Tools and terms for understanding illegal wildlife trade

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Illegal wildlife trade (IWT) is a global conservation issue that threatens thousands of species, including fish, fungi, medicinal plants, and charismatic mammals. Despite widespread recognition of the problem, debates on the science and policy of IWT generally concentrate on a few high-profile species (eg rhinoceros, tigers, elephants) and often overlook or conflate complex IWT products, actors, networks, and contexts. A poor understanding of IWT is aggravated by the lack of systematic vocabulary and conceptual tools with which to analyze complex phenomena in a more structured way. We synthesize the available evidence on IWT across taxa and contexts into a typology-based framework that considers (1) the diversity of wildlife products; (2) the roles of various actors involved with IWT, including harvesters, intermediaries, and consumers; and (3) common IWT network configurations. We propose ways in which these tools can inform structured analyses of IWT, to help ensure more nuanced, appropriate, targeted, and effective responses to illegal wildlife harvest, trade, and use.

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Illegal wildlife trade (IWT) targets thousands of species of terrestrial and marine animals, plants, and fungi worldwide (IUCN 2016), with cascading impacts on the environment, livelihoods, food security, national security, and sustainable development (Dickson 2008; Brashares *et al.* 2014; NOAA 2016). While trade in many taxa is legal and regulated, escalating illegal trade is of increasing conservation concern globally. IWT has attracted renewed societal, media, and political attention, as well as hundreds of millions of dollars in additional investment, largely in response to marked increases in elephant and rhinoceros poaching (Duffy and Humphreys 2014; Sutherland *et al.* 2014; UW 2014).

There are growing scientific and policy debates over which types of conservation interventions are most effective, including increased enforcement, demand reduction strategies, and provision of alternative livelihoods, as well as market-based and incentive-oriented approaches (Biggs *et al.* 2013; Sutherland *et al.* 2014; Duffy 2014; Bennett 2015). The diversity of proposed interventions reflects the complexity of IWT, yet many policy debates approach IWT as a simple and homogeneous phenomenon (Österblom *et al.* 2011; Brashares *et al.* 2014). For example, taxonomic biases mean that a few charismatic species (eg rhinoceros, tigers, elephants) are treated as representative of broader IWT (UW 2014), while the vast majority of traded species are overlooked (Nijman *et al.* 2012a). Similarly, IWT discussions frequently classify the roles and motivations of diverse actors into simplistic categories of "poachers", "perpetrators", and "criminals" (Duffy 2014; UW 2014; US 2014). Diversity is further obscured by a growing focus on organized criminal syndicates in the trade of some taxa, which overlooks more mundane forms of wildlife trade and use (Bennett 2011; Pires 2012; Douglas and Alie 2014; US 2014; Duffy 2016).

Indeed, illegal systems can be difficult to study directly; as a result, not surprisingly, many policies underappreciate associated patterns and nuances (von Lampe 2012). However, lessons from the illicit drug trade highlight the limitations of interventions based on popular misunderstandings about illegal trade dynamics. Broad assumptions about how trade is organized and responds to interventions have led to policies that overlook the

In a nutshell:

- Policy debates often treat illegal wildlife trade (IWT) as a homogeneous phenomenon that affects a small number of high-profile, charismatic species
- There is a need to recognize the diversity of products, actors, network structures, and contexts that define IWT activities
- We present a a set of tools and terms that can be used to evaluate this diversity more systematically
- The tools we present can help inform the design of conservation actions and research to ensure more appropriate and effective policy responses

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underlying causes of trade, and tend to ignore the resilience of trade networks to enforcement (Williams 1998; Kenny 2007; LSE 2014). These policies can also fail to anticipate unintended consequences such as social impacts and undesirable price signals (eg when enforcement restricts supply only to result in price increases that stimulate further trade).

Greater precision in IWT studies and debate is further impaired by the lack of a standardized vocabulary and an absence of frameworks to dissect IWT phenomena (South and Wyatt 2011). There is a clear need for tools to help navigate the diversity of products, actors, networks, and contexts that comprise IWT in a way that is structured and comprehensible (Ostrom 2009; Laird *et al.* 2010; von Lampe 2012). A shared lexicon would allow for more nuanced and productive dialogue, and improve formulation of research and conservation interventions.

Here, we review IWT across taxa and contexts, drawing from the IWT literature and field experience in order to (1) define IWT products, (2) present a typology (categorization based on shared attributes) to define the key roles of IWT actors, (3) present a typology to understand common IWT network configurations, and (4) illustrate how these tools can facilitate a structured analysis of IWT interventions.

Defining IWT products

IWT involves the harvest, trade, and use of wild, biological specimens for purposes ranging from food to ornaments to construction (Table 1). It affects a wide range of flora, fauna, and fungi, and both live specimens and various wildlife products needed or valued by humans. Notwithstanding that some forms of wildlife trade are legal, IWT is characterized by actions that contravene stated environmental regulations, including government legislation, rules governing private/community resource-holder rights, and/or international agreements (eg the Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES]). Equally, many instances of harvest and trade are unsustainable from an ecological perspective, but are not necessarily illegal.

Despite a tendency to associate IWT with a narrow range of taxa, trade affects thousands of species, including timber, marine organisms (eg illegal, unreported, and unregulated fishing), small mammals, insects, plants, and reptiles (Laird *et al.* 2010; Nijman *et al.* 2012a; IUCN 2016). Importantly, single species can provide multiple products that may enter completely different value chains (eg medicinal versus ornamental orchids). In addition, different forms or sources of a single product may be legal, while others are illegal (eg farmed versus wild-collected specimens; organisms collected within or outside of official quotas; individuals traded domestically versus internationally).

