBES, 2019). The global political response to increasing human pressures has included the formation of multilateral environmental agreements (MEAs) that cover a diversity of environmental issues (Hensz & Soberón, 2018). While it seems likely that the conservation status of species would have been worse without these MEAs, the failure to halt biodiversity loss is considered due partially to limitations with implementation of the conventions (Rogalla von Bieberstein et al., 2018). At an international level, convention obligations may be too numerous to be effective and often overlap. Such "treaty congestion" arises from poor cooperation and fragmentation between MEAs (Rogalla von Bieberstein et al., 2018) and leads to the creation of obligations that can conflict, compete with, or duplicate other conventions (Caddell, 2013; Scott, 2011). Gomar, Stringer, and Paavola (2014) suggest that to address the current biodiversity crisis successfully, this lack of coherence must be resolved. It is increasingly important that the efficacy of these conventions is increased given the lack of progress toward global biodiversity targets (IPBES, 2019) and the emerging Post-2020 Global Biodiversity Framework (CBD Secretariat, 2020).

Greater synergy among conventions has the potential to improve efficacy, strengthen biodiversity governance, and improve conservation outcomes through shared goals, harmonized implementation mechanisms and better use of limited resources (Gomar, 2016). Over the last decade, work to promote synergies has considered the harmonization of national reporting and the role of IPBES in guiding decision-making at the science-policy interface (Herkenrath, 2012), as well as working together on a small number of thematic issues (UNEP-WCMC,- 2018). Despite the current global species conservation crisis and our developing understanding of the diversity of threats that species face (IPBES, 2019), such analyses have yet to consider opportunities for convention synergy from a species perspective. We therefore focus here on exploring the potential for convention synergy among four MEAs of particular relevance to species conservation. Almost every country is signatory (=Party) to at least one of these MEAs (Rogalla von Bieberstein et al., 2018), and many to all four. These MEAs are the Conservation of Wetlands of International Importance especially as a Waterfowl Habitat (Ramsar), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on the Conservation of Migratory Species of Wild Animals (CMS), and the Convention on Biological Diversity (CBD; Table S1). Together these MEAs could be considered to form a substantial part of the global governance system aiming to protect biodiversity. The first three conventions were established to address specific issues during the 1970s. The Convention on Biological Diversity entered into force in 1993 and was intended to provide a framework for the conservation and sustainable use of biodiversity and to ensure that benefits were shared equitably.

The four MEAs work together through the Biodiversity Liaison Group (CDB, 2004) and have established Memorandas of Understanding (Caddell, 2011). Following the adoption by Parties to the CBD in 2010 of the Strategic Plan for Biodiversity 2011–2020 (CBD, 2010), CMS, CITES and Ramsar explicitly considered Target 12 of the plan (aimed at halting extinctions and improving the conservation status of threatened species) when creating their own strategic plans, meaning some targets and objectives contribute toward Target 12 directly (Table S1). Indeed, previous work has suggested synergy among these conventions is feasible, as they have similar objectives and structure of their institutional bodies and therefore commonalities are likely to be identified (Gomar, 2016; Jóhannsdóttir, Cresswell, & Bridgewater, 2010; Scott, 2011). There are, however, concerns; for example, the scope of the CBD may be too large to adequately protect the species listed by other conventions (Gomar, 2016) and the bodies of Ramsar are administered outside the United Nations Environment (formerly the UN Environment Programme [UNEP] system; Caddell, 2011). The identification of overlaps among conventions may allow increased synergy through the creation of joint work programmes, enabling more successful protection of species (Scott, 2011). "Overlap" describes where the subject of treaties and their framework intersects each other, and without deliberate interaction (Scott, 2011).

Convention synergy could be informed by identifying the extent of overlap in convention purpose, implementation mechanisms, and species protected. Our aim was to assess the possibility for greater coherence among Ramsar, CITES, CBD and CMS. We used a topic modeling approach (Westgate, Barton, Pierson, & Lindenmayer, 2015) to quantitatively assess overlap and commonalities between the four MEA convention texts, as these texts specify the purpose and implementation mechanisms of each convention. We suggest that the greater the overlap in implementation mechanisms among conventions, the greater the potential for synergy. Similarly, commonality in convention purpose could indicate potential areas for shared work programs. Any differences in convention purpose are expected to indicate the particular niche that each convention occupies and provide an understanding of the extent of complementarity among conventions. We also identified specific opportunities for increased convention synergy by identifying overlap in focal species among conventions. Species that are of concern to multiple conventions face a suite of pressures, meaning that a co-operative approach is probably necessary to reduce these pressures effectively and conserve the species. In order to quantify overlaps in focal species among the four MEAs, we extracted and compared species Appendices, where possible, and compared the geographic distribution of species listed among conventions. Using these analyses, we considered whether synergies are possible between Ramsar, CITES, CBD, and CMS, to create an ambitious target for the protection of species post-2020.

2 | METHODS

2.1 | Analysis of convention texts

2.1.1 | Preparing convention texts

Ramsar, CITES, CBD, and CMS convention texts were downloaded from the respective convention websites (CBD, 1992; CITES, 1973; CMS, 1979; Ramsar, 1971). Each convention text was split sequentially into Articles, starting from the preamble or contracting Parties' statement as the first Article, and splitting the text by each subsequent heading. This yielded 107 Articles in total: 14 Ramsar, 26 CITES, 21 CMS, and 46 CBD. Article cleaning was carried out using the *bibliometrix* package (Aria & Cuccurullo, 2017) and *tm* package (Feinerer, Hornik, & Meyer, 2008) in the program R (R Core Team, 2019). Text was transformed to lower case and stopwords were removed (Feinerer et al., 2008; Table S2). Words that were common within the convention texts, but that provided little information, were also removed (-Table S3), as well as all punctuation and numbers (Feinerer et al., 2008). Hyphens and forward slashes were converted to spaces. Words were stemmed to reduce them to their common root. Words that appeared in three or fewer Articles were removed (Griffiths & Steyvers, 2004; Lu, Cai, Ajiferuke, & Wolfram, 2017). This produced a body of 491 words for analysis using topic modeling.

