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Commercial trade of wild animals: examining the use of the IUCN Red List and CITES Appendices as the basis for corporate trade policies

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Wildlife exploitation is considered a predominant factor driving global biodiversity loss and zoonotic disease transmission, in addition to a range of concerns for animal welfare and ecosystem health. One of the ways in which wild animals are exploited is for commercial trade as exotic pets, fashion products, luxury foods, traditional medicine, entertainment, ornaments and more. While the trade in some wildlife species is restricted or prohibited under various domestic and international laws, many species are not bound by legal protection and are traded in largely unmonitored numbers with the potential for severe consequences. Companies, particularly large e-commerce platforms, are increasingly adopting policies to restrict the legal trade in wild animals. Due to the absence of clear guidelines for corporate services of wildlife trade, these policies commonly adopt pre-determined species lists, such as the International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species or the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices, as the basis for 'negative lists' to guide which species to restrict trade in. However, these databases were not intended for this application and there has been no assessment of their use for this purpose. Here, we summarise and compare the scale and scope of species listed on the IUCN Red List and the CITES Appendices, to discuss how much additional protection these lists provide wild animals if used as policy instruments to guide corporate wildlife trade restrictions beyond the relevant legal bounds. Based on our results, we discuss why that using one list or another would likely omit taxa of conservation concern from protection, and using both lists in conjunction would still not comprehensively reflect all species vulnerable to extinction as a result of exploitation. Further, neither list can mitigate the animal welfare and public health concerns inherently associated with all commercial wildlife trade. We recommend that companies looking to develop policies relating to commercial wildlife trade consider going beyond the scope of predetermined species lists to help mitigate the harmful effects of commercial wildlife exploitation *via* trade for all wild animals.

KEYWORDS

wildlife trade, CSR, policy, IUCN Red List, CITES Appendices

1 Introduction

Unsustainable wildlife exploitation has been identified as one of the key drivers of net global biodiversity loss (Brondizio et al., 2019), and the deteriorating conservation status of species across the world has led to the suggestion that we are entering the sixth mass extinction event (Barnosky et al., 2011; Mair et al., 2019). Although estimating the full extent of the threats facing wildlife populations is challenging (Frank and Wilcove, 2019), current regulations that protect only some species from trade appear to be insufficient in preventing unsustainable exploitation, and many species that are currently perceived as common may not remain so if current levels of exploitation continue (Heinrich et al., 2020). Considering the wide range of negative consequences that [legal and illegal] commercial wildlife trade can have on ecosystem health, animal welfare, financial security, equitability and public health across the world, there is growing recognition that the challenges associated with the industry may not be surmountable through improvements to current regulations alone (D'Cruze et al., 2020).

Wild animals are commercially traded for use as exotic pets, luxury goods and food, entertainment, and traditional medicine (Dutton et al., 2013; Díaz et al., 2019; D'Cruze et al., 2020). With the advent of e-commerce platforms and increasing global access to the internet, there has been an unprecedented surge in online trade of wild animals for these purposes (IFAW, 2012; Stringham et al., 2021). One study highlighted as many as 70,000 individual live wild animals sold on a single online platform in only 5 months (Ye et al., 2020). The use of the internet for trading wildlife has become so popular that it has overtaken the trade in physical markets for several taxa (Harrison et al., 2016; Siriwat and Nijman, 2020). The relationship between the trade of species and conservation outcomes is not straightforward and trade can be negative, neutral, or positive for wild animal populations (Challender et al., 2022). For example, where a species is considered threatened by alternate factors such as climate change, habitat loss or conflict, trade could place beneficial economic value on the species that in turn aids conservation efforts. However, determining the impact of trade requires extensive monitoring and a copious amount of time, money, and expertise, meanwhile the negative effects of trade can have irreversible consequences for species survival (Frank and Wilcove, 2019; Marshall et al., 2020; Hughes et al., 2021).

Although some wildlife trade is restricted or prohibited under various domestic and international laws, most species are not bound by legal protection. With online trade facilitating the sale of wild animals, e-commerce platforms are under increasing pressure to develop company policies to regulate trade as part of corporate social responsibility (CSR) strategies, to mitigate any potential harmful effects of trade on global wildlife populations. Many companies are now moving towards prohibiting the sale of products derived from species considered threatened in addition to illegal wildlife products. For example, multinational e-commerce corporation eBay stipulates in their Animal Products Policy that products from endangered or protected species can't be listed due to their commitments to animal welfare and the protection of native, endangered, and threatened species (Ebay, 2021). The policy stipulates that it prohibits the sale of products derived from species listed as endangered by various international agreements and government agencies including the US Fish and Wildlife Service and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as well a small selection of additional wildlife parts. Similarly, e-commerce company Etsy updated their Prohibited Items Policy in 2013 to prohibit products made from wild animals designated as threatened or endangered according to the US Fish and Wildlife Services or Appendix I of CITES [although it should be noted this is a legal requirement in most cases], and ivory or parts from ivory producing mammals.

Due to the absence of clear guidelines for corporate services of wildlife trade, it is logical that corporations are turning to pre-determined lists of species created by prominent organisations in the remit of wildlife assessment and protection. For example, two of the most recognised species lists from international organisations in this field are the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices."The purpose of the IUCN's Red List is to provide information and analyses on the status, trends, and threats to species to inform and catalyze action for biodiversity conservation (Betts et al, 2020). The main aim for CITES is to enable a regulated trade of wildlife that protects threatened populations of fauna and flora (Possibgham et al, 2002). The IUCN Red List considers threats to populations based on a number of factors (including habitat modification, trade, biological resource use, commercial development, human conflict and more), while CITES is only concerned with conservation of populations in relation to trade. The IUCN Red List is purely informational and provides no immediate legal protection for species, whereas CITES does offer varying levels of legal protection dependent on species classification across their Appendices (Frank and Wilcove, 2019). For the purpose of this study, our comparison will focus on species listed across all of the CITES Appendices, irrespective of the legal restrictions relevant for each Appendix (Species+, 2021).

