Mischaracterising wildlife trade and its impacts may mislead policy processes

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Abstract

Overexploitation is a key driver of biodiversity loss but the relationship between the use and trade of species and conservation outcomes is not always straightforward. Accurately characterising wildlife trade and understanding the impact it has on wildlife populations are therefore critical to evaluating the potential threat trade poses to species and informing local to international policy responses. However, a review of recent research that uses wildlife and trade-related databases to investigate these topics highlights three relatively widespread issues: (1) mischaracterisation of the threat that trade poses to certain species or groups, (2) misinterpretation of wildlife trade data (and illegal trade data in particular), resulting in the mischaracterisation of trade, and (3) misrepresentation of international policy processes and instruments. This is concerning because these studies may unwittingly misinform policymaking to the detriment of conservation, for example by undermining positive outcomes for species and people along wildlife supply chains. Moreover, these issues demonstrate flaws in the peer-review process. As wildlife trade articles published in peer-reviewed journals can be highly influential, we propose ways for authors, journal editors, database managers, and policymakers to identify, understand and avoid these issues as we all work towards more sustainable futures.

Introduction

Overexploitation is a key driver of biodiversity loss (Maxwell et al., 2016) but the relationship between the use and trade of species and conservation outcomes is not always straightforward. While harvest and trade can sometimes benefit both wildlife populations and people, at other times it can drive biodiversity loss (Hutton & Leader-Williams, 2003; Cooney et al., 2015). Accurate characterisation of wildlife trade and an understanding of the impact it has on wildlife populations are therefore critical to evaluating the potential threat trade poses to species and to informing local to international policy responses. Large-scale databases are increasingly being used as tools to guide international conservation policy. These include the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (hereafter 'Red List') and the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Trade Database. Similar databases focus on illegal wildlife trade (Supplementary Material 1). There is also an increasing body of research using datasets derived from monitoring of wildlife trade that takes place online (e.g., Hinsley et al., 2016). Studies using these data sources frequently offer policy recommendations to inform international policymaking (e.g., CITES, 2019a).

Although many examples of wildlife trade research using these datasets appropriately exist (e.g., Gale et al., 2019), research studies that describe wildlife trade and its impacts – and suggest policy interventions – sometimes misunderstand or misinterpret the datasets used and/or inappropriately interpret the results. As research has the potential to influence policymakers taking critical decisions on the sustainability and regulation of wildlife trade, this is problematic. These studies also demonstrate flaws in the peer-review process, and the problem is compounded when subsequent authors apply the same methodologies and make identical errors.

Here, we examine a non-random selection of recent (last ~5 years) research studies and discuss three key issues in wildlife trade research. These are (1) mischaracterisation of the threat wildlife trade poses to species, (2) misinterpretation of wildlife trade data, and illegal trade data in particular, and (3) misrepresentation of international policy processes and instruments. We highlight a generic challenge for researchers through to end-users, and propose ways authors, journal editors, database managers, and policymakers can identify and address these issues. Our purpose is not to specifically critique the authors or their work. Rather, while recognizing that many of these studies present important methodological or other scientific advances, we discuss these articles because they are contemporary and illustrate the issues.

Mischaracterisation of the threat wildlife trade poses to species

Various studies have characterised the threat of wildlife trade to species (Table 1). However, these threats can be mischaracterised where data are misinterpreted, or results are overinterpreted by authors subjectively evaluating the impact of trade on wild populations without supporting evidence.

Misinterpretation of datasets can arise if researchers are not aware of important limitations to the datasets they are using. Regarding the Red List for instance, not all taxonomic groups have been comprehensively assessed, so there are biases in species taxonomic coverage. In addition, not all species have complete data on scope and severity of threats (making it difficult to distinguish the relative impacts of different threats), and information on use and trade of species is incomplete for many taxa because it is not required documentation for Red List assessments (IUCN, 2013). Fukushima et al. (2020), for example, analysed patterns of use and trade among species on the Red List without reference to inconsistencies in documentation. They further estimated the proportion of 'traded' species among threatened species in different phyla but present the results as the proportion of species 'threatened by trade', an incorrect and highly misleading assumption. Using the Red List to determine if use and/or trade is a threat to species requires interrogating the threats classification scheme (particularly scheme 5 on Biological Resource Use) and paying close attention to the associated threat codings. Scheffers et al. (2019) constructed a list of 'traded' species by combining data from the Red List with the species in the CITES Appendices and estimated that trade affects 24% of terrestrial vertebrates globally. However, this mistakenly equates *being in trade* with *risk of extinction from trade* and assumes that all species listed in the CITES Appendices are in trade when they are not (Challender et al., 2019a). Many species are included in CITES for precautionary purposes because they resemble traded species (i.e., are 'lookalikes'; CITES Res. Conf. 9.24, Rev. CoP17), or as part of taxonomic groups where the entire group is listed (higher-taxon listings; e.g., parrots [Psittaciformes spp.]). Additionally, listing species in CITES Appendix I is intended to prevent commercial, international trade (rather than indicate that a species is in trade). A more appropriate analytical approach would have been to identify species *known* to be in trade using the CITES trade data (for international trade in CITES-listed species) combined with data from the Red List and other sources. Table 1 summarises these issues, together with the consequences for the arguments made, and provides additional examples.

