

*Annual Review of Environment and Resources*  
**Illegal Wildlife Trade: Scale,  
 Processes, and Governance**

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**Abstract**

Illegal wildlife trade (IWT) has increased in profile in recent years as a global policy issue, largely because of its association with declines in prominent internationally trafficked species. In this review, we explore the scale of IWT, associated threats to biodiversity, and appropriate responses to these threats. We discuss the historical development of IWT research and highlight the uncertainties that plague the evidence base, emphasizing the need for more systematic approaches to addressing evidence gaps in a way that minimizes the risk of unethical or counterproductive outcomes for wildlife and people. We highlight the need for evaluating interventions in order to learn, and the importance of sharing datasets and lessons learned. A more collaborative approach to linking IWT research, practice, and policy would better align public policy discourse and action with research evidence. This in turn would enable more effective policy making that contributes to reducing the threat to biodiversity that IWT represents.

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## INTRODUCTION

The trade in wildlife is at least as old as recorded history (1). Early Egyptian and Greek civilizations documented commercial transactions involving wildlife, a practice that has continued uninterrupted ever since (2). Large-scale unsustainable commercial wildlife use was documented during the Roman Empire (1), and contemporary conservation concern about unsustainable use of wildlife dates back to at least the 1960s (3). A renewed interest in wildlife trade among governments, researchers, nongovernmental organizations (NGOs), and the general public over the past decade has been prompted, at least in part, by an apparent surge in East Asian consumer demand and associated increasingly widespread illegal and unsustainable exploitation of high-profile threatened taxa such as rhinoceroses (rhinos), elephants, and big cats, along with others such as pangolins, helmeted hornbills, rosewood trees, and various marine species, including sharks and sea turtles (4–7).

Regulation (e.g., national laws) has been the predominant approach to controlling wildlife trade. The recent focus on internationally traded wildlife has brought calls for increased regulatory attention to controlling the illegal wildlife trade (IWT) from a range of actors, particularly international NGOs. However, there is also a case against excessive and undiscerning regulation. Wildlife trade provides substantial benefits to humanity; harvested wild animals and plants are sought for food, medicine, ornaments, fuel, construction materials, and various other purposes linked to utility, recreation, and culture. Appropriately governed at sustainable levels, wildlife trade may also help mitigate other threats to biodiversity, such as habitat loss through land conversion, by providing livelihood incentives to relevant local stakeholders and bolstering essential economic support to area-based conservation initiatives (8, 9). Wildlife can therefore act as a renewable economic resource, and trade that is legitimate and sustainable can support the pursuit of the internationally endorsed United Nations (UN) Sustainable Development Goals. To this end, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) provides a regulatory framework intended to enable international wildlife trade that is sustainable and discourage trade that is not. Accordingly, the governments of the member countries (Parties) to the Convention play a role in delineating illegality of wildlife trade at an international level

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**Illegal wildlife trade (IWT):** unlawful activities associated with commercial exploitation and trade of harvested specimens of wild organisms

**Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):** regulates international wildlife trade

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through their collective decisions. However, the effectiveness and universal legitimacy of CITES has been questioned (10, 11), most notably in relation to large charismatic mammal species such as rhinos and elephants (12, 13).

The rapidly growing interest in IWT has been accompanied by a surge in published material on the topic, ranging from popular to academic literature, with the latter representing diverse disciplinary perspectives, including those of conservation biologists (14), resource economists (15), policy analysts (7, 16), legal scholars (17, 18), and criminologists (2, 19). These reviews follow earlier broad treatments of wildlife trade policy, which mostly tended to be CITES-focused (10, 20–22). In this article, we review the literature on wildlife trade policy and regulation, as well as trade-related wildlife crime, including poaching and the apparent growing involvement of transnational organized crime syndicates. After defining and discussing essential elements of the trade, we outline the development of theoretical and empirical interdisciplinary research to address it. We then discuss governance and mitigation measures and the evidence on successful interventions to date at three different levels of trade chains, namely supply-side, transactional, and consumer demand. We conclude by reflecting on future directions for effective evidence-based policy to reduce harmful illegal activity to sustainable levels.

## CHARACTERIZING ILLEGAL WILDLIFE TRADE

### Defining Illegal Wildlife Trade

For the purposes of this review our definition of IWT is pragmatic. We define IWT as all unlawful activities associated with the commercial exploitation and trade of wildlife specimens (living organisms or harvested parts thereof). We define wildlife to include all wild fauna, flora (including timber), and fungi; this differs from common usage that often is assumed to mean mammals, or slightly more broadly, terrestrial vertebrates. This is important, because some of the most traded species do not fall into the common usage of the word wildlife. Whereas high-value trade in rhino, elephant, and tiger products is typically prominent, species substantially affected by trade represent diverse taxonomic groups, including birds, reptiles, fish, insects, fungi, and plants such as orchids, aloes, and timber-yielding trees.

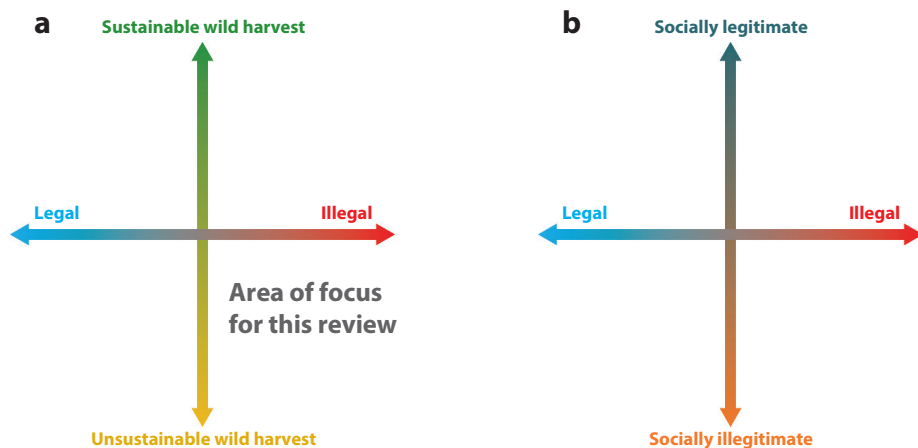
We define trade to include all activities relating to the human harvesting, transportation, commercial exchange (involving money or barter), and end use of wildlife and harvested wildlife products, both at local levels and across legal jurisdictions. Our definition of IWT includes activities that may be illegal but do not necessarily constitute direct or even identifiable threats to species. It does not include activities that are legal but may nevertheless be associated with unsustainable harvesting or damage-causing spread of invasive species; even though these remain issues of conservation concern, our main focus here is on activities that are both associated with overexploitation of wildlife and officially illegal (see **Figure 1**, below).

Challenging our attempt at definitional accuracy, legality constitutes a highly fluid and variable attribute across meaningful scales of analysis. Activities along so-called trade chains, from harvest to end use, are seldom universally classified as completely illegal, especially when such activities cross jurisdictional boundaries. For example, it may be illegal to harvest a particular species from one location, but not from another, as in the case of the majority of orchid species in India, for which it is illegal to harvest inside legally protected areas such as National Parks but not outside them (23). Alternatively, trade in a product may be legal within certain countries but become illegal once it crosses an international border, for example, the Chinese trade in bile from farmed Asiatic black bears, which is legal within China but illegal to export because the species is CITES-listed. Furthermore, harvesting and trade may be illegal in most source countries, but consumption may remain legal in critical consumer countries, as is currently the case for pangolin scales in China and elephant ivory in Japan.

