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The gravity of wildlife trade

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ABSTRACT

Unsustainable trade in wildlife products both legally and illegally is a leading cause of population declines and increased extinction risk in commercially valuable species. However due to the clandestine nature of illegal trade and paucity of overarching studies of legal trade our understanding on international trade networks is patchy. We develop a gravity–underreporting modelling framework to analyse and compare: (i) data on the legal trade in mammalian, avian and reptilian products from recorded by The Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) and (ii) to data on the seizures of illegal products entering the USA between 2004 and 2013. We find substantial differences in the factors driving legal trade for the 3 taxonomic groups considered, indicating different drivers for different product markets. Illegal imports for all groups were associated with increasing exporter GDP. We found higher probabilities of underreporting for avian and reptile products, and in general central Africa, central Asia, Eastern Europe and Pacific Island states showed higher underreporting than other regions, indicating the existence of complex trade networks and the potential for the laundering of illegal products through legal markets. Our results show the important regional and economic trends driving wildlife trade. Our new modelling framework can also help illuminate previously unseen aspects of illegal and legal wildlife trade, which can help with the implementation of interventions to curb the impact of trade on wild populations.

1. Introduction

The legal trade in wildlife products globally is vast with an estimated value in excess of US$300 billion in 2005 (Engler and Parry-Jones, 2007). Unsustainable harvesting of wild populations driven by demand can lead to population reductions or even extirpation of species from some areas (Harris et al., 2017; Harrison, 2011; Sreekar et al., 2015). Furthermore, with unregulated trade, humans, native species and livestock are at risk from disease and pathogens which can lead to significant outbreaks, causing both social and economic harm (Rosen and Smith, 2010; Wyler and Sheikh, 2008). Wildlife trade is now one of the most pressing threats to species survival globally.

To address this, The Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates the trade in species of conservation concern between its 183 signatory countries (CITES, 2016a), through a system of appendices and permits/licenses (CITES, 2016b, 2015). As a result, CITES maintains a publically available database of legal trade in restricted species which contains approximately 15 million records (CITES and UNEP-WCMC, 2016). Unfortunately, despite being an excellent resource, the data collection relies on the submission of annual reports, which can be undermined by weak domestic legislation and governance (Reeve, 2006). Consequently, there are inconsistent reporting standards and submission of annual reports across the signatory countries (UNEP-WCMC, 2013), leading to potential underreporting issues and undermining the reliability of some data. More broadly, a lack of integration with economic, human development and governance issues driving wildlife trade (Hinsley et al., 2016; Phelps and Webb, 2015; Reeve, 2006), the low priority given to CITES, and a dearth of resources for its implementation (Poole and Shepherd, 2016; UNODC, 2010) has undermined the ability of CITES to monitor legal trade (Challender et al., 2015).

Due to the illicit nature of illegal wildlife trade (IWT) and the complexity of the criminal networks involved, it is difficult to characterise, quantify and police (Haas and Ferreira, 2015). While similarities between IWT and other flows of illicit goods (e.g. drugs and weapons) exist (Broad et al., 2003), the degree of expertise needed to successfully import some wildlife products may have led to the development of product specific and idiosyncratic networks (Petrossian et al., 2016; Reuter and O'Regan, 2016; UNODC, 2013). Reliable information on the flow of IWT, is difficult to obtain and while several organisations maintain databases of seizures; for example the United States Fish and Wildlife Services Law Enforcement Management

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Information System (LEMIS), the European Union Trade in Wildlife Information eXchange (EU-TWIX) and the World Customs Organisation Customs Enforcement Network (WCO-CEN); the majority are not publically available.

In addition there is a strong taxonomic bias in the literature to high value trade in products from globally threatened species such as tigers (Nowell, 2000), elephants (Beyers et al., 2011; Stiles, 2004) and rhinoceros (Biggs et al., 2013; Milliken, 2014). Consequently our understanding of IWT is geographically biased towards pathways for those products (Kurland and Pires, 2016). Furthermore, available data on the products, volumes and values of the wildlife product being traded illegally present underreporting problems (Blundell and Mascia, 2005; Broad et al., 2003), making any quantification challenging.

Gravity modelling is a technique commonly used in the study of international trade to characterise the drivers and strength of bilateral trade routes (Anderson, 1979; Gómez-Herrera, 2013). In their simplest forms, these models assume the level of bilateral trade (gravity) is determined by economic masses of the countries and distance between them, in the same way the Newtonian gravity estimates the attraction between two bodies. These models can be easily augmented with other terms such as institutional distance, common language and contiguous border (Anderson and Wincoop, 2001) and thus can be used to explore what national level factors determine the volume of trade between two countries.