2.1.2 | Topic modeling of the convention texts

Topic modeling is a statistical tool that uses the frequency of co-occurrence of words within texts to identify the main ideas, or topics, in a body of literature (Griffiths & Steyvers, 2004; Westgate et al., 2015). Each topic consists of a set of words that co-occur with unusual frequency, therefore each topic represents a meaningful combination of ideas within the literature (Westgate et al., 2015). Topic modeling allows each Article in the body of literature to be assigned to the topic that best represents its contents. The approach enabled us to (a) identify the main topics within the convention texts, and (b) assign each Article of the convention texts to a topic, in order to objectively identify commonality and overlap in the content of convention texts.

The most appropriate number of topics to be identified for a specific body of literature can be determined a priori using block-cross validation (Grun & Hornik, 2011). We applied a 10-fold block-cross validation (Supporting Information) and found that 30 topics were optimal to cover the complexity of the convention texts (Figure S1). We then fitted a Latent Dirichlet Allocation model with Gibbs Sampling using the *topicmodels* package in R, (Grun & Hornik, 2011) to identify 30 topics within the convention texts.

Each topic was named based on the 20 highest weighted words in the topic. We identified the primary topic per convention Article, which was the topic with the highest weighting per Article. Article topics were used to determine the distribution of topics among conventions. Where topics were linked to multiple conventions, this demonstrated overlap in the topics of convention texts.

Topic modeling is often applied to the abstracts of scientific articles, which tend to be relatively short and of similar length (i.e., 150–300 words). In contrast, the Articles of convention texts can vary greatly in length. In order to quantify variation in Article length, we compared the number of unique words per Article among conventions. The organization of the content of Articles may also vary; one Article may contain multiple topics, or the same topic may be split among multiple Articles, and this may vary among conventions. To explore this, we inspected the relationship between the probability of the highest weighted topic per Article and the unique number of words per Article, across all conventions. The greater the probability of the highest weighted topic per Article, the more specific the Article is to that topic. If there are similar patterns in this relationship among conventions, then we can infer that the conventions organize the contents of their Articles in similar ways, and so variation in Article length likely would not introduce biases in the comparison of topics among conventions.

2.2 | Identifying concentrations in taxonomic and regional overlaps among conventions

Not all countries are party to each convention, which affects the areas over which species are protected under different conventions. We therefore obtained information on the Parties to CITES (CITES, 2019), CMS (CMS, 2019), and CBD (https://www.cbd.int/information/parties.shtml) and mapped the distribution of Parties to each convention.

In order to assess concentrations in taxonomic and regional overlap among conventions, the taxonomy and distribution (countries of occurrence) of animal species listed on CMS (Appendices I and II) and CITES (Appendices I, II, and III) were downloaded from Species + (UNEP-WCMC, 2019). Only listings at the species-level were included; this excludes sub-species but includes any species that are part of a genus (or higher) level listing. Only animal species were considered because animals are covered by both conventions (CMS by nature does not include plants). CMS not only lists species on Appendices, but also establishes Agreements and Memoranda of Understanding (MoU) for individual or groups of related species; the species list for CMS included both species listed on the Appendices and species covered by particular Agreements and MoUs.

Target 12 of the CBD refers to “known threatened species,” which are those categorized as Vulnerable, Endangered or Critically Endangered according to the IUCN Red List. We therefore downloaded data on the taxonomy and distribution (countries of occurrence) of all animal species in these three categories from the IUCN Red List website (IUCN, 2019).

There is currently no database listing species protected at Ramsar sites. Ramsar Information Sheets (RIS) compiled pre-2012 include “noteworthy fauna” and post-2012 list “animal species whose presence relates to the international importance of the site” (Gillespie, 2007; Ramsar, 2012, Resolution XI.4, see paragraph 5). This means that even if the names of species was extracted from the 2,386 Ramsar Information Sheets (Ramsar Sites Information Service, 2020), the list would be incomplete. Therefore, due to the lack of data, species protected at Ramsar sites were excluded from the analysis.

Species listings for both CMS and CITES may not apply to each species' entire geographic distribution. Information on whether only particular countries or geographic areas were covered by each convention was included as notes for each species in the data downloaded from Species+ (UNEP-WCMC, 2019). We therefore mapped the number of species per country on the CMS and CITES appendices firstly according to each species' complete geographic distribution, and secondly considering only the countries within which each species is protected under the respective convention.

The IUCN Red List does not include assessments for all species globally. We therefore mapped firstly the number of threatened species per country across all threatened animal species, and secondly the number of threatened animal species per country for only those taxonomic groups that have been comprehensively assessed (defined as >80% of known species within a taxonomic group having been assessed). The latter map aims to reduce the impact of geographic biases in assessment efforts and biases toward the assessment of more threatened species among incompletely assessed taxonomic groups.

In order to identify species in common among conventions, we matched species names among all three conventions and between each pair of conventions. In order to map the number of species in common among conventions per country, we used species' complete geographic distributions and included only comprehensively assessed taxonomic groups. Regions and countries with a large number of species in common among conventions were suggested as areas of conservation concern.

3 | RESULTS

3.1 | Analysis of convention texts

Thirty topics were identified in the convention texts (Table S4). There were four topics that had no Articles assigned to them, meaning they were not the highest weighted topic of any Article (Table S5). These topics generally focused on language and wording of the texts, rather than the themes within them.