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**Trade chains (supply chains):** distribution networks from harvesters and suppliers of wildlife products via intermediaries to consumers

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**Figure 1**

Simplified representation of contrasting dimensions of legality with (a) sustainability of wild harvest, and (b) social legitimacy. Panel b adapted, with permission, from Beckert & Dewey (26).

Legality also varies in scale and type, from local bylaws, to national laws, to international treaties. Legal violations may similarly vary in nature and scale, from trading activity that is banned outright, to less obvious quota violations, underreporting to avoid tax, and failure to meet certain norms and standards. Recognition of the law and perceptions of the severity of legal violations also vary, and there are instances in which formal laws conflict with local social norms. Institutional theory, in which institutions may be defined as “the humanly devised constraints that structure political, economic and social interaction,” distinguishes between formal institutions (official laws and rights established by government structures) and informal institutions (social customs, traditions, taboos, and codes of conduct), recognizing the critical role of both in shaping human behavior (24). There is therefore a difference between legality and social legitimacy (25), and we need to recognize them as different attributes that overlap to varying degrees across different contexts (26) (Figure 1).

### Measuring Illegal Wildlife Trade

Given the ambiguities inherent in defining IWT, measuring it is challenging (if not impossible) to do with accuracy, and there are no available methods that can produce a global estimate of the species and quantities involved. The majority of analyses are case studies that aim to quantify IWT in specific taxonomic groups or regions [e.g., African elephants (27)], or broad estimates derived from available data [e.g., nearly 7,000 species (7)]. However, such estimates are often based on seizure data reported at the national level, which are subject to detection and reporting biases, for example, toward higher-income countries with better enforcement or reporting capacity (27). Underreporting is also more likely for trade in certain species and products that may be easier to conceal or not high-profile and therefore lower priority for customs agents (28). In a few cases, specialized methods can account for some of these biases, producing more robust estimates of illegal trade, albeit relative trends, such as those associated with the Elephant Trade Information System (ETIS) (27). However, although methods to quantify underreporting are being adopted from other disciplines [e.g., gravity-underreporting models (28)], the majority of seizure data analyses do not adequately account for these important biases (see the sidebar titled Valuing the Illegal Wildlife Trade; also see Figure 2).

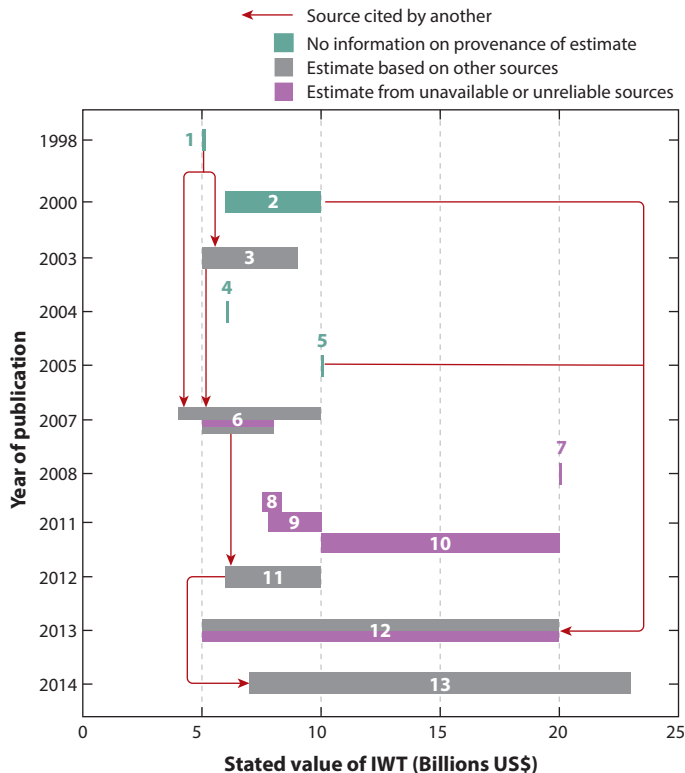
#### Social legitimacy:

a widely shared perception that official rules or actions are acceptable within socially constructed sets of norms

## VALUING THE ILLEGAL WILDLIFE TRADE

To date there have been no robust large-scale efforts to quantify the global illegal wildlife trade. However, there are a number of different estimated financial values for the illegal wildlife trade (usually separating wildlife from timber and fisheries) that are widely cited in the literature, often greatly varying in magnitude (**Figure 2**). The challenge is that most, if not all, of these estimates were obtained either from unreliable sources and/or using unknown methodologies, lending these numbers limited credibility. The lack of clarity in the calculation and dissemination of this key statistic is emblematic of the broader challenges faced by researchers in this field to obtain reliable quantitative data, and a key reason why we have kept the focus of this review on qualitative information.

In contrast, analysis of the legal international wildlife trade is ostensibly more straightforward, due to the availability of data on several traded species. All CITES Parties are required under Article VIII of the Convention to submit annual reports of the number of permits issued, the species and products traded and their quantities, and the origin/destination countries. These data are freely available in the CITES Trade Database, which currently holds more than 18 million records of international trade (40). The CITES trade data also have several limitations, including



**Figure 2**

Dates and sources of global value estimates for illegal wildlife trade (excluding fisheries and timber).

① UNEP (29), ② US Government Interagency Working Group (30), ③ Broad et al. (8), ④ Warchol (4), ⑤ US Department of State (31), ⑥ Lawson (32), ⑦ Alacs & Georges (33), ⑧ Haken (34), ⑨ Pietschmann & Walker (35), ⑩ South & Wyatt (36), ⑪ OECD (37), ⑫ Wyler & Sheikh (38), ⑬ Nelleman et al. (39).

inconsistent use of product, term and unit codes between Parties, misreporting or nonreporting, and the difficulty of comparing trade reported in different units (41). The only global analysis to date converted data into whole organism equivalents to allow comparison between taxa, finding that 100 million organisms per year are legally traded internationally under the CITES system, the vast majority of which are plants (41). In addition to CITES data, there have been calls for better use of customs data to measure the scale of trade, especially those using the Harmonized System codes applied to many taxa that are not CITES-listed (42).

There are some potential avenues for drawing conclusions on where illegal trade is taking place using patterns of underreporting in CITES data (41), or discrepancies between CITES and customs data (43). Furthermore, comparative analyses may reveal useful information for understanding illegal markets, such as when shared economic drivers of certain legal and illegal wildlife markets can be discerned (28).

### Illegal Wildlife Trade Actors

As a wildlife product moves from the point of harvest to an end user (hereafter, consumer) it typically changes hands several times between multiple actors. These actors introduce products into the trade chain (suppliers), facilitate the trade in some way (intermediaries), or purchase the final product (consumers) (Figure 3).

Within these categories, the exact actors vary between IWT trade chains depending on the context, including the species being traded, the scale of the trade, and the presence or absence of a legal market. For a domestic wildlife market, such as the trade in wild-harvested meat (bushmeat), the trade chain may be relatively simple and involve few actors. For example, Cowlishaw et al. (44) identified five key actors in a bushmeat trade chain in Ghana: two suppliers (professional hunters and part-time farmer hunters), and three intermediaries (wholesalers, market traders, and café owners) in addition to consumers. However, domestic trade chains can also be complex, with spatial and temporal variations in actor types and numbers. For example, bushmeat commodity chains in the Democratic Republic of Congo were found to be relatively simple in rural areas (five actor groups), but more complex in urban areas (ten actor groups), and to change significantly during periods of conflict (45).