Both of these species' databases have a range of benefits for wildlife protection within their respective remits. As a threatened species list, the IUCN Red List continues to be a valuable tool contributing to tackling species declines caused by over-exploitation (Mair et al., 2019). It is one of the few publicly accessible tools at the disposal of regulatory agencies to limit

adverse impacts to wildlife (Possingham et al., 2002). It also holds the potential to influence communication and awareness raising of species extinction risk to the scientific community and wider audiences (Betts et al., 2020). The IUCN Red List has been praised for its objectivity, transparency and traceability (Charra and Sarasa, 2018) and influences many aspects of conservation including policy development, awareness raising, priority setting and resource allocation (Betts et al., 2020). As a regulatory tool, CITES has become the primary international framework for preventing the loss of species due to international wildlife trade (Frank and Wilcove, 2019) and has positively influenced other trade regulatory frameworks at the national level (Marshall et al., 2020). However, while both of these databases are valuable in relation to their objectives, it is important to note they were not created for the purpose of guiding guiding corporate trade policies. Thus, they may not be suitable for this purpose, if the aim of the trade policies is to provide comprehensive protection for wild animals beyond [legal] commercial trade regulations.

Here, we aim to explore whether using one, or both, of these pre-determined species lists as the basis for 'negative lists' (i.e., lists of species that are prohibited in trade) used to guide corporate wildlife trade restrictions [beyond relevant legal restrictions, according to CITES or otherwise] could provide comprehensive additional protection for wild animals against exploitation from commercial trade. We summarise and compare the scope and scale of species listed on the IUCN Red List and the CITES Appendices, to provide context to discuss whether these lists are a suitable basis for considering which species to trade across e-commerce platforms to prevent unsustainable exploitation [outside of the mandatory legal bindings of Appendix listings]. We chose to focus on the IUCN Red List and the CITES Appendices because companies are increasingly choosing to incorporate these lists into their policies, due to the nature of these internationally recognised authorities. Given the extent to which over-exploitation is considered to be a threat to species, and the facilitating role that online international trade can play in wildlife exploitation (Harrison et al., 2016; Maxwell et al., 2016; Mair et al., 2019), we hope to provide insights that can be of help for the development of corporate policies that more effectively protect wild animal species from exploitative commercial trade.

2 Methods

The IUCN Red List is the most widely recognised assessment of the conservation status of species at the global scale (Charra and Sarasa, 2018). The Red List defines a set of categories to describe extinction risk, using parameters such as population status, distributional range, population size and structure and quantitative estimates of threats (Mair et al., 2019). We downloaded data detailing taxa listed on the IUCN Red List from the Red List online database (https://www.iucnredlist.org/search) on 14/06/2021. It is possible that some taxa have been re-categorized since we obtained the data, as the list is periodically updated. The data was filtered to contain all entries of taxa from the 'Animalia' Kingdom, in the Categories 'Critically Endangered', 'Endangered', 'Vulnerable', 'Near Threatened' and 'Least Concern'. Species in categories 'Data Deficient' (N = 14,912), 'Extinct' (N = 780) and 'Extinct in the Wild' (N = 37) were excluded from the data. Our search included all species on the 'Global' geographic scale. We did not apply any additional filters, and our search included the full list of threats considered by the IUCN assessments ('Residential and commercial development', 'Agriculture and aquaculture', 'Energy production and mining', 'Transportation and service corridors', 'Biological resource use', 'Human intrusions and disturbance', 'Natural system modifications', 'Invasive and other problematic species, genes and diseases', 'Pollution', 'Geological events', 'Climate change and severe weather' and 'Other'). Data pertaining to Aves was downloaded separately, with identical search terms [due to restrictions on data access placed by Bird Life International] and subsequently merged with the main dataset with all other taxa. An additional subset of the main dataset was obtained for species listed in the threat category 'Hunting and trapping terrestrial animals' within 'Biological resource use', as a proximate measure for species threatened due to trade. Although we acknowledge that some species in this category are considered threated due to small-scale informal trade or subsistence use, not commercial trade, this was the most appropriate method for us to obtain this data for top-level analysis. We highlight this limitation in the text and apply caution when discussing this data in the discussion. Throughout the text, we refer to species as "threatened according to the IUCN Red List", where threatened is determined as categories Near Threatened, Vulnerable, Endangered and Critically Endangered.

CITES is a multilateral treaty ratified by 183 party members worldwide that was formalized to coordinate and regulate international trade in wildlife products (Frank and Wilcove, 2019). Species are listed under one of three Appendices according to their extinction-risk level due to trade, where Appendix I listed species are the most endangered and their commercial trade the most restricted, Appendix II listed species may become threatened in the future if international trade is not regulated, and Appendix III species are protected in specific countries and seek other Parties' assistance for help controlling their trade (Heinrich and Gomez, 2021). Under CITES regulations, trade should only be permitted if it is 'non-detrimental' to wild populations (Mair et al., 2019). We downloaded data on taxa listed under CITES Appendices from the Checklist of CITES Species (http://checklist.cites.org) on 01/06/2021. The database contained a large amount of data categories irrelevant to our analysis, so across all species entries we excluded all information except for taxonomic rank (kingdom, phylum, class, order, genus, and species), the

individual taxon ID assigned to each species entry, and the corresponding current Appendix listing, within the Animalia kingdom. Both the CITES and IUCN Red List datasets were downloaded in Microsoft Excel format and all subsequent analysis was conducted in Excel. Analysis consisted of basic summary and comparative statistics between the two lists.