There were four topics common to all conventions (Figure 1); these were *Acceptance and ratification* (eight Articles), *Amendments to the convention* (seven Articles), *Signing to the convention* (six Articles), and *Bodies of the convention* (six Articles). A further five topics were common to CBD, CITES and RAMSAR (including *National sovereignty* and *Laws and agreements*), and two topics were common to CITES and CMS.

The remaining 14 topics were convention-specific. CBD (the convention with the largest number of articles) had nine convention-specific topics, including *Sustainable use of biodiversity* (the most frequent topic with 10 Articles), *Cooperative research*, *Financial mechanisms*, and *Genetic and technological resource sharing*. CITES had three convention-specific topics, which included *Trade mechanisms and legislation*. Ramsar has one convention-specific topic (*Conservation of wetlands*), as did CMS (*Conservation of migratory species*).

The text of each convention contained Articles of varying length (Figure S2). There was a positive relationship between the probability of the highest weight topic per Article and the number of unique words per Article, indicating that longer Articles were more specific to their

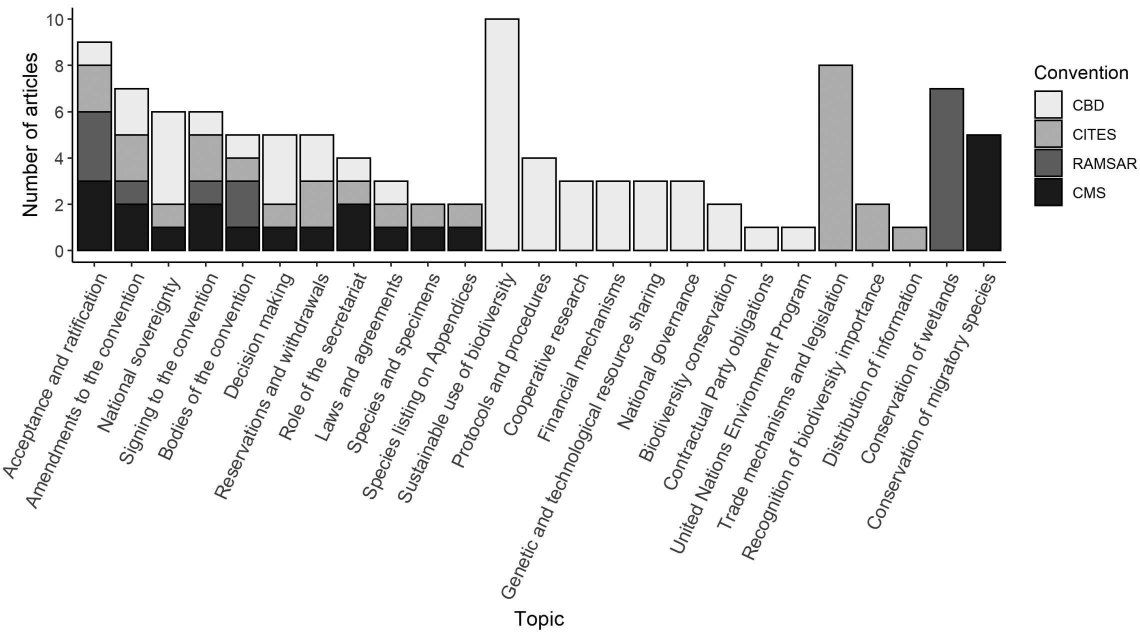
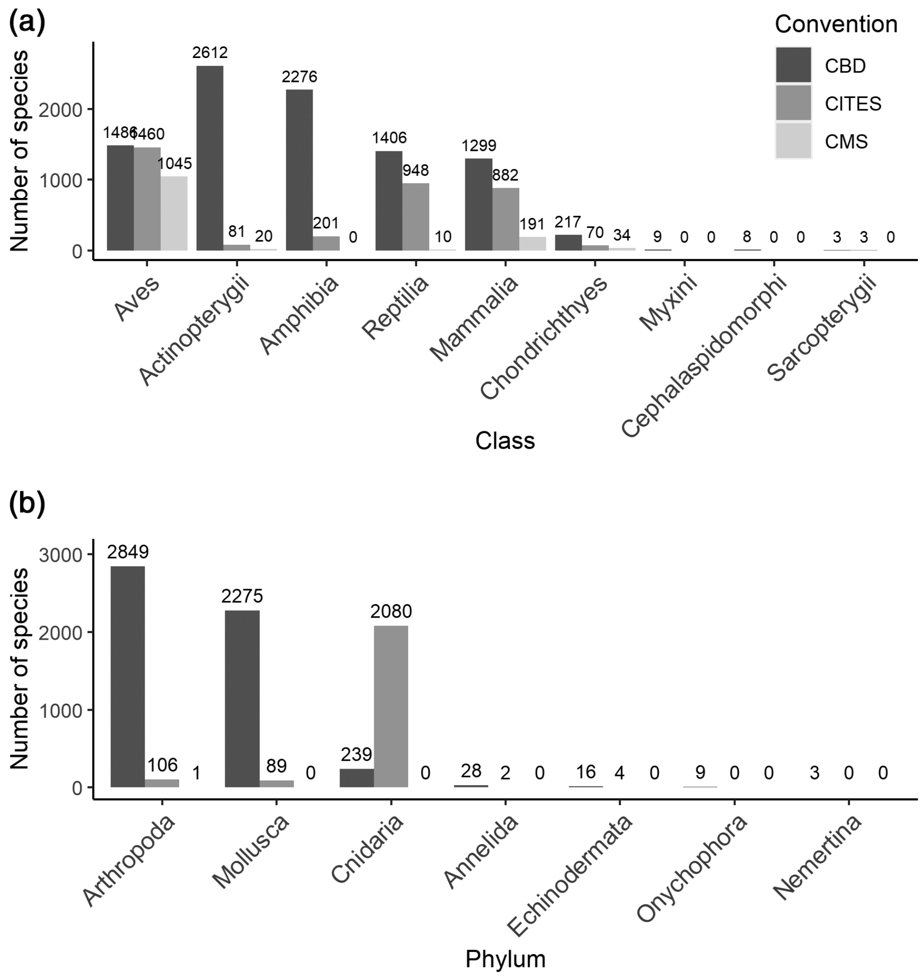