In contrast, international illegal trade in CITES-listed taxa, such as ornamental orchids from Southeast Asia, requires specialized actors to facilitate international movement. This means that orchids leaving Myanmar and Lao People's Democratic Republic for international markets pass through harvesters, transporters, and retailers, but also smugglers and launderers, in a trade chain involving up to 10 types of actors (46). This example also illustrates how legal and illegal trade

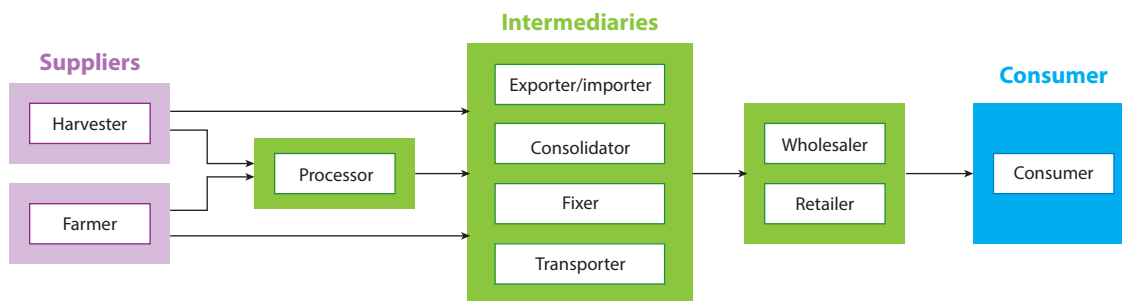


Figure 3

Simplified illegal wildlife trade chain, showing broad actor categories and specific examples of actors that may participate in trade.

in the same or similar products will often result in actors participating in both, including legal orchid farms laundering wild plants to obtain CITES permits, and retailers and consumers who may regularly switch between legal and illegal transactions (47).

Although the number and types of actors are important to consider, the structure of the network in which they operate will affect how resilient they are to different interventions (48). Although Phelps et al. (46) propose seven network types, ranging from a single-actor subsistence-use “network” to more complex networks involving multiple individuals, this analysis is based on only a small number of IWT products for which networks have been mapped, and further research is needed to understand how networks operate in different contexts.

## **ILLEGAL TRADE PATTERNS AND PROCESSES**

Although recognizing the heterogeneous nature of IWT, conservationists are primarily interested in three broad research questions relating to the topic. The first concerns the ultimate impacts of IWT on biological systems. The second involves identifying generic patterns and processes in the trade system that can improve overall understanding of what fundamentally drives IWT. This understanding can help to address the third question, which concerns the relative effectiveness of different interventions to mitigate IWT, such that any negative impacts may at least be reduced to sustainable levels. It follows that if the underlying processes and dynamics are properly understood, policymakers and practitioners are more likely to design and implement effective interventions.

Historically, theoretical and practical research on IWT has arisen from multiple sources, informed by different disciplines. More recently, some of this research and analysis has started to converge, with the increased application of interdisciplinary approaches. We outline some of the prominent epistemological history relating to IWT research and then present a synthesis of some contemporary approaches.

### **Early Evolution of Illegal Wildlife Trade Research**

One way to approach wildlife trade research is to frame it as a natural resource management issue, using the theory developed for renewable resources such as timber and fisheries. Seminal contributions in the economics of exhaustible resources (49), fishery economics (50, 51), and forestry economics (52) established two important insights regarding the regulation of commercial resource harvesting. The first is that, for renewable resource harvesting, the economically optimal level of harvesting is unlikely to equate to the level produced at the biological maximum sustainable yield, and in fact is almost always likely to be lower. The harvest rate is critically influenced by the relative costs and benefits of harvesting as well as the economic discount rate applied by the harvester. This insight was further expounded in the emergent field of mathematical bioeconomics (53), which, despite a strong focus on fisheries, has also been applied to the extinction of terrestrial wild animal species (54).

The second related insight from the resource economics literature is the crucial role of property rights in determining the incentives of custodians, managers, and harvesters and, therefore, rates of exploitation. Whereas the theoretical development of the economic and social significance of property rights took place largely within the domain of law and economics (55, 56), it reached a wider audience following Garret Hardin’s influential “Tragedy of the Commons” article (57). Hardin’s use of the term commons is potentially confusing, as the dilemma he describes relates to conditions of unregulated open access rather than appropriately governed communal property, as subsequently elucidated by the work of Elinor Ostrom and others (58, 59).



Following the establishment of CITES in the 1970s, the World Wild Fund for Nature (WWF) and International Union for Conservation of Nature (IUCN) in 1979 cofounded TRAFFIC, the Wildlife Trade Monitoring Network, as a vehicle to monitor both legal and illegal wildlife trade. This period heralded a new era of more practically oriented research into trade of specific taxa, such as the geographer Esmond Bradley Martin's pioneering work on rhino products (60). The Ivory Trade Review Group's interdisciplinary work on elephant ivory trade included biologists providing evidence on the likely impact of the trade on elephant populations (e.g., 61, 62) and economists exploring the likely impact of an ivory ban on the trade (63). This research was commissioned by CITES to inform its discussions on the 1989 CITES ivory ban, in an early attempt to promote evidence-based international policy making in the wildlife trade arena.

Unlike most elephant biologists (e.g., 64), the economists generally cautioned against using an ivory trade ban as a conservation strategy (63). Supporting this position were theoretical contributions warning of potential adverse price-raising effects of supply restrictions (65) and arguing that wildlife trade bans follow open-access fishery logics, but may be less appropriate for terrestrial animals, for which the opportunity costs of habitat retention and management inputs also require consideration (66). These assertions were followed by a lively exchange between economists over the theoretical efficacy of so-called supply-side approaches to conservation, including the question of managing ivory stockpiles (67), legalizing previously illegal trade (68), possible impacts of wildlife farming (69, 70), the impact of one-off ivory sales (71), and the possible confounding role of speculators (72).

Although most of this work focused on elephants, rhinos, and tigers, the insights derived have potential broader implications for wildlife trade policy in general. However, this body of research affirms that this is a highly complex topic, that the multiplicity of interacting factors substantially challenges the prediction of final outcomes (15, 73), and that outcomes will vary with geography and associated institutional factors (74). This work is relatively unknown outside of the economics literature, and has provided little recent theoretical development or supporting empirical research to discern between competing hypotheses about the nature of demand and the elasticities of either supply or demand curves, apart from a recent empirical estimate of elephant ivory supply elasticity (75). Consequently, more recent approaches to tackling IWT have been grounded in broader and more pragmatic assessments of relevant economic and social drivers (76), and heavily influenced by diverse strands of thought in criminology (77). Nonetheless, the influence of economic thinking remains evident in the evolving transdisciplinary IWT literature.