Preliminary exploration of the data revealed some variation in taxonomic information between the two lists. On the IUCN Red List, species in the order Coelacanthiformes were listed in the class Sarcopterygii, whereas on the CITES Appendices Coelacanthiformes were listed in the class Coelacanthi. Coelacanths are considered part of the clade Sarcopterygii, so Coelacanthiformes in the CITES list were reassigned to the class Sarcopterygii to ensure consistency between the datasets. This only applied to two species (*Latimeria chalumnae and Latimeria menadoensis*). Additionally, the CITES Appendices included species listed as belonging to orders Serpentes and Sauria, whereas the IUCN listed Squamata as the relevant order for the same species. These species belonged to the families Boidae, Bolyeriidae, Colubridae, Elapidae, Loxocemidae, Pythonidae, Tropidophiidae, Viperidae [listed as Serpentes] and Agamidae, Anguidae, Chamaeleonidae, Cordylidae, Eublepharidae, Gekkonidae, Helodermatidae, Iguanidae, Lacertidae, Lanthanotidae, Scincidae, Teiidae, Varanidae and Xenosauridae [listed as Sauria]. To ensure consistency, species belonging to these families were all reassigned to the order Squamata in the CITES dataset. Similarly, the IUCN Red List included the class Actinopterygii, whereas the CITES Appendices list 'Actinopteri' as the relevant class for the same species. Actinopteri is a subclass of Actinopterygii, and so all species listed as Actinopteri on the CITES database were reassigned to Actinopterygii, to ensure consistency between the datasets.

3 Results

3.1 Summary data for each database

3.1.1 IUCN Red List data

Our search returned a result of 64,411 species of fauna listed on the IUCN Red List. Of these species, the vast majority (N = 44,204, 69%) were in the 'Least Concern' category, followed by 6,593 (10%) 'Vulnerable', 5,426 (9%) 'Endangered', 4,457 (7%) 'Near Threatened' and 3,483 (5%) 'Critically Endangered'. A much smaller fraction of species were listed as a combination of categories 'Lower Risk/Near Threatened' (198, <1%) and 'Lower risk/Least Concern' (49, <1%) (Figure 1A).

3.1.2 CITES Appendices data

Our search returned a result of 6,011 species of fauna listed on the CITES Appendices. Of these, the majority (N = 5,048, 84%) are listed on Appendix II, followed by 696 (12%) on Appendix I, 237 (4%) on Appendix III and a much smaller proportion (30, <1%) on a combination of both Appendix I and II (Figure 1B).

Comparison of species listed in both datasets revealed that there is a crossover of 3,675 species that appear on both the IUCN Red List [Categories 'Critically Endangered', 'Endangered', 'Vulnerable', 'Near Threatened' and 'Least Concern'] and the CITES Appendices [I, II and III]. A total of 2,248 species are listed on CITES Appendices but do not appear

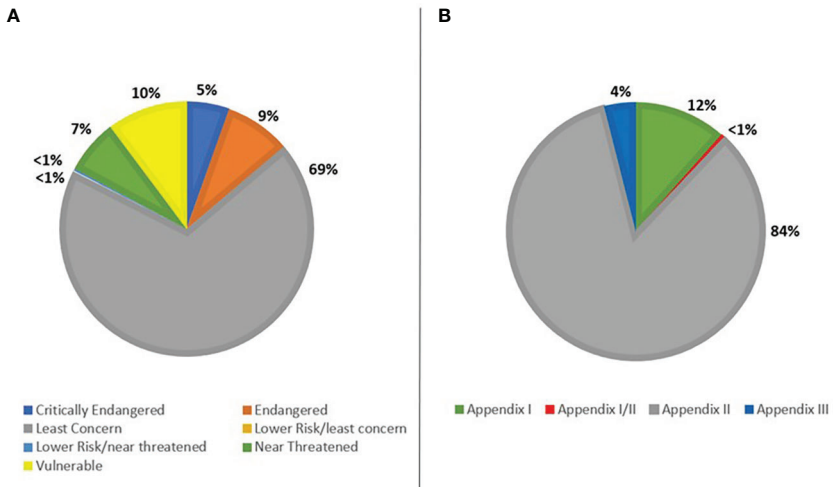

FIGURE 1
(A) Number of species listed in each of the IUCN Red List categories, within our search terms **(B)** Number of fauna species listed in each of the CITES Appendices.

in this study's subset of the IUCN Red List [of which 139 are on Appendix I and are therefore already effectively prohibited from international commercial trade except for limited circumstances], and 58,488 species are listed on this study's subset of the IUCN Red List but do not appear on the CITES Appendices. Of the IUCN Red List species that do not appear on the CITES Appendices, 42,496 (73%) fall under the Red List's 'Least Concern' category.

After our initial analysis of the data, species listed as 'Least Concern' on the IUCN Red List were excluded from further analysis. This allowed us to focus our results on taxa that are of greater concern for conservation purposes and made the results more applicable to evaluate actual policy choices by corporates that most commonly limit their restrictions to 'threatened' species when referring to CITES or IUCN Red List species lists.