FIGURE 1 The number of convention articles for the Conservation of Wetlands of International Importance especially as a Waterfowl Habitat (Ramsar), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), and the Convention on Biological Diversity (CBD) assigned to each topic

FIGURE 2 The number of (a) vertebrates species per Class and (b) invertebrate species per Phylum that are threatened according to the IUCN Red List, listed on the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and listed on the Appendices of the Conservation of Migratory Species of Wild Animals (CMS)



assigned topic (Figure S2). This positive relationship existed across all conventions, suggesting that conventions organize the content of their Articles in a similar manner.

3.2 | Identifying taxonomic and regional conservation foci overlaps among conventions

3.2.1 | Taxonomy of species under individual conventions

There were 5,926 animal species listed on the CITES Appendices (Figure 2). The majority of these were vertebrates, composed primarily of birds (24.6% of all species), reptiles (16.0%) and mammals (14.9%). Among the invertebrates, the largest group was Cnidaria (35.1% of all species).

There were 1,131 animal species listed on the CMS Appendices (Figure 2). All but one species (*Danaus plexippus*) were vertebrates. The vast majority of species listed on CMS Appendices were birds (80.3%).

There were 14,735 animal species assessed as threatened on the IUCN Red List (Figure 2). The majority of these were vertebrates (63.2%). Within vertebrates, the largest group were fish (17.7% of species assessed were within the Class *Actinopterygii*). Within invertebrates, the largest group were the Phylum *Arthropoda* (19.3% of all species).

3.2.2 | Distribution of species under individual conventions

Not all countries are party to each convention (Figure 3). The majority of countries globally are Party to CITES (Figure 3a). Fewer countries are Party to CMS, however countries that are not Party to the Convention may be Party to one or more Agreements or MoUs (Figure 3b). In the case of the CBD, not all countries are Party to the Convention (Figure 3c), however it should be noted that the IUCN Red List assessments (that identify the threatened species that Aichi Target 12 refers to) are independent of any policy process and are carried out for species' global distributions.

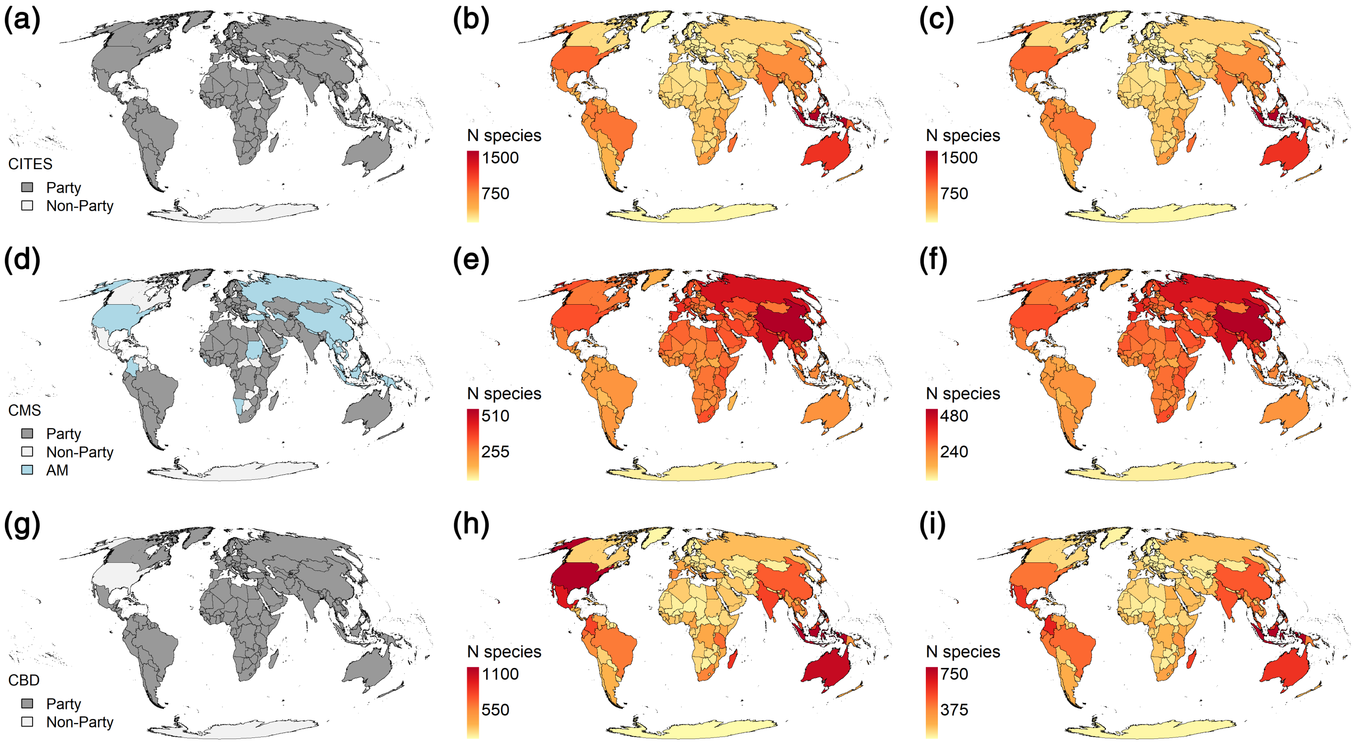


FIGURE 3 For CITES, the distribution of (a) Parties to the convention, (b) the number of species per country listed on the Appendices, and (c) the number of species per country listed on the Appendices accounting for only those countries in which CITES protected for the species is afforded. For CMS, the distribution of (d) Parties to the convention and Parties to Agreements and Memorandum (labeled as AM), (e) the number of species per country listed on the Appendices, and (f) the number of species per country listed on the Appendices accounting for only those countries in which CMS protected for the species is afforded. For CBD, the distribution of (g) Parties to the convention, (h) the number of threatened animal species per country on the IUCN Red List, and (i) the number of threatened animal species within comprehensively assessed taxonomic groups per country on the IUCN Red List. Note the varying color scales between maps