### **Evolving Interdisciplinarity**

In the early 1990s, conservation scientists combined insights from bioeconomic harvesting theory with economic theories of crime to gain a better understanding of illegal harvesting (poaching) (78). Supported by empirical findings of the significance of antipoaching patrol efforts (79), this research revealed that deterrence depends significantly on a sufficiently high probability of early interception, without which even substantial potential penalties may be an insufficient deterrent of illegal activity. This result has been confirmed by more recent work, which also suggests that product prices are a less significant driver of illegal harvesting (80), and it aligns with contemporary thinking in criminology (81). Other recent progress on this topic includes field research using a range of indirect questioning methods to understand the prevalence of and motivations for illegal resource use in a range of settings (e.g., 82, 83), although there is scope for more exploration of the underpinnings of motivations using frameworks such as utility theory and rational choice.

Notwithstanding cases reflecting some price insensitivity at the level of the harvester (84), much of IWT is assumed to be consumer demand-driven and therefore stimulated by rising



## ETHICAL ASPECTS OF ILLEGAL WILDLIFE TRADE

Research into the ethical issues of human relationships with wildlife has started to draw more attention (97). Although there has not been a specific study of the ethics of IWT, there has been some research on animal welfare concerns associated with wildlife trade in general (98) and ethics of wildlife commodification (99). There is also an increasingly pronounced strand of “compassionate conservation” that employs ethical arguments to condemn the killing and associated commercial exploitation of wild animals regardless of the reasons (100, 101), and van Uhm (2) notes that the field of green criminology extends definitions of crimes beyond legal definitions. This parallels a shift among Western society toward increasingly clear-cut views on appropriate responses to threats to biodiversity, security, and animal welfare concerns, driving further delegitimization and criminalization of wildlife trading activity, even where it is currently legal and sustainable.

market prices. Both theoretical and empirical work demonstrates that restricting supply of a rare species for which demand persists under a ban can have perverse consequences. The underlying insight, labeled the anthropogenic Allee effect by conservation scientists (85), is supported by well-established resource economics principles (86) and calls into question whether supply restriction is a sensible approach for products subject to a so-called snob effect, i.e., those that become increasingly attractive to certain buyers once they become rare (87). Recent empirical work also highlights the critical role of social legitimacy, demonstrating that in the case of rhino horn, the trade of which has been mostly illegal for decades, the international ban continues to be contested by actors along the entire trade chain, thereby seriously undermining the ban’s efficacy (88).

High-value products such as rhino horn and elephant ivory have increasingly become subjects of interest among scholars concerned with transnational organized crime (4, 7, 89) and corruption (90). Recent research has focused on these aspects of IWT in at least two distinct ways. Some of it has been more technical, analyzing transactions costs (91, 92) or criminal networks (93) to understand the machinations of transnational illegal markets, including online markets (94, 95). Concurrently, there has been much critical analysis in the political ecology literature of the conflation of global security concerns with biodiversity loss, leading to so-called green militarization, which is associated with potentially negative impacts on both conservation and local people (96; also see the sidebar titled Ethical Aspects of Illegal Wildlife Trade).

The apparent limitations of policies that seek to restrict supply and trade of certain species products has resulted in an increasing focus on consumers as a key driver of IWT. Although demand for wildlife has been a topic of research for several decades (102), research focused directly on consumers has grown substantially since the start of the twenty-first century. This has included several studies focused on the issue of bushmeat in South America and sub-Saharan Africa (103, 104), followed by a focus on the potential for substitute products for Asian markets (105, 106). Again reflecting the influence of the field of economics in the study of wildlife trade, stated preference methodologies have become popular, being used to better understand the trade-offs that inform the decisions made by consumers of a variety of products (107, 108). However, the coverage of publicly available consumer research is still very sparse, often constraining the design of evidence-based interventions.

### Contemporary Cross-Scalar Analysis

The contemporary IWT research agenda is broad, varied, and driven by multiple agendas, which are informed by diverse disciplinary perspectives and, increasingly, interdisciplinary approaches.

Whereas some scholars (notably those in law and criminology) focus directly on IWT activity and how to prevent it, others (including conservation and social scientists) adopt a broader perspective, trying to better understand the complex links between aspects of IWT and its negative impacts on biodiversity and society. The latter may question whether the full criminalization of wildlife trade is always the most appropriate response to apparent unsustainable practices and would seek to contextualize policy within parameters that may vary between taxa, across physical and jurisdictional geographies, and over diverse consumer market segments. This more nuanced approach can benefit from analyses that cross all three of macro, meso and micro levels.

The illegal wildlife trade forms a part of a greater complex of patterns and processes driving biodiversity decline (109). The principal underlying cause of this decline is the rapid growth of the human footprint, driven by growth in population and per capita consumption, which, in turn places increasing demands on the world's resources. Biodiversity is thus substantially affected through the combined human-driven processes of terrestrial habitat conversion, direct harvesting of wild species, and displacement by introduced species, including domestic livestock, crops, and timber-yielding trees. Such processes take place in the context of complex adaptive social-ecological systems, in which there are multiple positive and negative feedback effects, both bio-physical (e.g., climate interactions) and anthropogenic (110). Within the anthropogenic domain, trade and other human behavior-driven activity is modulated by institutions, which evolve at varying rates (111).

At the macro level, global institutions such as CITES shape policies, consequent responses, and conservation outcomes. Although some scholars have examined the interactions between CITES and other institutions of global conservation governance (66, 112), identifying a need to better integrate habitat conservation objectives with species-oriented CITES approaches, there has been limited further analysis at this level. Scholars of international law have identified institutional mismatch between global governance institutions and implementation at national and local levels (18). Mismatches between macro- and meso-level institutions receive attention in other literature on environmental governance (113) but remain underexplored in relation to IWT.

At the micro level, individual decision making has been modeled in a wide variety of ways (114), including classical microeconomic analyses based on utility and rational choice theories, decision theory (115), and psychology [with a particular focus on the theory of planned behavior (116)]. Recently, fields such as marketing and consumer psychology have come to the fore in IWT research on consumers (117, 118), and criminology is starting to be put forward as a way to understand the motivations of poachers (19). Choice experiments, based on utility theory, are being used both at the consumer end (107) and to explore ways to disincentivize poaching (119). While utility theory can yield important insights, it has also been challenged by fields such as behavioral economics; however, reviewing the theoretical foundations of these disparate fields is outside the scope of this review.

Perhaps least explored to date is interdisciplinary analysis at the meso level. Here, researchers explore how individual behavior is shaped by evolving societal norms, and how individual choices interact with policy through markets. Some interdisciplinary approaches to these questions include contextual criminology, economic sociology (26, 88), and evolutionary institutional economics (120). These approaches remain nascent. The relationship between legal and illegal trade and the manner and extent to which such markets interact remains poorly understood (due to the clandestine nature of the latter) (68). This relationship warrants further penetrating interdisciplinary research using novel combinations of methods, examples of which are starting to emerge (121).

## GOVERNANCE AND POLICY

Prior to the twentieth century, most laws to prevent overexploitation of wildlife took the form of area-based or takings-based regulations set at national or more localized levels of government. In 1900, the United States government established the Lacey Act, the first national legislation to specifically target commercial wildlife trade. Thereafter, several multilateral agreements to control international wildlife trade came into being, including the Fur Seal Convention (1911), the Convention for Protection of Migratory Birds (1916), and the Convention on Regulation of Whaling (1946) (122, 123). Driven by growing concern among conservation groups about the impact of international wildlife trade in the mid-twentieth century, in particular on spotted cats and crocodilians, CITES entered into force in 1975 (124).