Wildlife trade can positively or negatively affect populations of wild species and sustainability depends on appropriate governance of varying interactions between biological, economic, and social factors (Hutton & Leader-Williams, 2003; Cooney et al., 2015). Understanding the impact of trade-driven harvest on wild populations requires data on critical population parameters, including intertemporal harvest rates and their influence on density (Sutherland, 2001). However, various studies (Table 1) have bypassed such in-depth analyses and used trade volumes subjectively to determine that trade is (or is likely to be) detrimental to species populations and thus prescribed policy responses (e.g., include species in the CITES Appendices). Auliya et al. (2016) discussed the impact of trade on particular reptile taxa but concluded that trade in a broader range of species (whether legal or illegal) should, by default, be considered detrimental to their survival. This is problematic because in many cases whether trade-driven harvest is detrimental to populations remains an open question requiring further research. While some species may be threatened by modest levels of trade, others can be traded in large volumes without trade posing a threat to the survival of the species in the wild (e.g., reticulated python *Malayopython reticulatus* and American Alligator *Alligator mississippiensis*; Natusch et al., 2016; Joanen et al., 2021).

Misinterpretation of wildlife trade data

Since 2010, ~130 studies have used the CITES Trade Database to characterise international wildlife trade (UNEP-WCMC, unpubl. data); others have used the US Fish and Wildlife Service Law Enforcement Management Information System (LEMIS) data, or other databases (Supplementary Material 1). However, numerous studies have misinterpreted these databases, resulting in the mischaracterisation of trade dynamics and volumes (Table 1). For example, a common error is treating each row of data in the 'comparative tabulation' output from the CITES Trade Database (which may comprise many shipments aggregated into a single row) as a single trade transaction, which miscalculates transaction frequency (Table 1). Similar misinterpretation applies to LEMIS data, which records trade in all wildlife species that cross US borders. Sosnowski and Petrossian (2020) analysed seizures of fashion-related wildlife products in the US but inflated the number of seizures. They assumed each row of data represented a single seizure, but whether a single seizure is represented by one or more data rows varies. For example, a single confiscated item derived from more than one wildlife species will appear as multiple rows of LEMIS data and should not be counted as multiple seizure events (Natusch et al., 2021). Failure to correctly interpret the number of seizures and/or items seized can erroneously inflate the extent of illegal trade.

Another problem regarding CITES trade data is interpretation of source code ‘I’, which has been used to describe illegal international trade dynamics (Table 1). This code can refer to seizures made due to a lack of valid permits accompanying specimens in trade, or international trade in specimens of species that have previously been seized or confiscated but are being legally exported in accordance with CITES Res. Conf. 17.8 paragraph 8 (e.g., repatriation to the source country). Hence, the code may or may not indicate illegal trade. Without verification from the relevant CITES Management Authorities that trade records do indeed refer to illegal trade it is not possible to accurately characterise illegal trade using these data. Alternative illegal wildlife trade datasets exist (Supplementary Material 1).