3.2 Taxonomic comparison between IUCN Red List and CITES Appendices

Species of animals listed across the IUCN Red List threatened and near-threatened categories ('Critically Endangered', 'Endangered', 'Vulnerable' and 'Near Threatened') and the CITES Appendices belong to 34 different taxonomic classes and 32 taxonomic orders (Figures 2, 3). Figures 2, 3 depict the comparison of the number of species listed per class, and per order, for all species listed on the CITES Appendices and all species listed on the IUCN Red List threatened and near-threatened categories. The top five classes with the highest number of species listed on the IUCN Red List all contain over 1500 species that feature on the list. In comparison, four of the same classes contain less than 250 species that feature on the CITES Appendices. Specifically, Actinopterygii contains 3451 species (IUCN Red List) compared with 81 (CITES Appendices), Amphibia comprise 2863 species (IUCN Red List) compared with 202 (CITES Appendices), Gastropoda comprise 2641 species (IUCN Red List) compared with 47 (CITES Appendices) and Insecta comprise 2519 species (IUCN Red List) compared with 69 (CITES Appendices). The top five classes with the highest number of species belonging to them on the CITES Appendices (Anthozoa, Aves, Hydrozoa, Mammalia and Reptilia) all have less species listed on the Appendices than the number of species belonging to the same class, listed in any of the threatened and near threatened categories on the IUCN Red List.

Figures 4, 5 detail the number of species listed in each of the IUCN Red List threatened and near threatened categories and CITES Appendices for the largest taxonomic classes [defined here as more than 1000 species for the IUCN Red List and more than 500 species for CITES]. For the IUCN Red List, the proportion of species listed in each category varies per class, with 'Vulnerable' being the most common category for species in over half of the classes. Across most classes, 'Critically Endangered' was the class with the fewest species listed (excluding Actinopterygii and Amphibia). Amphibia feature the highest number of species listed as 'Critically Endangered' and Aves feature the highest number of species as 'Near Threatened'. For the CITES Appendices, the vast majority of species across all 4 classes were listed on Appendix II [99.7% of Anthozoa species (N = 1817/1821), 87% of Ave species (N = 1283/1473), 56% of mammal species (N = 516/917) and 79% of reptile species (N = 771/972)]. Mammalia had the highest number of species listed on Appendix I comprising 35% of the total number of species in the class.

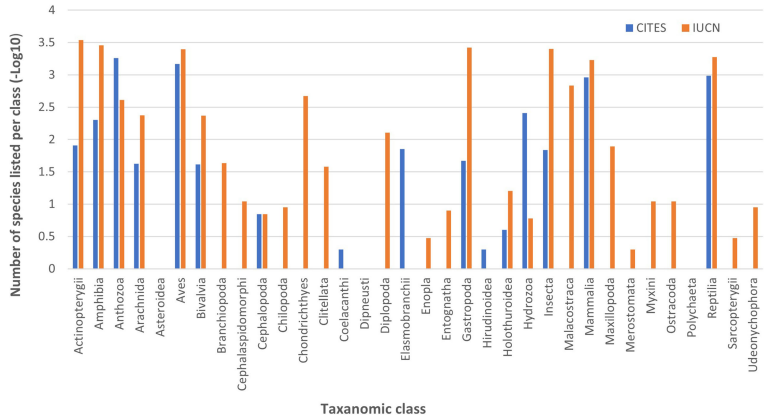

FIGURE 2
Number of species [log transformed] listed per taxonomic class, on the IUCN Red List and the CITES Appendices.

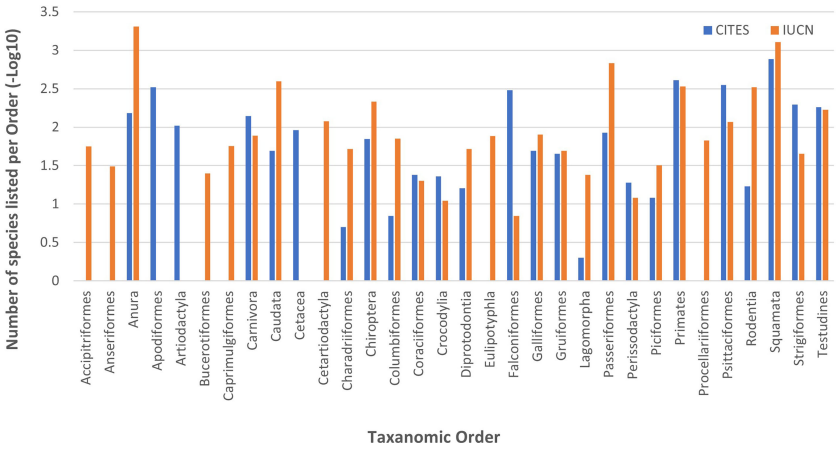

FIGURE 3
Number of species [log transformed] listed per taxonomic order on the IUCN Red List [threatened categories] and the CITES Appendices.

3.3 Comparison between IUCN Red List and CITES Appendices for commonly commercially traded vertebrate taxa

Aves, Amphibia, Mammalia and Reptilia are all commonly commercially traded classes of vertebrates (Scheffers et al., 2019; Fukushima et al., 2020; Morton et al., 2022). The IUCN Red List threatened and near-threatened categories include a total of 8931 species across these classes (2482 Aves, 2863 Amphibia, 1693 Mammalia and 1893 Reptilia) and the CITES Appendices include a total of 3564 species (1473 Aves, 202 Amphibia, 917 Mammalia and 972 Reptilia). A total of 1499 species across these four classes feature on both lists. Figures 6, 7 detail the number of species within each of these four classes listed in each category of the IUCN Red List and the CITES Appendices.