Contemporary attempts to address IWT take place within a global governance regime involving states, intergovernmental organizations (e.g., UN agencies), and nonstate actors (e.g., NGOs) (125). Internationally, CITES plays a key defining role in regulating cross-border trade. It is critical in terms of IWT because for species included in the Convention it is the regulatory framework that determines what can and cannot be traded internationally, including the purpose of trade (e.g., commercial versus personal). CITES seeks to ensure that international wildlife trade is legal, traceable, and supplied from sustainable sources (124). States accede to CITES voluntarily but, uniquely for UN conventions, adherence to CITES regulations is mandatory for Parties, with sanctions applied for noncompliance. CITES currently has 183 Parties [182 member states plus the European Union (EU)], and it regulates international trade in approximately 36,000 species, ~84% of which are plants. It includes species in its appendices with corresponding trade controls implemented through national legislation and enforcement measures. Ninety-seven percent of species (~35,000) are included in Appendix II, requiring trade to be closely regulated and subject to a nondetriment finding by the exporting country's scientific authority, and 3% of species (~1,000) are included in Appendix I, prohibiting any commercial international trade in wild-harvested specimens.

CITES has adopted the precautionary principle to guide its decision making on the extent of trade controls, although both the adoption and interpretation of this principle are subject to debate. This centers on inconsistencies between action-guiding and deliberation-guiding versions of the principle. The action-guiding approach implies that action to control international trade should be taken even in the absence of evidence that it threatens species. The deliberation-guiding version stipulates that uncertainty should not be used as a reason for failing to act in the best interest of the conservation of species (126, 127). Uncertainty results in polarized debate on policy directions and decisions, but the position of different actors may be underpinned by divergent values and other motivations (128). It is assumed that states are keen to uphold the Convention (129), but they may have vested interests. They may object to trade restrictions on economically important species or the relaxation of trade regulations for culturally salient species (129). It is also widely recognized that decisions in CITES are made for economic and political, as well as conservation, reasons (130). Moreover, the origins of the precautionary principle lie in 1950s US legislation, and it is an approach to wildlife management not shared by all actors; some, both state and nonstate, prefer an adaptive management approach.

Although decision making in CITES is limited to Parties and their nominated committees (e.g., the Standing Committee), other actors frequently aim to shape these decisions according to their own priorities. Since its inception, CITES has actively sought contributions from intergovernmental organizations and civil society, and many NGOs contribute to CITES, varying in *raison d'être*, size, and agenda. This includes NGOs advocating for sustainable use as well as NGOs concerned with preventing consumptive use of wildlife and promoting animal welfare. These

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### Sustainable use:

the use of biological diversity in a way and at a rate that does not lead to its long-term decline

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organizations employ a range of tactics in pursuit of their often narrow agendas, including framing issues as having a single policy response, (e.g., a trade ban). Examples of this are the 1989 elephant ivory trade ban (125) and proposals to include the polar bear in Appendix I at CoP15 and CoP16 (131). NGOs also work with receptive Parties on proposals to amend the appendices, and thereby play a role in setting the agenda at meetings: They also lobby to influence the position of other actors, most notably Parties.

CITES has adopted several, mainly species-focused, measures to address IWT directly. The most prominent of these are those adopted for elephants. They include the creation of the ETIS and Monitoring Illegal Killing of Elephants (MIKE) systems introduced in 1997 and National Ivory Action Plans (NIAPs) introduced in 2013; they are bespoke and expensive mechanisms designed to guide decision making and provide solutions to illegal trade in elephant parts, in particular ivory. Measures implemented for other species, largely in an ad hoc manner, include the adoption of Decisions, short-term actions, and Resolutions, informal provisions that urge or encourage Parties to take specific actions (e.g., increase penalties and enforcement, destroy stockpiles of given derivatives) to address illegal trade. They also include technical and political missions to problem countries and the creation of bespoke task forces (e.g., the Tiger Enforcement Task Force) to address IWT in specific species (see 21). Attempts at supporting regional action have taken place, to reduce the perception that CITES imposes Northern values toward wildlife on southern Parties, rather than enabling them to make more regionally relevant policy. These include the NIAPs and the Central African Bushmeat Working Group, and the CITES and Livelihoods working group. However, most CITES species do not receive such attention, despite high levels of illegal trade in some cases (e.g., orchids) (132). This lack of attention also extends to fisheries and timber, historically overlooked, but to which CITES is currently paying greater attention (130). Due to the magnitude of IWT in the past decade, CITES introduced an illegal trade reporting mechanism in 2017, meaning Parties are obliged to report on levels of illegal as well as legal trade.

IWT has taken place pervasively despite the efforts of the CITES Parties. Although corruption plays a confounding role, several Parties have genuinely struggled to implement the Convention due to shortfalls in capacity, both historic (133, 134) and contemporary. CITES uses both carrots (e.g., capacity-building support) and sticks (e.g., trade sanctions) to support compliance. However, while these mechanisms—trade sanctions, in particular (135)—have been used, the CITES Secretariat has only very recently started to use mechanisms to address serious noncompliance issues manifest in high volumes of illegal trade by making use of Article XIII of the Convention. Sanctions are perhaps also being used less because of geopolitical considerations, and economically important bilateral relations such that Parties may be more likely to avoid sanctions.

Opinions vary on the effectiveness of CITES, although it is worth highlighting that it was designed in the 1970s based on an understanding of trade at that time. Legal scholars have claimed it to be one of the most successful international conservation treaties of all time (see 136), but this assessment is based on official accession by Parties rather than ultimate conservation performance. By the latter measure, many are skeptical of the Convention. Indeed, it has long been recognized that causally attributing an improvement in species' status to decisions made in CITES is difficult due to the multiplicity of factors affecting species status, and attempting to do so discounts complementary conservation measures (see 137). Contemporary critics highlight that, despite the important role CITES plays, it is ineffective because it over-relies on regulation and fails to contend with the complex social, cultural, and economic nature of wildlife trade, especially the role of local communities in the developing world, despite recognizing the critical nature of these factors (137–139).

Nonstate actors have implemented a range of additional solutions in an effort to support stated commitments to combating IWT. These include NGOs securing and managing protected areas or parts thereof, providing capacity building and support to local enforcement agencies,

and investigating and reporting on illegal trade. Additionally, in the past few years, airlines and other transport sectors have committed to, and in some cases implemented, bans on transporting wildlife products. However, in some cases these measures have conflated trophy hunting and IWT and could potentially undermine effective conservation in wildlife source countries. They also include financial institutions that have committed to assisting in combating IWT through “follow the money” approaches. The effectiveness of such measures in reducing IWT has yet to be determined.

## ILLEGAL WILDLIFE TRADE MITIGATION MEASURES

Given the reality of imperfect enforcement, the prospects of eliminating IWT altogether, as with other forms of law-breaking, are remote. However, a range of IWT mitigation measures can assist in reducing activity to levels that are biologically and socioeconomically sustainable. Such measures can be classified into 3 categories: (a) supply-side, (b) transactional, and (c) demand-side. Supply-side measures can be further divided into those that specifically focus on reducing illegal harvesting and those that seek to provide legal substitutes. Transactional measures are those directed at all activities that take place along the trade chain between harvesting and final consumption. We use the term transactional here to avoid confusion with the word trade, which, by our earlier definition of IWT, includes supply and demand aspects. Demand-side measures are typically aimed at the end users of wildlife products and seek to change their behavior.