Analysis of seizure data is frequently used to understand illegal wildlife trade, but misinterpretation of these data is commonplace (Table 1). While seizure data can be useful to gain insights into illegal trade dynamics, they suffer from inherent biases related to enforcement effort (e.g., resources committed), rates of seizure (proportion of illegal transactions seized) and reporting (proportion of seizures reported to focal database), which differ between countries (Underwood et al., 2013). Critically, these biases need to be appropriately accounted for in order to derive meaningful temporal trade trends or spatial patterns. Underwood et al. (2013) used Bayesian hierarchical latent variable modelling to account for biases and produce relative trends in illegal international trade in elephant ivory using ETIS (Elephant Trade Information System) data. Similar analyses have not been completed for other species, in part because of the large and comprehensive datasets needed (ETIS holds >29,000 seizure records; TRAFFIC, 2019). Yet researchers commonly fail to recognise (or account for) these biases explicitly and/or incorrectly describe illegal trade trends from the raw data in qualitative terms (e.g., illegal trade is increasing) without the necessary caveats. These ‘trends’ are not meaningful. For example, an apparent increase in seizures may reflect greater law enforcement effort or discovery of a previously unknown smuggling method rather than an increase in illegal trade.

Seizure data can be used to: i) estimate the minimum number of individual animals or plants in illegal trade, ii) estimate minimum volumes or quantities of derivatives over a defined period, and iii) characterise spatial trafficking patterns (e.g., countries of origin, export, transit, and destination) based on reported seizures. However, studies using seizure data for these purposes should explicitly acknowledge the inherent biases and the fact that the data reflect known seizures, rather than absolute trade volumes or bias-adjusted trends or spatial patterns.

Misrepresentation of international policy processes and instruments

The framing of research can result in misguided recommendations, stemming in part from authors misunderstanding international policy processes and how policy instruments function. Frank and Wilcove (2019), for example, estimated that it takes ~10 years for species they determined to be threatened by international trade on the Red List to be included in CITES, and argued for a ‘near-automatic pathway by which unprotected species identified by the IUCN as threatened by international trade receive a vote for inclusion in CITES Appendix I or II’. However, this seemingly simple, but ultimately far-reaching, recommendation discounts four main issues, three of which are characteristic of other studies. First, the Red List and CITES apply independent (albeit related) criteria for determining threat status; the Red List sets quantitative thresholds for species to be listed in a particular Red List category, while the CITES listing criteria only provide indicative, non-binding guidelines on numerical values (see Annex 5 of Res. Conf. 9.24, [Rev. CoP17]). Consequently, a species determined to be threatened by international trade according to the Red List may, or may not, qualify for inclusion in CITES (Challender et al., 2019b). Other articles have also made this assumption (e.g., Gorobets, 2020). Second, Frank and Wilcove (2019) focus on Appendix I and II only, overlooking Appendix III. Parties to CITES may unilaterally include species in Appendix III without the lengthy process that would be required for proposing species be included in Appendices I and II, which would reduce the time-lags identified by the authors.

Third, the establishment of a 'near-automatic pathway' would require fundamental changes to the Convention, probably including amendment of the Convention text, requiring the agreement of the Parties. However, the feasibility and political palatability of the proposal were not considered by the authors. This is non-trivial because even suggestions agreed by the Parties can take many years to take effect. The Gaborone amendment allowing regional economic integration organisations to accede to CITES took 30 years to enter into force following its adoption (CITES, 2013). Other studies apply a similar approach to suggested reforms to wildlife trade regulation (Marshall et al., 2020), including the 'reverse listing' model (Altherr and Lameter, 2020), whereby all international trade would be prohibited unless it could be demonstrated to be sustainable. Scientific research should be used to inform potential wildlife trade policy reforms, but such studies should consider the realities of the policy frameworks discussed.

Fourth, Frank and Wilcove (2019) suggest that including species in CITES Appendix I or II may help to avoid the extinction of species, but they fail to acknowledge that such measures may at times do more harm than good. Although designed to restrict trade and reduce unsustainable harvesting, such listings may signal scarcity to speculative collectors, stockpilers, and organised crime groups, and at least in theory could lead to scarcity-driven price increases that in turn raise incentives for accelerated wild harvest (e.g., Asian arowana

Scleropages formosus; Crockett, 2021; Bergstrom, 1990; Courchamp et al., 2006). The assumption that including species in CITES is positive for their conservation is common in the wildlife trade literature. This includes articles which recommend that species be included in the Appendices but fail to evaluate realistically whether it would be positive for those species and how this may change over time (e.g., Shepherd et al., 2019; Table 1). Evaluating the potential conservation benefits and risks to including species in CITES requires an in-depth understanding of the social-ecological system in which harvest, trade and consumption of species occur (e.g., using theories of change; Cooney et al., 2021). Future research which considers CITES as a conservation tool should explicitly evaluate both the potential conservation benefits and risks of including species in the Convention.