Within the 8931 species of birds, mammals, amphibians, and reptiles listed as threatened on the IUCN Red List, a subset of 2406 species are listed under the threat category 'Hunting and trapping terrestrial animals' within the category 'Biological resource use' (See Figures 8). Of these 2406 species, 953 (40%) are also listed on the CITES Appendices, with 355 listed under Appendix I or a combination of Appendix I and II, and the remaining 598 listed on Appendix II and III. There are 2611 species listed on the CITES Appendices that are not listed under the threat category 'Hunting and trapping terrestrial animals'. Of these, 571 are considered threatened by the IUCN Red List under

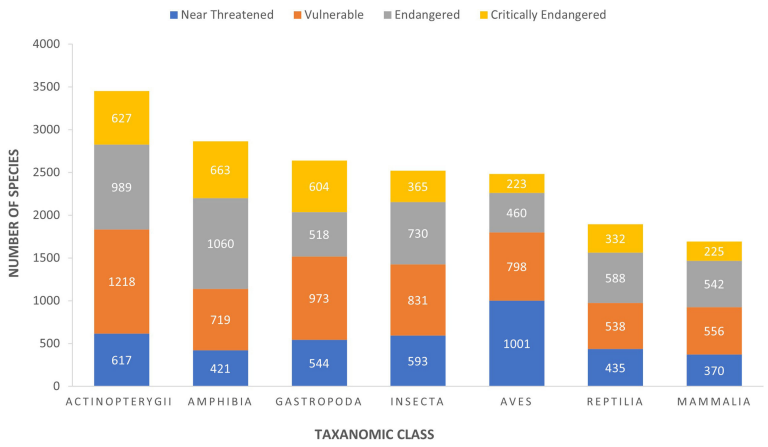

FIGURE 4
Number of species listed in each of the IUCN Red List threatened and near threatened categories 'Near Threatened', 'Vulnerable', 'Endangered' and 'Critically Endangered', for taxonomic classes with > 1000 species listed.

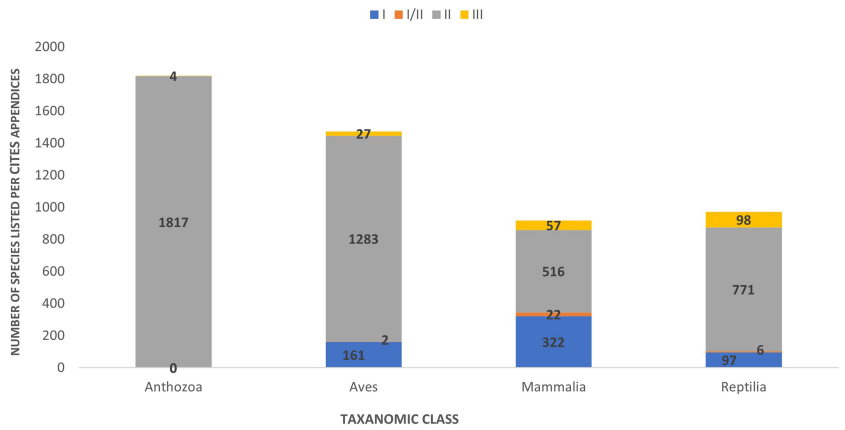

FIGURE 5
Number of species listed in each of the CITES Appendices (I, II and III), for taxonomic classes with > 500 species listed.

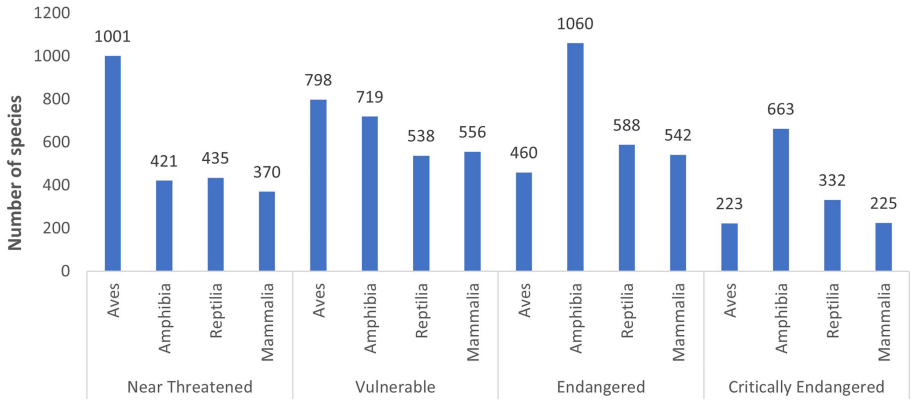

FIGURE 6
Number of species within each of the four classes Aves, Amphibia, Reptilia and Mammalia, listed as 'Near Threatened', 'Vulnerable', 'Endangered' or 'Critically Endangered' according to the IUCN Red List of Threatened Species. N = 8931.

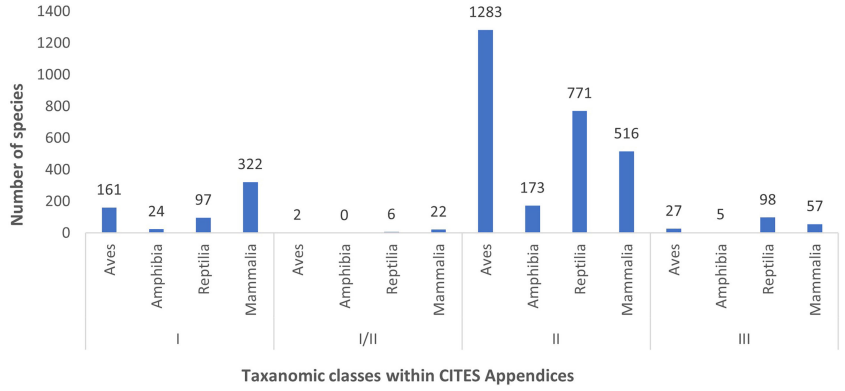

FIGURE 7
Number of species within each of the four classes Aves, Amphibia, Reptilia and Mammalia, listed on Appendix I, Appendix I/II, Appendix II or Appendix III according to the CITES Appendices. N = 3564.