Below we characterize how these different intervention types have been used, including a discussion of the available evidence on their effectiveness. The evaluation of these interventions is a complex and difficult task, given the range of drivers that can impact IWT. We consider an intervention to be effective if it changes the indicators of interest as per the intervention goals, in a way that is statistically distinct from what would have happened in the absence of the intervention. Thus, we place the concept of the counterfactual, i.e., what would have happened in the absence of the intervention, everything else being equal, at the heart of our considerations about intervention effectiveness (140, 141).

### Supply-Side Measures

Supply-side interventions can broadly be categorized into those that focus on reducing illegal harvesting and those that seek to provide legal substitutes. Supply-side measures to reduce illegal harvesting constitute the most basic and conventional measures for protecting species in situ. They can assume various forms, ranging from simple restrictions to incentive-based alternatives. Restrictions include basic laws that are either area-based (e.g., legally protected areas) or species-based (e.g., limits on harvest), as well as the enforcement thereof, typically by way of physical protection (e.g., antipoaching patrols, fences) and associated monitoring.

Between 2010 and 2016, at least USD 1.3 billion was invested in combating IWT globally, 46% (USD 609 million) of which was invested in protected area management, mainly in Africa and Asia (142). Systematic research into protected area effectiveness is nascent, but they generally underperform in meeting both their conservation and social objectives. Research suggests that just 20–50% of terrestrial and marine protected areas globally are effectively managed (143). This is principally because of a lack of resources for protected area management, thereby impeding effective law enforcement, as well as poor governance and corruption (143, 144). Traditional antipoaching efforts have been demonstrated to reduce poaching (145), but are characteristically limited in many source countries by human and technical capacity, corruption (146, 147), and insufficient state and donor funding (148).

New tools to address IWT have emerged in the past decade. These include the Spatial Monitoring and Reporting Tool, designed to improve the effectiveness of site-based law enforcement. It has demonstrably increased detection of illegal activities by more than 250% in field testing, but it is too early to assess impact systemically (see 149). Evaluation of species-based approaches is challenging due to a lack of robust ecological monitoring for the myriad species in IWT, also linked to resource shortfalls, and the fact that in many cases monitoring does not feed back into protected area management (144). It is possible to discern the impact of IWT on well-monitored species (e.g., tigers, rhinos) and thereby potentially assess the relative effectiveness of interventions, but these are exceptions; most species are inadequately monitored (150).

Incentive-based approaches have also had application. They have taken varied forms depending on property and resource rights (e.g., state-owned, devolved to local communities, and private landowners) and included sustainable use and management of wildlife and alternative livelihood approaches. They have had mixed success. For example, in Namibia, devolution of land and resource rights to local communities through conservancies has enabled local, community-led wildlife management. Limited harvest of species affected by IWT, including for trophy hunting, is contributing to species protection and increasing populations (e.g., lions, elephants, and others), and local communities receive financial and nonfinancial benefits from hunting as well as photo tourism (151). In contrast, despite widespread application of alternative livelihood-based measures, most projects have not directly monitored the effectiveness of interventions, meaning it is difficult to evaluate when, where, or why they work, if indeed they do (152).

Private landowners, particularly in South Africa, have invested in restocking land with wildlife over the past half century, including species now sought for IWT (e.g., rhinos). Although landowners can benefit from the sale of wildlife, they are currently unable to benefit from the sale of rhino horn because of the international trade ban (153); consequently, they bear the high security costs of conserving rhinos but are currently unable to cover these costs from the sale of rhino horns. For incentive-based approaches on state-owned and devolved land, there is increasing consensus that for supply-side restrictions to be effective for both species conservation and local people, they must be context-specific, designed by and with local communities, and have a clear theory of change; good governance is also essential (128, 152, 154).

Another distinct type of supply-side measure involves the deliberate provision of legal and sustainable alternatives for illegal products, which can be effected in numerous different ways: ranching, farming, artificial propagation, aquaculture, captive-breeding (open- and closed-cycle), and the production of biosynthetic substitutes. The most basic argument for this so-called supply-side approach holds that introducing cheaper substitutes for illegal wildlife products can drive down their prices and therefore reduce illegal harvesting pressure (69). There has been little objective and robust research on supply-side interventions or the impact they may have on wild species, which makes it difficult to draw conclusions about the effectiveness, or not, of these approaches (although see 155, 156). However, there are useful examples to draw upon. There is consensus that ranching and captive-breeding of crocodylians has been successful in displacing IWT of species in various countries in South America and sub-Saharan Africa (e.g., 138); however, this has not been the case in parts of Southeast Asia. Research on the impact of cultivation of the xaté palm concluded it may result in a negative impact on wild populations, because among other factors, it could increase harvesting for the establishment of plantations (156). Other potential examples include big cat farming. Domestic restrictions on the trade in tiger products in China means that farming as a supply-side intervention has, by definition, not been properly implemented. However, in South Africa, lion farming appears to have provided a substitute source for tiger bone products from 2008 to 2015 (157).

An absence of robust frameworks with which to evaluate the impact of supply-side measures also inhibits effective evaluation of these interventions. Evaluation would necessitate understanding production processes and costs (wild versus supply-side), consumer demand (e.g., cross-price elasticities of demand, consumer preferences), market actors, market power and structure, forms of competition (e.g., price versus quantity), and many other associated but context-specific factors (69, 158). Stockpiling effects and interactions between legal and illegal markets conflate the impact of supply-side interactions but also require consideration. Although generally receiving of scant research attention, Fischer (68) demonstrated that the results of specific policy decisions are dependent on specific market characteristics. Further research is needed to evaluate the potential impact of supply-side measures on species threatened by IWT, including the management of stockpiles (159) and proposals to use biosynthetic substitutes (160).

## Transactional Measures

Broadly, transactional measures fit into three categories: those that aid physical detection of illegal products in the trade chain, those that identify wider networks of actors and address the enabling environment for IWT, and high-level measures such as CITES and national legislation that aim to regulate trade.

Detection of illegal wildlife products as they move through the trade chain is essential for the enforcement of wildlife trade regulations and can also help to detect illegal actors and trade routes. Forensic analysis techniques can be used to spot-check the legality of traded products by determining key factors such as the species or even individual (161), the geographical origin (162), or its age. The utility of individual methods depends on the resources available and the specific question being asked. For example, potential methods for differentiating protected rosewood timber species from lookalike taxa range from mass spectrometry to the use of detector dogs, but the most widely used method is simple visual inspection of wood anatomy (163). In contrast, molecular methods are more effective for highly processed edible or medicinal products, which are often impossible to identify visually to the species level (164). Furthermore, molecular methods that can identify origin have identified the source of illegal ivory, to allow implementation of targeted antipoaching interventions (162). The application of potentially costly and complex methods may not be appropriate in all cases, and although there is a wide range of methods available, relatively few are in regular use by law enforcers. The main barriers to uptake for new methods are likely to be expense of equipment, lack of reference databases for most traded species, and a lack of trained personnel (163), reflecting the need for interventions to be designed based on real-world conditions.