Addressing the mischaracterisation of wildlife trade

The publication and dissemination of research that mischaracterises wildlife trade and its impact, and/or mispresents policy processes and instruments is concerning for two main reasons. First, this research may unwittingly misinform or misdirect wildlife trade policy and associated action by government agencies and conservation practitioners (at local to international scales), including the misallocation of resources. Such research may be interpreted uncritically by policymakers and practitioners who may not have the time or expertise to critically evaluate the methodologies used. This could lead to policy which undermines positive outcomes for species and associated benefits for people along wildlife supply chains, contributing to achievement of the Sustainable Development Goals (Booth et al., 2021). More broadly, this research may not contribute towards improved public understanding because the associated press coverage can repeat errors made in publications (e.g., Dunphy, 2019).

Second, the articles discussed demonstrate certain flaws in the peer-review process. Researchers may publish responses, but rebuttals seldom alter scientific or public perceptions of original articles (Banobi et al., 2011), and readers of an article are rarely made aware that a response has been published. Even where they do exist, responses are typically limited in terms of space, especially in high-impact journals, meaning it is not always possible to fully address the problems identified. Once published, the original articles continue to be cited (Cosentino and Veríssimo, 2016) and influence the conservation agenda, to the potential detriment of the science-policy interface.

To avoid the issues discussed in future research, we propose the following measures for researchers, journal editors, database managers, and policymakers.

For researchers: Researchers should familiarise themselves with the datasets they will use before starting their research, to avoid misinterpretation and so they are aware of important limitations and biases. Guidance accompanies various online databases including the CITES Trade Database (UNEP-WCMC, 2013; CITES, 2019b; and see Robinson and Sinovas, 2018) and IUCN maintains protocols and guidance documents pertaining to Red List data (e.g., IUCN, 2013). There are also resources on interpretation of illegal trade data (e.g., TRAFFIC, 2019). Uncertainties concerning the extraction, download, use, and/or interpretation of such datasets should be clarified with database providers and managers, and/or with other academics and CITES Management Authorities (e.g., for CITES source codes).

Researchers should report limitations in the data accurately and any associated caveats, as well as manipulations of the raw data they have made, when presenting analysis or interpretation. Researchers should consider the biological significance of their results and whether use and/or trade represents a risk for species conservation or not, or if there is insufficient evidence to objectively determine the risk. Language is also important and we urge care in its use. For example, a species being used for subsistence purposes does not equate to a species being in trade unless it is purchased/bartered for; being in trade does not mean that trade crosses international borders (though note that ‘trade’ within CITES does refer to international trade); and a species in use or trade is not automatically threatened by this use/trade. More evidence-based interpretation and reporting around use and trade will help to ensure that policy deliberations are well-targeted and that management interventions work for species conservation.

If making policy recommendations, authors should acquaint themselves with the treaties and institutions involved, and with the broader policy and regulatory landscape, to avoid misrepresenting policy processes and instruments. This could be achieved by dialogue with experts in relevant institutions (e.g., IUCN, CITES, and UNEP-WCMC). Critically, researchers should evaluate whether their recommendations (and implementation thereof) would in fact contribute to the conservation of species, or not, and explicitly consider areas of uncertainty and any associated risks (e.g., of CITES listings). If suggesting broader policy reforms (e.g., to treaties) researchers should also offer evaluation of how realistic their recommendations are; considering, for example, timelines, feasibility, and expected impact. This would hopefully result in more robust and informed recommendations.

For journal editors: Journal editors can best ensure the correct use and analysis of wildlife trade datasets by selecting peer-reviewers with in-depth knowledge of particular databases and/or methods used, or the policy instruments involved. These could include individuals with particular expertise (e.g., database managers), many of whom already sit on journal editorial boards, and could therefore be consulted on appropriate uses of data and possible reviewers. Conflicts of interest could be managed to ensure these individuals do not unduly influence the publishing process. While we are not suggesting that the articles we use as examples should be retracted, where wildlife trade articles are published in the future and post-publication review highlights very serious errors in the methods or data analyses which materially and fundamentally affect the key results and/or conclusions, journals could consider retractions as an option, as is done in other disciplines (e.g., medicine) to prevent perpetuation of the harmful errors. Responses which highlight key analytical issues should be presented alongside original articles and made available under open access terms.