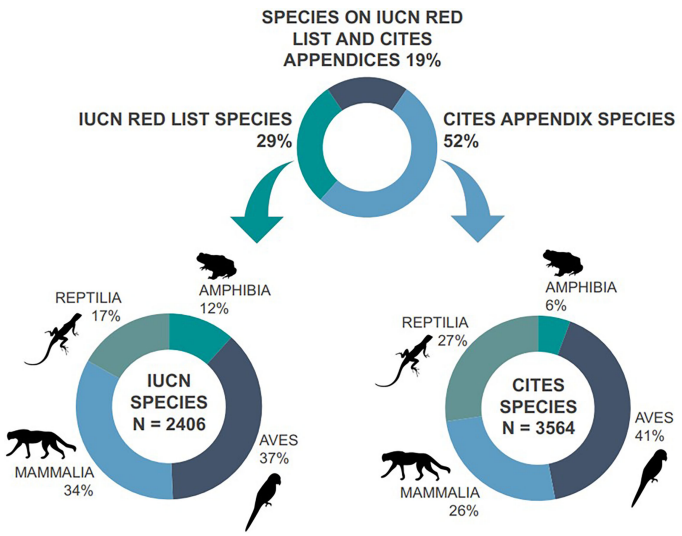

FIGURE 8
Top: The number of species listed on the IUCN Red List threat category 'Hunting and trapping terrestrial animals' N = 2406, the number of species listed on the IUCN Red List threat category 'Hunting and trapping terrestrial animals' that also appear listed on the CITES Appendices N = 953, and the number of species that are listed on the CITES Appendices that are not listed on the IUCN Red List threat category 'Hunting and trapping terrestrial animals' N = 2611 Bottom left: A breakdown of the percentage of species belonging to each taxonomic class (birds, mammals, amphibians, and reptiles) for the 2406 species listed on the IUCN Red List threat category 'Hunting and trapping terrestrial animals' Bottom right: A breakdown of the percentage of species belonging to each taxonomic class (birds, mammals, amphibians, and reptiles) for the 2611 species listed on the CITES Appendices that are not listed under the threat category 'Hunting and trapping terrestrial animals'.

alternative threat categories, and 2,040 are not considered threatened by the IUCN Red List at all.

4 Discussion

Our results show a combined total of 70,422 species listed across the IUCN Red List [including 'Least Concern' species] and CITES Appendices, inclusive of 12,495 species belonging to common commercially traded classes of vertebrae [amphibians, birds, reptiles, and mammals]. Of the total species listed, 2,248 are listed on the CITES Appendices but not mentioned on the IUCN Red List, and 58,488 are listed on the IUCN Red List but excluded from the CITES Appendices. The aim of our study was to interrogate these datasets to explore to what degree they can provide additional protection for wild animals if included in corporate policies prohibiting sales [i.e., trade in species that do not fall under governing legislation from CITES or other applicable international or national laws]. We chose to focus on the IUCN Red List and the CITES Appendices as a case example because of their international ambit, extensive global influence and discernability for non-scientific audiences rendering them popular choices by corporates looking for pre-determined wildlife species lists, but future studies may also benefit from examining additional threatened species categorisation systems with different remits, such as national level databases, including IUCN national Red Lists [see (De Grammont and Cuarón, 2006)].

Our results show that both the IUCN Red List and CITES Appendices list species across a wide range of taxonomic categories, spanning 34 classes [29 under the four IUCN threatened and near-threatened categories and 16 under CITES] and 32 orders [29 under the four IUCN threatened and near-threatened categories and 26 under CITES]. However, the limited number of 'cross-over' species that appear on both lists in our dataset [3,675 species], indicates that only a small fraction of species considered threatened by IUCN population assessments benefit from trade regulations to protect species from overexploitation by international commercial trade according to CITES. While differences in the taxa listed are expected due to the variation in scope between the two organisations [CITES is only concerned with species considered threatened due to trade, where-as the IUCN lists species deemed threatened from a wide range of factors (Berec and Šetlíková, 2021)], we argue that regardless of the cause, there is value in protecting all species threatened with extinction from commercial trade to prevent potential compounding impacts to population declines, particularly as the data required to determine the impact of trade is too often lacking.

Narrowing our comparison to the IUCN's threat category of 'Hunting and trapping terrestrial animals' within the category of 'Biological resource use' showed that of the 2,406 species of

birds, mammals, amphibians and reptiles listed that are potentially threatened by trade, only 355 are listed on CITES Appendix I and are thus effectively prohibited from international commercial trade except for in limited circumstances [It is important to note here that not all of the species listed in this Red List category are considered threatened by commercial trade, some are listed as threatened for small-scale informal trade or subsistence use. Therefore, caution should be applied interpreting this comparison]. A further 598 of these species are listed on Appendix II or III, where commercial trade is largely permitted [with the appropriate documentation]. Therefore, a combined total of 2051 species [598 listed on Appendix II or III and 1453 not listed at all] within common commercially traded taxonomic classes of taxa, receive little or no regulatory protection under CITES. Conversely, there are 2611 species listed on the CITES Appendices that are not listed as threatened in the 'Biological resource use' category of the IUCN Red List. Of these, 571 are considered threatened under alternative threat categories, and 2,040 are not considered threatened by the IUCN Red List at all. This raises questions about why these species, which are considered necessary to regulate for protection by CITES, are not included on the IUCN Red List. It is possible this is due to limitations of the Red List, for example the practical challenges of continuously monitoring such vast numbers of taxa as well as varying levels of resources and expertise (De Grammont and Cuarón, 2006; Heinrich et al., 2020; Hughes et al., 2021). It is also plausible they are included on the CITES Appendices because their trade has been recognised as a threat to other species (via enabling trade in 'look-alike' species), which would indicate that referring to the IUCN Red List as a foundation for corporate trade policy might not be sufficient despite the IUCN Red List including a larger number of species as threatened overall.