There were 5,843 species with distribution information on the CITES Appendices. There was little difference in the number of species per country listed on the CITES Appendices when comparing the complete geographic distribution of species against the geographic distribution of protection under the Convention (Figure 3b,c). In both cases, the largest (and same) number of species were found in Indonesia (n = 1,488), followed by Australia (n = 1,053) and the Philippines (n = 905).

There were 1,131 species with distribution information on the CMS Appendices. There was similarly little difference in the number of species per country listed on the CMS Appendices when comparing the complete geographic distribution of species against the geographic distribution of protection under the Convention (Figure 3e–f). In both cases, the largest (and same) number of species were found in China (n = 508), India (n = 449), and Russia (n = 437).

There were 14,726 threatened animal species with distribution information available on the IUCN Red List. Of these, 6,220 species were in comprehensively assessed taxonomic groups. There was considerable variation in the number of threatened species per country according to the IUCN Red List between all assessed species and only those in comprehensively assessed taxonomic groups (Figure 3h–i). Considering all assessed species (Figure 3h), the largest number of species were found in the United States (n = 1,094), followed by Indonesia (n = 1,091) and Australia (n = 1,010). When only comprehensively assessed groups were included (Figure 3i), the largest number of species were found in Indonesia (n = 736), followed by Colombia (n = 572) and Australia (n = 528). Australia appears in the top three due to the large number of threatened *Anthozoa*.

3.2.3 | Species in common among conventions

For comprehensively assessed taxonomic groups, there were 137 species in common among all three Conventions (i.e., species that were threatened and listed on both CMS and CITES Appendices). These species were all vertebrates, composed of 35.0% (n = 48) birds and 30.7% (n = 42) mammals. 36.5% were Vulnerable, 32.1% Endangered, and 31.4% Critically Endangered. Large number of species in common among all three Conventions were concentrated in China (n = 57) and India (n = 50), followed by Iran (n = 45), Kenya (n = 43), and Tanzania (n = 43) (Figure 4a).

Among comprehensively assessed taxa, there were 1,198 species in common between CBD and CITES. 17.8% of these species were *Cnidaria* and rest were vertebrates, with the majority being mammals (34.4% of all species) and birds (26.0%). 49.8% were Vulnerable, 31.5% Endangered, and 18.7% Critically Endangered. The largest number of species in common between these conventions were found in Indonesia (n = 356), Malaysia (n = 268), Thailand (n = 252), and the Philippines (n = 235) (Figure 4b).

There were 250 species in the comprehensively assessed taxa in common between CBD and CMS. All species were

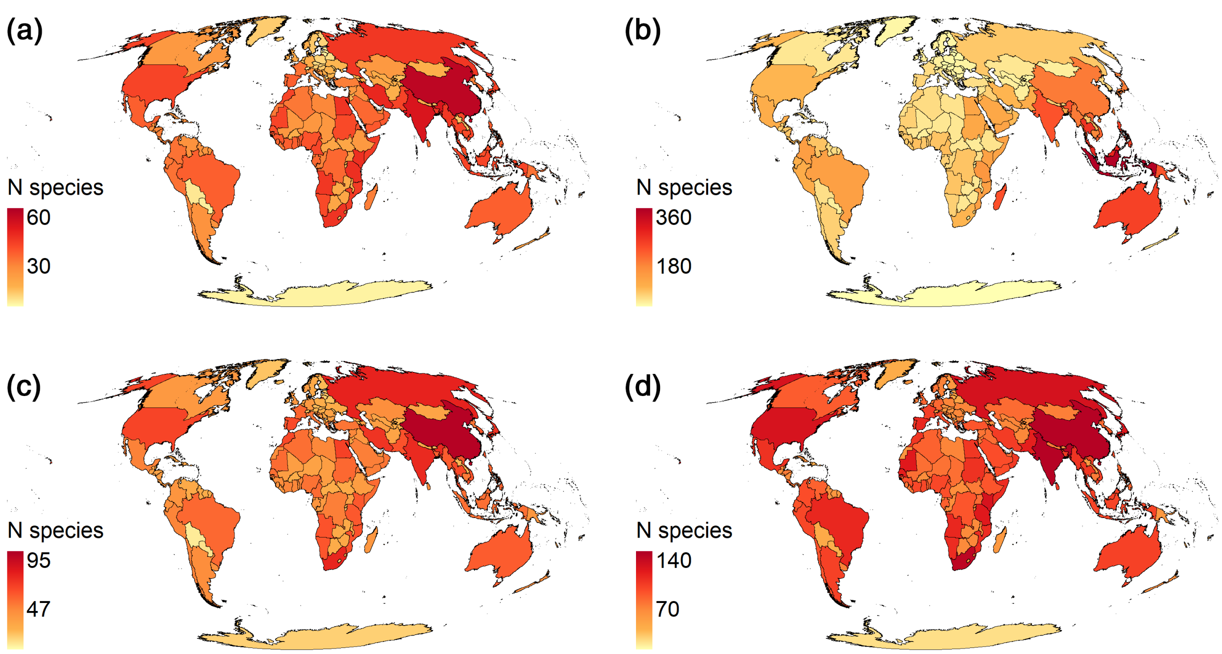


FIGURE 4 The number of threatened animal species in common among (a) CBD, CITES, and CMS, (b) CBD and CITES, (c) CBS and CMS, and (d) CITES and CMS, for those species in comprehensively assessed taxonomic groups according to the IUCN Red List

vertebrates and the majority (56.4%) were birds, followed by mammals (23.2%). 45.6% were Vulnerable, 31.6% Endangered, and 22.8% Critically Endangered. The largest numbers of species in common between these conventions were found in China (n = 93), Russia (n = 74), South Africa (n = 72), and India (n = 70) (Figure 4c).