For database managers: To facilitate accurate and robust analysis of data on wildlife trade, database managers should provide accessible, up-to-date guidance on the use and misuse of the data they manage, including examples of best practice. Where feasible (e.g., subject to resources) data managers and/or compilers should engage with researchers to develop methodologically sound analyses and support correct interpretation of the data.

For policymakers and civil society organisations: It is important to critically evaluate research before taking a position on an issue, in order to identify methodological errors, especially where these may materially influence the results and conclusions. It is worth checking if any responses to specific articles have been posted online that refute or invalidate the research findings, or if articles have been retracted. If in doubt, and where important policy decisions are being made, policymakers should seek assurances from the authors and independent experts, including the managers of the datasets in question, on the validity of the results.

There is broad research interest in the use and trade of wildlife species. The intention behind this article is not to discourage or criticise much-needed independent research in this field. We strongly support ongoing innovative and exploratory research but emphasise the need for care and caution in analysis, interpretation, and discussion of results – and in making policy recommendations. Specifically, we want to highlight that using datasets in this space (especially those that are publicly available) may require specialist analysis (Dobson et al. 2020). Researchers should be encouraged to take advantage of these datasets, but they should do this with due consideration, aware of the broader policy context and of the potential pitfalls of using secondary data. More effective communication between data generators, analysts, and users would lead to more pertinent, more meaningful, and ultimately more impactful science that is better positioned to make a positive contribution to conservation.

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Author contributions

All authors contributed to the conception, writing, editing and reviewing of the manuscript.

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No primary data were collected for this manuscript and an ethical review process was not undertaken.

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No primary data were collected for this manuscript.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. Issues, consequences for the arguments made by authors, and example articles

Summary	Issue	Consequences for argument made	Examples*
Mischaracterisation of threat from trade	Assuming use/trade constitutes a threat to species or is detrimental to wild populations	Mischaracterizes species as threatened by trade or assumes that trade is detrimental to wild populations when this may not necessarily be the case	Auliya et al. (2016), Fukushima et al. (2020), Harrington et al. (2016), Jensen et al. (2019), Luiselli et al. (2012), Marshall et al. (2020), Scheffers et al. (2019)
Misinterpretation of wildlife trade data	Misinterpretation of CITES trade data:		
	Incorrectly comparing importer- and exporter-reported data	Assumes that differences in quantity between importer- and exporter-reported data reflect reporting issues, errors or 'missing data' when they may result from legitimate differences (e.g., differences in source or purpose code)	Andersson and Gibson (2018), Berec et al. (2018)
	Incorrectly combining direct and indirect trade data	May inflate trade volumes for items that have been imported and (re-)exported several times by treating each export/re-export as a new item	Poole and Shepherd (2016)
	Misunderstanding the use of source and purpose codes†	Mischaracterises trade (e.g., conflates source of specimens/purpose of trade)	Nellemann et al. (2018)
	Conflation in use of terms/units† *E.g., misinterpreting blank units in trade records as missing data (and assuming trade involved the recommended unit for specific derivatives e.g., kg) rather than 'number of items'*	Mischaracterises trade volumes (e.g., inflating the number of individual animals or plants in trade)	Andersson and Gibson (2018)
	Assuming each row of data comprises a single shipment/incident‡	Miscalculates transaction frequency since rows in e.g. a comparative tabulation output may contain multiple records (see Pavitt et al. 2018)	Berec et al. (2018), Can et al. (2019), D'Cruze and Macdonald (2015), Vall-Llosera and Su (2018)
	Assuming source code I refers to illegal trade	Misrepresents illegal trade levels (e.g., number of individual animals or plants involved)	D'Cruze and Macdonald (2015, 2016), Ribeiro et al. (2019), Ye et al. (2020)
	Misinterpretation of LEMIS data:		
	Treating each row of data as a single seizure event	Mistakenly inflates the number of seizures and thereby the extent of illegal trade	Govenechea and Indenbaum (2015), Petrossian et al. (2016), Petrossian et al. (2020), Sosnowski and Petrossian (2020)