For all species [regardless of threat category] within commonly commercially traded taxonomic classes [Aves, Amphibia, Mammalia and Reptilia], there are large discrepancies in the number of species listed between the IUCN Red List and CITES Appendices. This is due to the difference in objectives and remits of the two databases. A total of 8,931 species are listed on the IUCN Red List as threatened or near threatened but 1,012 of these (11%) are only listed on Appendix II and III of CITES, where commercial trade is largely permitted, and 7,445 (83%) are not listed by CITES at all. These differences are particularly pronounced in the class Amphibia, for which 1,893 species are listed as threatened in the Red List with most (91%) being Endangered or Critically Endangered, but only 202 Amphibia species are listed in the CITES Appendices, with most (88%) appearing in the lesser regulated Appendix II and III. Similarly, a previous study analysing which species listed on the CITES Appendices overlap with those classified as threatened under the IUCN Red List found that only between 6-8% of the species [within the classes Aves, Amphibia, Mammalia and Reptilia] appear on both lists (Jouvet et al., 2017), while another study found that out of 958 species that the Red List classifies as threatened due to intentional use and which are traded internationally, 271 (28%) lack CITES protection (Frank and Wilcove, 2019). This suggests that a high number of threatened IUCN Red List taxa are unprotected under formal trade regulation *via* CITES, which could be due to trade not being considered as a threat. For example, many of the Amphibia species listed as Endangered or Critically Endangered are likely so due to widespread chytridiomycosis infection (Fisher et al., 2021). Or, they could be omitted from the CITES Appendices due to limitations with regards to or due to limitations with regards to the amount of time and knowledge required to review a species under CITES. The higher number of species listed by the IUCN Red List could thus indicate that the Red List may be superior as a policy baseline for protective impact for prohibitive sales policies across e-commerce platforms.

However, the discrepancy in listed species does not necessarily mean that the IUCN Red List is a better indicator of species requiring protection from trade, overall. On one hand, CITES is consistently behind the IUCN in species assessment and inclusion (Marshall et al., 2020) and hundreds of species that the IUCN classifies as Critically Endangered, Endangered, or Vulnerable due to international trade currently lack CITES protection (Frank and Wilcove, 2019). But on the other hand, CITES offers wider species inclusion than the IUCN Red List by listing species that look very similar to species that are threatened by trade, on the premise that they are deemed a risk of exploitation by proxy *via* misidentification but do not yet meet criteria for inclusion on the IUCN Red List (Mair et al., 2019). Further, there are significant time lags between the two systems in both directions: data show that when the IUCN assesses a species as threatened due to international trade, there is an average of 10.3 years until CITES lists the same species in Appendix I or II, and conversely, when CITES pre-empts the IUCN Red List there is an average of 19.8 years until species are classified as threatened by the IUCN after they are placed on CITES Appendices (Frank and Wilcove, 2019).

This comparison may lead to the conclusion that using the two lists in conjunction would be a more comprehensive approach for corporates to develop prohibitive trade policies. However, using both lists may still omit taxa that are at risk of exploitation that have not yet been categorised as threatened or had their trade regulated by formal assessments according to either system. For example, despite a recent study providing evidence that almost 4,000 species of reptiles are commercially traded (Marshall et al., 2020), our data show only 1,893 reptile species are considered threatened or near threatened according to the IUCN Red List and only 972 reptile species are listed across the CITES Appendices. Similarly, data from a study assessing confiscated wildlife in Cambodia found that over 60% of trafficked species were not listed at all by CITES, and only listed as 'Least Concern' by the IUCN Red List, further indicating that many species are being trafficked without trade being recognised as a threat to them (Heinrich et al., 2020). Although we acknowledge that trade per se does not necessarily equate to

unsustainable use and that some of these traded species may not currently be threatened, time lags for assessment updates as well as taxonomic bias and gaps in monitoring could mean species are overlooked or could be exploited by trade before they are formally recognised as threatened (Frank and Wilcove, 2019; Marshall et al., 2020; Hughes et al., 2021), particularly for species with life-history characteristics that make them vulnerable to overharvesting (Schlaepfer et al., 2005). The number of threatened animal species recognized by the IUCN Red List has grown steadily by 299% between 2000 and 2021, indicating that a non-threatened species status is all-too often transient if threats persist (IUCN Red List, 2022). Species that are not currently listed may also be at risk of future trade given their high phylogenetic similarity with traded conspecifics, or due to becoming more accessible to hunters as home ranges change as a consequence of climate change and as a result of habitat degradation (Scheffers et al., 2019). Therefore, while trade could theoretically be carried out sustainably, there are many instances where unrestricted commercial trade could exploit wild populations before the impact of the trade can be determined.

Due to the rapidly growing magnitude of the wildlife trade industry, it is unrealistic to expect that populations of all commercially traded species can be comprehensively assessed, or that assessments of wild populations for all species listed will be kept up to date, particularly considering ambitious targets such as the previous aim to reach 160,000 species assessments by 2020 (Betts et al., 2020). Even for up-to-date assessments, the changes in categorisation on lists can reflect change in our knowledge of population status rather than change in status itself (Possingham et al., 2002). This leads us to suggest that caution is required before relying on current threatened species lists to determine species' vulnerability to trade; while these lists may constitute a good foundation to indicate some species that would benefit from protection from exploitation, they are unlikely to be comprehensive enough to be considered an exhaustive list of all species that would be negatively impacted by unrestricted commercial trade.