Although forensic analysis can be used to verify whether a suspect item is illegal, methods to track legal products through the trade chain can also prevent laundering and support supply-side measures. These approaches include voluntary certification schemes, such as the Forest Stewardship Council for timber, and the Marine Stewardship Council for seafood (165), which confirm the legality of transactions at each step in the trade chain. Although not widespread for other wildlife products, voluntary certification has been suggested as a potential traceability measure for products such as ivory (90) and orchids (47). Although limitations exist, successful certification schemes are those with a combination of external and internal characteristics, including governmental support, and stakeholder engagement (165). Effectiveness in reducing IWT is not often considered in evaluations of certification, but well-known forestry certification schemes often comply well with principles related to protecting endangered taxa and preventing overexploitation of target species (166). Certification schemes may be underpinned by whole supply-chain traceability methods, which include physically marking or tagging a product to allow customs and enforcement personnel to identify it as legal during transit. Methods that have been employed in the wildlife trade



include the use of tamper-evident seals, which are required by CITES for international trade in crocodile and leopard products. These methods have several drawbacks, including the expense of applying them, and the potential for forgery. Although forgery is more likely with simple physical markings, there is also the risk that more sophisticated systems can be undermined if tags or codes are removed during processing, or stolen, as happened with crocodile and leopard tags from Mozambique (76).

Detecting physical movement of products through a trade chain is one approach, but it often neither addresses the problem of wider enabling factors that allow IWT to take place nor identifies many types of illegal actors. For example, corrupt government officials or legal, enforcement, or financial professionals may never physically handle a product, but their actions can prevent the enforcement of legislation and facilitate illegal trade chains (167, 168). Improving identification of actors is essential, as corruption cannot be addressed as an entity in itself, instead requiring a targeted response tailored to the specific issue or actor group (90). For example, corruption can lead to the leakage of ivory stockpiles into the illegal trade, which may be addressed through the destruction of stockpiles (169), although the effectiveness of this approach is unknown (159). Social network analysis has been demonstrated as an effective method for identifying key countries or actors that play crucial roles in an IWT network (170), and is implemented by NGOs to gather intelligence and design interventions to disrupt networks (171). Although financial investigation to gain intelligence on transactions between illegal actors is considered a key intervention to address other transnational organized crimes, there has been little implementation of these measures for IWT in practice (172). Similarly, intelligence-led approaches have been suggested as an important step for IWT following their success in other illicit trades, but one evaluation of their application in Uganda noted that a lack of trained intelligence analysts was a major limitation to their use on the ground (77). Measures used to address the illegal drugs trade, such as controlled deliveries, may have application to IWT (173), but no studies of their implementation have been carried out.

Ensuring that wildlife trade is adequately regulated, and enforcing these regulations, is a key transactional measure. In broad terms, evaluating the success of CITES is complex, but the persistence of illegal trade in listed species has been used as evidence that the Convention is not succeeding in its aims (137). Some cases of reduced demand following up-listing of species to Appendix I exist, but with the wealth of interventions taking place on both the supply and demand sides, it is difficult to attribute these reductions solely to the implementation of CITES (137). To further highlight the complexity, up-listing of some species to Appendix I has been shown to increase trade in the months prior to it taking effect (174). Overall, although efforts have been made to understand patterns of illegal trade through seizure data in some high-profile species (27), data on trends and scale of noncompliant trade in the majority of CITES-listed taxa [e.g., orchids, which comprise >70% of CITES species (132)] are too poor to draw firm conclusions.

One measure of success is the extent to which CITES Parties have adopted appropriate domestic legislation for its implementation. This is tracked through the CITES National Legislation project (NLP), which reported in 2017 that only 55% of Parties have legislation that meets the requirements for implementation of the Convention, showing little progress from 51% in 2013 (137). In some cases, domestic or regional legislation can impose stricter controls than CITES. For example, Annex A of the EU Wildlife Trade Regulations imposes stricter import conditions than the broadly analogous CITES Appendix I, and contains several species, such as the crested porcupine *Hystrix cristata*, that are not CITES-listed. In reality, there is huge variation in the ability of Parties to enforce CITES due to capacity levels; the extent to which wildlife trade, and IWT, is a priority; and among other factors, political limitations to enforcement. The development of the International Consortium on Combating Wildlife Crime (ICWC) has led to multiple

collaborative initiatives to support national governments and improve enforcement of IWT legislation, including the provision of capacity building training and online toolkits focused on key enforcement issues. This move to a coordinated, holistic approach has received support as an effective way to address IWT on local, regional, and global scales (175).

## Demand-Side Measures

Demand-side measures may be coercive, such as when they take the form of legal measures (bans on purchase, consumption, or possession) or may rely on volunteer behavior change, as in the case of social marketing or education campaigns (117, 176). Although there are some recent examples of the former, such as limits to consumption of shark fin soup in official state functions in China (177), little is known about their use and effectiveness. Recently, NGO-led demand-side measures have focused on voluntary behavior change, with interventions ranging from awareness-raising campaigns, which aim to simply disseminate information, to more strategic and evidence-based attempts at behavior change, such as social marketing campaigns (178). These measures may aim to redirect consumers from illegal product sources to legal and sustainable substitutes or to discourage consumers from using a certain type of product altogether. They can target consumers directly or indirectly, through the use of key influencers such as peers, doctors, or religious leaders. These groups may not only have the ability to influence end consumers but in some contexts, such as in the case of doctors, may themselves be the driving force behind the demand for a wildlife product (108, 179).

Demand reduction activities are increasingly recognized as indispensable for efforts to address IWT to be sustainable in the long-term, which explains why there has been an increase in such interventions (178). However, demand reduction has to date received a small proportion of the funds allocated to tackle IWT globally (142).

Looking at the focus of past demand reduction campaigns, there is a clear taxonomic bias, with large terrestrial mammals receiving the most attention, although marine IWT is also represented mostly by sharks and by efforts related to seafood (178). However, groups such as plants have been virtually ignored, despite the fact that they represent the overwhelming majority of species listed in CITES, and in cases such as timber species, also some of the highest market value (178). This taxonomic bias also has implications for the spatial distribution of demand reduction efforts to date. With most consumers of high-profile products such as rhino horn, elephant ivory, tiger bone, or pangolin scales residing in Asia, it is not surprising that this region has been the most targeted by these efforts (178). There has also been a large proportion of campaigns with a global focus or that did not target a specific product or target audience. These campaigns, based on a one-size-fits-all model, highlight some of the limitations around design and evaluation that have been documented for demand reduction interventions, although there is wide heterogeneity across campaigns and organizations (117, 180).

In terms of design, the key limitations have been a reliance on anecdotes and personal experience instead of robust consumer research, a lack of use of behavioral theory, lack of audience segmentation, and the use of messaging that is not evidence-based (117, 180). In the context of intervention, one aspect that has been scarcely researched, despite receiving much public attention, is the use of key influencers, namely celebrities from the entertainment and sports world, as part of the strategy of several demand reduction campaigns (181). Although the existing evidence base is limited, it suggests that the involvement of celebrities in these campaigns is often not strategic and there are clear trade-offs between, for example, willingness of the public to engage and message recall (181).