	Misinterpretation of seizure data:		
	Failing to acknowledge and/or account for inherent biases in seizure data and describing illegal trade as increasing or similar	Misrepresents illegal trade data and the ‘trends’ derived are not meaningful	C4ADS (2020), Hitchens and Blakeslee (2020), Morcatty et al. (2020), Paudel et al. (2020), Siriwat and Nijman (2018), UNODC (2020), Wildlife Justice Commission (2020)
Misrepresentation of international policy processes and instruments	Assuming species determined to be threatened by international trade based on the Red List would automatically qualify for inclusion in CITES	Overlooks the fact that IUCN and CITES have independent criteria and processes for determining threat status	Frank and Wilcove (2019), Gorobets (2020)
	Assuming all species included in the CITES Appendices are traded	Misrepresents the CITES Appendices and inflates the number of CITES-listed species considered to be in trade	Scheffers et al. (2019)
	Failing to consider the feasibility of recommended changes to policy instruments (e.g., CITES) or trade regulations	The utility of recommendations is difficult to determine because they have not been evaluated in realistic terms	Altherr and Lameter (2020), Frank and Wilcove (2019), Marshall et al. (2020).
	Assuming the inclusion of species in CITES will be positive for their conservation	This assumption is misleading because the inclusion of species in CITES Appendix I or II may be positive or negative for species and change over time	Frank and Wilcove (2019), Harrington et al. (2016), Gomez (2021), Rowley et al. (2016), Shepherd et al. (2018, 2019)

*See Supplementary Material 2 for full citations of articles not discussed in the main text.
†Based on Robinson and Sinovas (2018).
‡Since 2019 shipment-level trade data (with anonymised permit numbers) has been made available as a static download from the CITES Trade Database, updated once a year.

Supplementary Material 1. Known databases focusing on illegal wildlife trade.*

Geographic focus	Database	Description	URL (where applicable)	Publicly available (Y/N)
Global	UNODC World WISE (World Wildlife Seizures) database	Global database of seizures compiled from a multitude of sources, including the CITES Trade Database, CITES Annual Illegal Trade Reports, LEMIS, EU-TWIX, ETIS, World Customs Organisation, government agencies, NGOs, and from UNODC fieldwork.	https://www.unodc.org/unodc/en/data-and-analysis/wildlife.html	N
	TRAFFIC's Wildlife Trade Portal	Global database of open-source wildlife seizure and incident data.	www.wildlifetradeportal.org	Y
	ETIS (Elephant Trade Information System)	Database on seizures of elephant specimens, i.e., including but not limited to ivory, that have been made globally since 1989. The database is supported by various secondary databases which include data on law enforcement effort and efficiency, rates of reporting, domestic ivory markets, and background economic variables.	https://cites.org/eng/prog/eti`s/index.php	N
	World Customs Organization, Customs Enforcement Network Database	A database of seizures, offences, and pictures facilitating analysis of trafficking by agencies with Customs expertise.		N
	Great Apes seizure database	Database of seizures and unlawful situations involving great apes and their parts and carcasses.	https://database.un-grasp.org/	N
	Environmental Investigation Agency (EIA)	Global database of seizures involving elephants, rhinos, pangolins, and big cats.		N
	Wildlife Justice Commission	Global database of seizures on selected species (e.g., pangolins)		N
	Researcher databases†	Seizure databases built by researchers (e.g., from reports of seizures online) which focus on individual species or species groups globally.		N
Regional	EU-TWIX (European Union – Trade in Wildlife Information eXchange)	Database on seizures and offences involving wildlife reported by EU Member States.	https://www.eu-twix.org/	N

	ASEAN-WEN (Association of Southeast Asian Nations-Wildlife Enforcement Network) Seizures database	Database of seizures involving wildlife in the ASEAN region as reported to the ASEAN-WEN Secretariat by law enforcement agencies.		N
National	CITES Annual Illegal Trade Reports	Database of seizures reported by CITES Parties in their annual illegal trade reports as per CITES Res. Conf. 11.17 (Rev. CoP18) on *National Reports.* Parties are required to submit reports on seizures for violations involving CITES-listed species, including those made domestically and at international borders.	For information see: https://www.cites.org/eng/resources/reports/Annual_Illegal_trade_report	N
	US Fish and Wildlife Service Law Enforcement Management Information System (LEMIS)	Database on US imports and exports of live organisms and other wildlife products.		N (except on request via FOIA)
	Other national seizure databases focused on wildlife products held by government agencies	Databases of seizures involving wildlife products made within country.		N

*A range of other organisations likely maintain seizure databases focusing on illegal wildlife trade. See UNODC: https://www.unodc.org/documents/data-and-analysis/wildlife/2020/WWCR2_Methods_Annext.pdf.

†These databases are also known to exist with a focus on particular regions (e.g., ASEAN) or countries only.

Supplementary Material 2. Full citations of articles included in Table 1 but not discussed in the main text.

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