Here we develop a gravity modelling–underreporting framework, a technique new to the IWT literature, but well established in the study of international trade, and apply it to a database of trade in mammalian, avian and reptilian products requiring CITES permits between 2004 and 2013. We then apply the same modelling framework to seizures of illegally traded products (from the same groups) entering the USA from the LEMIS database. We use this framework to explore the drivers of both legal trade in species of conservation concern and IWT in the USA. We provide the first global overview of factors driving the legal trade in mammal, bird and reptile products from species of conservation concern and estimates of regional trade flows accounting for underreporting. Further, we use the framework to assess the sources of underreporting in both datasets, allowing us to identify potential flows of illegal wildlife products into the USA that are currently undetected.

2. Materials & methods

2.1. Data collection

We obtained data on imports and exports of products from 3 groups, mammals, birds and reptiles, between 2004 and 2013 from the CITES database (CITES and UNEP-WCMC, 2016). We included all source types except 'I' (seizures and confiscations) and 'U' (unknown), and all the purpose types. All the data were requested directly from the UNEP-WCMC and were received on the 16th March 2016. To reduce the impact of many small transactions on our model we used a comparative tabulation of the data, where the trade is summed if they have the same information in several fields (taxon, term, importer, exporter, country of origin, purpose of transaction source of specimen and year). We then counted each record as a single transaction, regardless of the quantity of goods seized/traded. We excluded all records for which the export country was not known and for which the import and export country were the same.

We also obtained seizure records from the LEMIS (TRAFFIC and WWF, 2014) database for the same period, these data were taken from the website http://wildlifetradetracker.org/?db=lemis (accessed on the 20th of March 2016) and the records were manually coded into taxonomic groups. We included all country pairs where legal trade in wildlife products had been reported to CITES between 1996 and 2013. Our country pairs were unidirectional, such that if a pair of countries both import and export to each other it was represented by two observations (e.g. USA to China and China to the USA were included separately). We included re-exports in the same manner as direct trade, and data on the original source country was not included. We assumed the original import of re-exported goods was included in the database separately from the re-export record.

In line with the gravity modelling framework (see below), we modelled the volume of trade in wildlife products between the country pairs as a function of importer and exporter gross domestic products (GDPs) (The World Bank, 2015) and several multilateral resistance terms (Anderson and Wincoop, 2001): the distance between the countries (as measured by the great circle distance between the capital cities), whether there was a contiguous border and if they shared a common language. We also included several additional variables hypothesised to influence the volume of trade and/or rates of reporting between the two countries. For the data on illegal trade, since the importing country is always the same (the USA), only terms relating to the exporter could be included. For consistency we used the same terms for the legal and illegal trade models.

2.1.1. Control of corruption

We hypothesised that countries with higher levels of corruption will trade higher volumes of wildlife products as control over the issuing of permits becomes more lax. We also hypothesised that since the harvesting, export and import of illegal wildlife products often requires the collusion of public officials, the degree to which those officials exercise public power for private gains would increase the level of illegal trade and decrease the rate of reporting for both legal and illegal trade. These data were given in standard normal unites ranging from -2.5 to 2.5 with a higher number referring to less corruption (data taken from www.govindicators.org (Kaufmann et al., 2010)).

2.1.2. Global environmental fund benefits index for biodiversity (BIB)

This is a composite measure of the diversity of habitats available in a country and the degree to which they are protected, where countries with a large range of habitats score highly (e.g. Brazil). We hypothesised that countries with a higher biodiversity benefits index score will trade in higher volume than those with lower biodiversity potential (data taken from http://data.worldbank.org/ (Pandey et al., 2006)).

2.1.3. Environmental performance index (EPI)

The EPI is a measure of environmental performance by country, it has multiple factors including pollution, natural resource management and biodiversity protection. We hypothesised both legal and illegal trade is more likely to move from countries with a low EPI score to countries with a higher EPI score, as better environmental regulations could cause international supply displacement for illegal wildlife products. We used the 2014 figures obtained from http://epi.yale.edu/data (Hsu et al., 2014).

2.1.4. Biodiversity protection

This is the total score from the biodiversity and habitat section of the EPI indicators, it accounts for 25% of the overall EPI score. In this indicator, countries are rated based on the proportion of nationally and internationally important biomes and species found inside the country that are under some kind of official protection (Hsu et al., 2014). We hypothesised that countries with a high score will be more likely to report both legal and illegal trade and will trade in lower volumes as the sources of the products will likely be under legal protection. We took this variable from the EPI 2014.

2.1.5. IUCN member organisations per million people

We constructed this variable by dividing the number of IUCN affiliated organisations in a country by the population in millions. This was used as a proxy for the countries' investment in conservation and civil society engagement. We hypothesised the higher the number of IUCN organisations the lower levels of underreporting.