This is particularly true for commonly commercially traded vertebrae. Species in these classes [e.g., reptiles] are frequently traded as exotic pets, where vulnerability to increased demand for novel species can exacerbate exploitation for trade (Marshall et al., 2020). The low financial values of many species in groups like reptiles are unlikely to raise sufficient attention to up-list them to a formal CITES Appendix, resulting in limited knowledge of trade in these species (Marshall et al., 2020). High demand for novelty also means newly described species, including threatened and unassessed species, can be traded rapidly before status' can be determined or protective measures can be put in place (Hughes et al., 2021). This leads to some experts calling for use of the precautionary principle, whereby trade is only permitted where proof of sustainability is evident, in reverse to the current system which allows trade until proven unsustainable (Marshall et al., 2020).

One problem with this approach is that it would allow trade of some wildlife species and not others, which can create legal loopholes and increased opportunity for laundering of species (D'Cruze et al., 2020). A complex relationship exists between legal and illegal wildlife trade markets, which can be difficult to monitor due to unintentional mistakes such as inadequate record keeping and mislabelling of species, as well as intentional fraudulent activity and infiltration of criminal networks (D'Cruze et al., 2020). Detection of illegal trade among limited permitted trade would require considerable monitoring and enforcement capacity, which would likely be costly and depend on expert knowledge and training throughout the trade chain. These difficulties are exemplified by e-commerce giant Rakuten struggling to maintain compliance with relevant domestic legislation among online retailers, that proved insufficient to prevent the illegal ivory flow across the platform, necessitating a complete ban to close regulatory loopholes (TRAFFIC, 2017).

An additional important factor for corporates to consider when developing wildlife trade policies is that pre-determined species lists like the IUCN Red List and CITES were not created for this purpose. Their remits are only concerned with the extinction risk and conservation status of wildlife species, but there are many other adverse consequences of commercial wildlife trade beyond sustainability, biodiversity loss and species extinction. For example, wildlife trade is a common vector for infectious diseases and invasive species that affect global agriculture production and public health (Phelps et al., 2010). Trade of wild animals provides increased opportunity for the inadvertent movement of pathogens across international boundaries which subsequently creates opportunity for zoonotic disease emergence and transmission on a global scale (Karesh et al., 2005), illustrating why the trade of wild animals has been referred to as a "perfect microbial storm" for pathogenic disease (Brown, 2004). There is no authority for biosecurity regulation or oversight for the international wildlife trade, and where measures are in place to prevent zoonotic disease introduction the current available disease surveillance systems are inadequate for some wildlife diseases or unfeasible to use to screen large volumes of wildlife in transit (Green et al., 2020). Further to the spread of disease, the unintentional introduction of invasive species can indirectly lead to biodiversity loss *via* pathogen emergence (Smith et al., 2009) and cause damages that cost the global economy an estimated US$162.7 billion per year (Cardoso et al., 2021; Diagne et al., 2021).

There are also substantial animal welfare concerns associated with commercial wildlife trade irrespective of the legality or sustainability of the species being traded. The potential for both physical and psychological suffering exists for animals at each stage of the trade chain from wild capture or captive breeding, through to transport and slaughter or final destination/private ownership (Baker et al., 2013; Grant et al.,

2017; D'Cruze et al., 2020). There is no international agreement regulating animal welfare in commercial trade (Whitfort, 2021) and even if efforts were made to improve welfare throughout the trade chain, they are unlikely to be to a degree that enables wild animals to thrive, or that improvements would be consistently implemented across the industry at the expense of financial profit. The animal welfare, public health and biodiversity risks intrinsically associated with commercial wildlife trade remain a concern irrespective of conservation matters addressed by the IUCN and CITES, and are important considerations for companies' CSR strategies, because of their impact on safety, equitability and financial security for communities across the world (D'Cruze et al., 2020).

5 Conclusion

As the corporate sector becomes progressively aware of their role in enabling the trade in wild animals on a larger scale, norms and standards for wildlife trade policies are developing. While there is no doubt that species lists such as the IUCN Red List and the CITES Appendices fulfil important political, social and scientific needs (Possingham et al., 2002) and can provide benefits for species protection, our results demonstrate that these lists alone are not suitable to use as guidance for corporate wildlife trade restrictions if the aim is to provide comprehensive protection for wild animals beyond [legal] commercial trade regulations. Using one list or another would omit taxa at risk of exploitation from protection due to differences in the size and scope of species listed and using both lists in conjunction with each other would still not comprehensively reflect all species at risk of exploitation in the required timeframe, due to the time, money, and expertise required to determine the impacts of trade on wild populations. Further, conservation and sustainability is only one lens for companies to consider for corporate social responsibility, but crucially neither of these lists can mitigate the animal welfare and public health concerns inherently associated with all commercial wildlife trade. A continuation of commercial trade of species not currently listed by IUCN or CITES will continue to pose risks to people, animals, and ecosystems globally. We recommend that corporations looking to develop CSR policies pertaining to commercial wildlife trade consider going beyond the scope of predetermined species lists to help mitigate the harmful effects of commercial wildlife exploitation *via* trade for all wild animals.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: CITES Appendices from https://speciesplus.net/, IUCN Red List data from https://www.iucnredlist.org/search.

Author contributions

JG lead the development of the manuscript and data collection, and wrote the original manuscript. JS-B supported the development of the manuscript in a supervisory role, contributed some text to the original manuscript and provided contributions to the material through reviews of each version of the manuscript. AE provided contributions to the material through reviews of each version of the manuscript and assisted with data analysis and figure production. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

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