Finally, there were 348 species in common between CITES and CMS (considering only comprehensively assessed taxa, in line with the preceding comparisons). These species were all vertebrates and the majority (52.3%) were birds followed by mammals (31.6%). 14.4% were Vulnerable, 12.6% Endangered, and 12.4% Critically Endangered (the remainder not considered threatened or not listed on the IUCN Red List). The largest numbers of species in common between these conventions were found in China (n = 137), India (n = 137), South Africa (n = 132), and Russia (n = 119) (Figure 4d).

Inclusion of all species (rather than only those from comprehensively assessed groups) led to a larger number of species in common among conventions. Across all species, there were 139 species in common among all three conventions. There were 1,536 species in common between CBD and CITES, in other words 25.9% of species listed on CITES were threatened according to the IUCN Red List (composed of 46.1% Vulnerable, 32.2% Endangered, and 21.6% Critically Endangered). There were 252 in common between CBD and CMS, meaning 19.4% of species listed on CMS were threatened (composed of 45.2% Vulnerable, 21.3% Endangered, and 23.4% Critically Endangered). Finally, there were 351 species in common between CMS and CITES (of which 39.6% were threatened, with 14.2% Vulnerable, 12.5% Endangered, and 12.8% Critically Endangered). Conclusions about the countries with the largest number of species in common among conventions were unchanged when considering all species (Figure S3).

4 | DISCUSSION

Our analyses show that while there is considerable overlap in the topics of convention texts among CBD, CITES, CMS, and Ramsar, suggesting that structures may be in place to facilitate co-operation among conventions, there are also a considerable number of topics unique to each individual convention, and so co-operation would probably bring complementarity rather than overlap. Furthermore, we identified 137 animal species that are migratory, subject to international trade and threatened, and hence priorities for CMS, CITES, and CBD. The highest numbers of these species occur in Asia (specifically China and India), suggesting that it is possible to identify both taxonomic and geographic priorities where greater synergy among conventions could facilitate improved species conservation outcomes.

4.1 | Convention texts

Our topic modeling analysis showed that there were 11 topics in common among two or more conventions. These topics related to implementation mechanisms, including general procedural issues (such as ratification and amendments) but also topics that could be considered particularly important for achieving multi-lateral and inter-convention co-operation, such as decision making, national sovereignty and laws and agreements. Synergy among conventions should be greatly assisted by alignment of procedures and implementation mechanisms, and our analyses suggest this is likely to be the case. The chronology of adoption of the conventions helps to explain these commonalities in institutional structure and treaty process. Ramsar was adopted in 1971 and as the other conventions were adopted subsequently, they agreed a similar structure (Caddell, 2011). It is notable, however, that there was most similarity in implementation topics among CBD, CMS, and CITES; Ramsar was both the first to be adopted and is the only MEA outside of the UN system of environmental treaties, being administered by IUCN. There are also some areas of implementation where CBD stands apart from the other MEAs; it is the only convention with Articles assigned to topics on Party obligations, national governance, and financial mechanisms. While we assume that similarities in implementation mechanisms would facilitate co-operation, it is unclear to what extent unique or divergent mechanisms may pose a barrier. We suggest that a further challenge is likely to come from the diversity in participating Parties among conventions.

We found that the majority of topics that were unique to individual conventions dealt with the purpose of each convention. Given that all four conventions have biodiversity conservation as their motivation, and the breadth of CBD's objectives, some overlap may be expected. However, our analysis suggests that each convention defines particular challenges facing species and as such, we suggest that greater cooperation among conventions should help tackle the complexity of pressures that some species and particular regions face, without resulting in redundancy.

4.2 | Species in common among conventions

The largest concentrations in species that were listed across multiple conventions (or in the case of CBD, listed as threatened on the IUCN Red List) were generally found in Asia, with large numbers of threatened species impacted by trade found in South-East Asia and large numbers of threatened migratory species in China and India. This analysis demonstrates that it is possible to identify not only groups of species that would benefit from a concentrated effort to enhance co-operation among conventions in order to tackle the complex pressures faced, but also particular geographic areas where such action could be prioritized to take place. Asia, and South-East Asia in particular, is often identified as a region of high conservation priority based on the number of threatened species (Hoffmann et al., 2010) and our analysis shows that there is a concentration of species that require a diversity of policy responses for their conservation.

The taxonomic coverage of species listed on CMS and CITES Appendices and that have been assessed on the IUCN Red List showed considerable variation. It is possible that these patterns reflect genuine taxonomic differences in the need for special attention under these conventions, but it is also possible that there are other reasons. For example, the process of listing species on Appendices is particularly contentious for CITES (Baur, Nowell, Sillero-Zubiri, & Macdonald, 2018), and there has been a historical bias in conservation toward vertebrates and especially birds (Di Marco et al., 2017), suggesting that other taxonomic groups may be relatively neglected.

While Ramsar operates by designating sites (rather than listing species), the presence of waterfowl and other wetland species are a critical consideration in site designation. Area-based action plays a major role in species conservation (Gray et al., 2016) and there is therefore a clear role for Ramsar in species conservation. It would be particularly advantageous to be able to identify wetland species of common concern with other conventions given that freshwaters are among the most threatened ecosystems globally, with species populations declining faster than in terrestrial and marine habitats (He et al., 2019). Freshwaters cover approximately 1% of Earth's surface, yet harbor around one third of all vertebrates and nearly half of all fish species globally (Dudgeon et al., 2006). A clear statement of the taxonomic coverage of Ramsar is therefore critical to assessing the scope for overlap and complementarity among conventions.