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**Demand reduction:** efforts aimed at reducing the public desire to consume wildlife products from illegal and unsustainable sources

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In terms of monitoring and evaluation, a major obstacle has been measuring demand. Although price data are often possible to obtain, their interpretation is not simple, as changes in both supply and demand affect prices. Moreover, simply asking consumers about their consumption patterns is not feasible in situations where the use of wildlife products is illegal or socially sensitive. To address these challenges, conservation scientists have increasingly adopted specialized survey techniques that ensure respondent anonymity and thus reduce nonresponse and social desirability biases (182). These techniques have their own complexities, both technical and in implementation (83, 182). Beyond determining the prevalence of consumption behavior, the evaluation of demand reduction interventions has suffered from a lack of basic reporting of data related to changes in the behavior of target audiences (i.e., outcomes) and to changes in biodiversity (i.e., impact). The majority of campaigns only report information on campaign strategy and output, which relates to campaign implementation not to results (178). When outcomes and impact are reported, their usefulness is often undermined by a lack of focus on behavior, with many campaigns focusing only on knowledge or attitudes, and a reliance on experimental designs that have a high risk of bias in terms of their ability to determine causal relationships (e.g., uncontrolled before-after designs) (178).

There has often also been a lack of recognition of the many and heterogeneous societal drivers of demand, beyond the actions of conservationists. Examples of this complexity can be seen in the context of the declining demand for shark fin in China, commonly attributed to demand reduction campaigns, and the demand for owls as pets in the United Kingdom, often linked with the Harry Potter film series, despite the fact that neither of these narratives is supported by evidence (177, 183).

All these limitations are not restricted to IWT but are shared more broadly with behavior change interventions for conservation in general (140, 184). Moreover, recent publications have explored a range of impact evaluation techniques and demonstrated that robust impact evaluation is possible in the context of IWT (185–187). For example, work by Chaves et al. (185) showcased how randomized control trials can be used to evaluate demand reduction for bushmeat in an urban context using social marketing, demonstrating a positive impact of the intervention. In East Africa, Veríssimo et al. (187) focused on the nuances of evaluating behavior change interventions for bushmeat consumption delivered through mass media. Salazar et al. (186) used general elimination theory, a qualitative impact evaluation technique, to understand the role played by social marketing and education efforts in the recovery of the Yellow-shouldered Amazon parrot (*Amazona barbadensis*) in Bonaire.

## FUTURE PERSPECTIVES

IWT is a complex, fast-changing, and heterogeneous issue. Given limited resources and differing (or even conflicting) values and objectives among those seeking to address it, uncomfortable trade-offs in decision making and final outcomes are inevitable. Contemporary research is becoming increasingly interdisciplinary and policy-oriented, but still suffers to some extent from silo effects and associated inherent biases. Policy, especially toward charismatic species, appears to be driven more by public sentiment and political considerations than by evidence, and issues of legality, social legitimacy, sustainability, and animal welfare are frequently conflated (e.g., legal trophy hunting being equated with IWT). If such conflation results in the closure of markets for legal and sustainable wildlife products, the consequent negative impacts on equity and human development among local communities (due to loss of property rights and increased human-wildlife conflict) could have adverse socioeconomic impacts and ultimately further undermine biodiversity conservation.

For the sake of biodiversity, the current emphasis on IWT involving large charismatic animals could usefully be redirected toward addressing the most threatened taxa, many of which are

receiving inadequate attention relative to their conservation status. In some instances, this emphasis has helped to fund security in specific state-protected areas (for example, for key rhino populations); however, many other areas also require substantially more effective protection and management to control the supply of harvested products. Whereas CITES will probably remain a core instrument in addressing IWT, its somewhat simplistic regulatory logic is both inflexible and outdated. To be effective, IWT policy requires evidence-based multifaceted interventions from both state and nonstate actors that go beyond regulation. Future solutions should be informed by appropriate cross-scalar analysis and innovative thinking across natural and social sciences, arts, and humanities. They should also involve all relevant stakeholders and incorporate local and indigenous knowledge. Appropriate solutions will vary between species, geographical areas and other contexts, and might consist of diverse combinations of measures at the supply, transactional, and demand levels.

Innovative research can help identify appropriate specific mitigation measures but should be informed by complex adaptive systems thinking and draw on past theoretical economic and institutional analyses that are supported by empirical evidence. Areas in need of further research include the interactions of legal and illegal markets and more critical analysis of the effectiveness of various interventions (to ensure that, for example, demand reduction measures do not result in counterproductive boomerang effects). Although consumer engagement shows promise as a rapidly growing focal point, effective demand reduction activities need to be long-term, coordinated efforts forming part of unifying strategies rather than ad hoc campaigns; they further need to be informed by disciplines such as behavioral economics and social marketing and subjected to rigorous impact evaluation. Finally, the inevitable ongoing paucity of data and persistence of value conflicts will continue to undermine attempts at evidence-based policy. To this end, future research initiatives should also employ methods such as participatory scenario planning and horizon scanning (188), to engage a wider range of relevant stakeholders. This will support the development of better predictive models that are robust to uncertainty in a rapidly changing and unpredictable world (189).

## SUMMARY POINTS

1. Illegal wildlife trade (IWT) is associated with threats to the Earth's biological diversity and has gained international political profile in recent years.
2. Not all trade that is classified as illegal is of equal concern to conservation scientists. Of particular concern is trade that is linked to unsustainable levels of exploitation, although certain charismatic taxa tend to receive more attention than others. Trade that is both illegal and unsustainable, but retains social legitimacy among harvesters, intermediary actors, and consumers, presents the greatest challenge to policy makers.
3. Although overall volumes of IWT are known to be substantial, IWT is complex and highly heterogeneous, and eliciting information is challenging given its illegal nature. Robust quantification is therefore very difficult.
4. Research on illegal wildlife trade is becoming increasingly interdisciplinary in nature, incorporating biological research with various strands of social science, and necessitating cross-scalar analysis integrating macro, meso, and micro levels.
5. Governance of IWT is framed by the UN Convention on International Trade in Endangered Species of Wild Fauna and Flora, but increasingly influenced by nonstate actors.

6. Mitigation measures vary widely, targeting the supply, transactional, or demand points of supply chains. Although limited evaluation of the effectiveness of such measures has taken place to date, it seems clear that a lack of integration and consistency between actions taken at different points in the trade chain will undermine the chances of success.

## FUTURE ISSUES

1. Can international governance of IWT (including CITES) be reformed to better accommodate habitat-based concerns and more complex social-ecological nuances across different contexts, including more appropriate engagement with relevant local communities?
2. How can scholars and policy-makers engage all relevant stakeholders and overcome inherent value conflicts that drive inconsistent approaches to IWT mitigation, thereby often undermining it?
3. To what extent will future IWT policy be driven by scientific evidence rather than public sentiment, and what are the implications?
4. Can the attention of policy-makers and the public be redirected from less seriously threatened large charismatic mammal species to the thousands of less prominent animal and plant species that are more critically threatened by unsustainable levels of illegal commercial harvesting?
5. How can researchers robustly measure changes in wildlife abundance and distribution, and attribute them to the effects of IWT and associated mitigation measures, so as to quantify progress toward any chosen conservation goal, in the context of a dynamic, multiscale, partially observable social-ecological system?
6. How can researchers improve understanding of the complex interactions of legal and illegal markets along entire trade chains?
7. How can researchers improve understanding of IWT consumer motivations and behavior, in order to bring about effective and sustainable behavior change?

## DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review. Some authors have existing collaborations with various governmental and nongovernmental organizations, but these are governed by intellectual property clauses to preserve our academic independence.

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