4.3 | Recommendations for post-2020

There have been repeated calls for much greater co-operation between the environmental conventions. The assessment that Aichi Target 12 of the CBD's Strategic Plan for 2011–2020 was on course to be missed (IPBES, 2019) and the ongoing negotiations for the Plan's successor, the Global Biodiversity Framework, suggest an added urgency to efforts to reduce treaty congestion, improve coherence and deliver greater outcomes for species conservation. Our findings suggest that there seems sufficient commonality in the implementation processes and structures between the four conventions to allow for much greater synergy. Their purposes complement each other and so if their activities were aligned better, they could both achieve greater effectiveness in tackling threats to species facing especially difficult issues and identify subsets of species that are facing more than one such complex challenge (such as migration and international trade). As the Post-2020 Global Biodiversity Framework is negotiated (CBD Secretariat, 2020), there is the prospect of a global biodiversity agenda being agreed in 2021 that will have defined outcomes, targets and indicators for species conservation. This presents a clear opportunity to sharpen focus on where coherence may be achieved in tackling the targets that will contribute to the agreed outcomes, and how progress will be measured.

The Post-2020 Global Biodiversity Framework that is adopted at CoP15 will determine the CBD's work for the next decade at least, and toward 2050. There would seem to be clear potential for CMS, CITES and Ramsar to deliver challenging parts of this global species conservation agenda. Interestingly, none of the conventions have "sunset" provisions whereby they anticipate a time when they might be reviewed to see if they still serve its purpose: the three conventions tackling specific biodiversity issues, Ramsar, CMS and CITES, entered into force between 10 and 18 years before the much wider-ranging CBD (December 1993). How can these older and more narrowly focused conventions maximize their effectiveness to the global species conservation challenges post-2020?

Harmonizing species Appendices to the fullest extent possible would seem a clear first step. Development of a list of species that are of concern to Ramsar would be a significant step forward, along with the collation and curation of species information for its sites. The influence of the conventions varies, as not all countries are Parties to the convention that addresses issues of importance to their species. For example; China, Japan and Russia are amongst the five countries with the largest number of threatened species listed on the CMS appendices, yet none of these countries is Party to CMS (although they are signatories to one or more CMS instruments on particular species). Hensz and Soberón (2018) suggested that CMS is under-utilized, and it would appear that strategic engagement by CMS with countries that have large numbers of migratory species may help to increase co-ordination of conservation policy and action for those species. There is, therefore, a further need to encourage the participation of all relevant range States in relevant conventions. A clearer sense of what the world's species need, as envisaged by the post-2020 Global Biodiversity Framework, would provide a strong context for this.

There is sufficient commonality in the design of these four MEAs and convergence in at least some of their focal species that much greater synergies than at present are possible, which should support much stronger species outcomes by 2030 than have been achieved so far.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Philip J. K. McGowan conceived the study. Stephanie Kuunal carried out analyses and wrote the first draft. All authors contributed to manuscript writing and revision.

DATA AVAILABILITY STATEMENT

Convention texts and Parties to each Convention are publicly available (cites.org; cms.int; cbd.int; Ramsar.org). Species listed on CITES and CMS appendices are publicly available from Species+ (speciesplus.net). Threatened species data are publicly available from IUCN Red List (iucnredlist.org).

ETHICS STATEMENT

This study did not involve human or animal subjects.

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REFERENCES

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R tool for comprehensive analysis of scientific literature. *Journal of Informetrics*, *11*, 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Baakman, K. (2011). *Testing times: The effectiveness of five international biodiversity-related conventions*. Nijmegen: Wolf Legal Publishers.

Baur, H., Nowell, K., Sillero-Zubiri, C., & Macdonald, D. W. (2018). Lions in the modern area of CITES. *Conservation Letters*, *11*, e12444. https://doi.org/10.1111/conl.12444

Caddell, R. (2011). The integration of multilateral environmental agreements: Lessons from the biodiversity-related conventions. *Yearbook of International Environmental Law*, *22*, 37–75. https://doi.org/10.1093/yiel/yvs066

Caddell, R. (2013). Inter-treaty cooperation, biodiversity conservation and the trade in endangered species. *Review of European, Comparative & International Environmental Law*, *22*, 264–280. https://doi.org/10.1111/reel.12039

CBD. (1992). *Text of the convention*. Rio de Janeiro, Brazil: CBD. Available from https://www.cbd.int/convention/text/.

CBD. (2010). *Decision X/2. Strategic plan for biodiversity 2011–2020*. Nagoya, Japan: COP10.

CBD. (2004). *Decision VII/26. Cooperation with other conventions and international organizations and initiatives*. Kuala Lumpur, Malaysia: COP7.

CBD Secretariat. (2020). Zero Draft of the Post-2020 Global Biodiversity Framework: Note by the Co-Chairs of the Open-ended Working Group on the Post-2020 Global Biodiversity Framework. Available from https://www.cbd.int/doc/c/efb0/1f84/a892b98d2982a829962b6371/wg2020-02-03-en.pdf.

CITES. (1973). Text of the convention. Including Bonn Amendment in 1979 and Garborone amendment in 1983. Washington, United States of America. Available from https://www.cites.org/eng/disc/text.php.

CITES. (2019). List of contracting parties. Available from https://www.cites.org/eng/disc/parties/chronolo.php.

CMS. (1979). *Text of the convention*. Bonn, Germany: CMS. Available from https://www.cms.int/en/convention-text

CMS. (2019). Parties and range states. Available from https://www.cms.int/en/parties-range-states.

Di Marco, M., Chapman, S., Althor G., Kearney, S., Besancon, C., & Watson James, E. M. (2017). Changing trends and persisting biases in three decades of conservation science. *Global Ecology and Conservation*, *10*, 32–42. http://doi.org/10.1016/j.gecco.2017.01.008.

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C., … Sullivan, C. A. (2006). Freshwater biodiversity importance, threats, status and conservation challenges. *Biological Reviews*, *81*, 163–182.

Feinerer, I., Hornik, K., & Meyer, D. (2008). Text mining infrastructure in R. *Journal of Statistical Software*, *25*, 1–54. https://doi.org/10.18637/jss.v025.i05

Gillespie, A. (2007). *Protected areas and international environmental law*. Leiden: Koninklijke Brill NV.

Gomar, J. O. V., Stringer, L. C., & Paavola, J. (2014). Regime complexes and national policy coherence: Experiences in the biodiversity cluster. *Global Governance*, *20*, 119–145.

Gomar, J. O. V. (2016). Environmental policy integration among multilateral environmental agreements: The case of biodiversity. *International Environmental Agreements: Politics, Law and Economics*, *16*, 525–541. https://doi.org/10.1007/s10784-014-9263-4

Gray, C., Hill, S., Newbold, T., Hudson, L. N., Börger, L., Contu, S., … Scharlemann, J. P. W. (2016). Local biodiversity is higher inside than outside terrestrial protected areas worldwide. *Nature Communications*, *7*, 12306. https://doi.org/10.1038/ncomms12306

Griffiths, T. L., & Steyvers, M. (2004). Finding scientific topics. *Proceedings of the National Academy of Sciences of the United States of America*, *101*, 5228–5235. https://doi.org/10.1073/pnas.0307752101

Grun, B., & Hornik, K. (2011). Topicmodels: An R package for fitting topic models. *Journal of Statistical Software*, *40*, 1–30. https://doi.org/10.18637/jss.v040.i13

Hensz, C. M., & Soberón, J. (2018). Participation in the convention on migratory species: A biogeographic assessment. *Ambio*, *47*, 739–746. https://doi.org/10.1007/s13280-018-1024-0

He, F., Zarfl, C., Bremerich, V., David, J. N. W., Hogan, Z., Kalinkat, G., … Jähnig, S. C. (2019). The global decline of freshwater megafauna. *Global Change Biology*, *25*, 3883–3892. https://doi.org/10.1111/gcb.14753

Herkenrath, P. (2012). *Promoting synergies within the cluster of biodiversity-related multilateral environmental agreements*. Cambridge, UK: UNEP-WCMC. www.unep-wcmc.org/resources-and-data/promoting-synergies-within-the-biodiversity-cluster-of-biodiversity-related-multilateral-environmental-agreements

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T. M., Butchart, S. H., … Darwall, W. R. (2010). The impact of conservation on the status of the world's vertebrates. *science*, *330* (6010), 1503–1509.

IPBES (2019). In S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, et al. (Eds.), *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services* (p. 56). Bonn, Germany: IPBES Secretariat. https://doi.org/10.5281/zenodo.3553579

IUCN. (2019). The IUCN Red List of threatened species. Version 2019-1. Available from https://www.iucnredlist.org.

Jóhannsdóttir, A., Cresswell, A., & Bridgewater, P. (2010). The current framework for international governance of biodiversity: Is it doing more harm than good? *Review of European, Comparative & International Environmental Law*, *19*, 139–149. https://doi.org/10.1111/j.1467-9388.2010.00673.x

Lu, K., Cai, X., Ajiferuke, I., & Wolfram, D. (2017). Vocabulary size and its effect on topic representation. *Information Processing and Management*, *53*, 653–665. https://doi.org/10.1016/j.ipm.2017.01.003

Pimm, S. L., Jenkins, C. N., Abell, R., Brook, T. M., Gittleman, J. L., Joppa, L. N., … Sexton, J. O. (2014). The biodiversity of species and their rates of extinction, distribution and protection. *Science*, *344*, 1246752. https://doi.org/10.1126/science.1246752

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Ramsar. (1971). *Text of the convention*. Iran: Ramsar. Available from https://www.ramsar.org/.

Ramsar. (2012). The status of sites on the List of Wetlands of International Importance. (Resolution XI.4.4 (Rev. CoP11)]. Bucharest, Romania. Available from https://www.ramsar.org/sites/default/files/documents/pdf/cop11/res/cop11-res04-e.pdf.

Ramsar Sites Information Service. (2020). Ramsar Sites Information Service 2,386 Sites covering 253, 771,681 ha. Available from https://rsis.ramsar.org.

Rogalla von Bieberstein, K., Sattout, E., Christensen, M., Pisupati, B., Burgess, N. D., Harrison, J., & Geldmann, J. (2018). Improving collaboration in the implementation of global biodiversity conventions. *Conservation Biology*, *33*, 821–831. https://doi.org/10.1111/cobi.13252

Scott, K. N. (2011). International environmental governance: Managing fragmentation through institutional connection. *Melbourne Journal of International Law*, *12*, 1–40.

UNEP-WCMC. (2018). *Compendium of guidance on achieving synergies among biodiversity-related conventions at the national level*. Cambridge, UK: UNEP-WCMC. www.informea.org/en/compendium-guidance-achieving-synergies-among-biodiversity-related-conventions-national-level

UNEP-WCMC. (2019). Species+. Available from www.speciesplus.net.

Westgate, M. J., Barton, P. S., Pierson, J. C., & Lindenmayer, D. B. (2015). Text analysis tools for identification of emerging topics and research gaps in conservation science. *Conservation Biology*, *24*, 1119–1129. https://doi.org/10.1111/cobi.12605

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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