Characterizing IWT actors

IWT involves a range of actors in harvest, trade, and use dimensions. Actors differ not only in roles they play along market chains, but also in their socioeconomic attributes, preferences, and motivations; scales of operation and intensities of harvest; levels of technological investment; and sources of funding, levels of economic reliance, and knowledge, including that of associated regulations (Muth and Bowe 1998; Wyatt 2009; South and Wyatt 2011; Duffy *et al.* 2015).

Our typology distinguishes roles played by harvesters, intermediaries, and consumers that, while not mutually exclusive, categorize key patterns across IWT situations (Table 1; Figure 1). Actors can participate in multiple roles, with a wide range of motivations that are both context- and value-dependent, and that can change over time (South and Wyatt 2011; Duffy *et al.* 2015). Some actors are also highly specialized and focus on target-specific taxa, while others are more generic (eg wild meat, fish). Although illegal wildlife harvest and consumption are frequently characterized as the result of economic poverty or greed, motivations are usually far more complex (Duffy *et al.* 2015); even among comparatively poor communities, wildlife consumption can be associated with preferences, stature, and higher incomes (Mbete *et al.* 2011). Similarly, harvesters may be poor in absolute terms, but well off in comparison to their neighbors, where IWT offers better economic prospects than alternative opportunities (Vira *et al.* 2014).

Wildlife harvesters

We distinguish among eight broad categories of harvester roles (Table 1; Figure 1). Subsistence harvesters are primarily engaged in the collection of wild resources for household or non-commercial local uses (Golden *et al.* 2013), but can overlap with more specialized commercial harvest. For example, in central Vietnam's Thua Thien Hue Province, forest-accessing communities regularly use snares in subsistence harvest, although some residents also rely on targeted, specialized cages to trap stump-tailed macaques (*Macaca arctoides*) to supply luxury urban markets. Similar combinations of subsistence and commercial harvest exist among the Waorani communities in the Ecuadorian Amazon (see Example 3, below).

Both subsistence and commercial markets can also involve opportunistic harvest. In central Vietnam, residents sometimes fell *Scaphium lychnophorum* trees to more easily harvest its seeds for international markets (ELW, pers obs). While commercially motivated, behaviors such as this represent neither a regular nor primary livelihood, and are usually overlooked in IWT discussions (Muth and Bowe 1998; Eliason 1999; Pires 2012).

Specialized commercial harvesting often requires sophisticated technologies, networks, funding, and coor-

Table 1. Typology of key actor roles along IWT market chains

Harvesters	Subsistence	Non-commercial harvest for household or local use (eg food, cultural, see list below), usually comparatively small scale
	Specialist commercial	Harvest with an explicit commercial orientation that often involves specialist skills or technologies. Includes different harvest intensities and levels of technological investment, and is led by both self-employed and hired harvesters, as well as by local residents and non-residents.
	Opportunist	Harvest based on chance encounters and circumstances, but not as a primary objective or livelihood strategy
	Local guide	Local residents hired to guide non-resident harvesters
	Rule abuser	Knowing abuse of harvest rules, such as quotas (eg under or mis-reporting), boundaries (eg protected area), or restrictions on technology (eg certain traps, nets)
	Bycatch	Unintentional harvest of non-target species
	Recreational	Harvest for enjoyment
	Reactionary	Harvest associated with discontent or protest (eg in reaction to conservation policies or conflict with wildlife)
Intermediaries	Logistician	Involved in ordering, aggregation, and transport, as well as financing and planning trade. May be directly involved in handling trade or involved at a distance.
	Specialized smuggler	Transport that requires specialized actions to evade detection or negotiate access, usually across borders (eg transboundary smuggling, specialist networks)
	Government colluder	Involved in using an official government position (eg park ranger, police officer, judge, prosecutor) to facilitate trade, whether for financial (corruption), social, or personal gain
	Third party	External services hired to support trade, but potentially unknowingly (eg bus or air transport)
	Processor	Involved in product transformation (eg skinning, medicine preparation)
	Launderer	Involved in laundering illegal wildlife into legal markets chains (eg via captive breeding or processing operations)
	Vendor	Involved in direct sale to consumers or to other intermediaries (eg market, online platform)
Consumers	Medicinal	Use associated with medicinal practices, usually traditional but some novel
	Ornamental	Use associated with ornaments and pets (eg ivory, shell, live parrots, aquarium fish)
	Cultural	Use associated with long-standing traditional practices (eg feathers, pelts, ritual harvest)
	Gift	Use as a gift, often to gain/demonstrate social standing or show respect
	Investment	Use as an investment, usually of high-value taxa
	Recreational	Use associated with the act of recreational harvest (eg game hunting, sport fishing)
	Animal food	Use as food for other animals (eg fodder, bait, small animals)
	Construction materials	Use for construction materials (eg timber, rattan)
	Fuel	Use for burning for heat or cooking
	Food	Use for direct consumption, ranging from luxury consumption to basic nutritional need

Notes: Categories are not mutually exclusive.

dination. At the extreme, harvesting of high-value taxa and products (eg tigers, rhinos, birds of prey, shark fins, hardwood timber) often involves non-local professional harvesters, criminal syndicates, and connections to the political elite. These individuals or groups may hire local residents (local guide) to harvest wildlife or guide non-local harvesters (GW 2007; Wyatt 2009; Bennett 2011). Recent African ivory seizures highlight the ability of these commercial harvesters to adapt to increasing enforcement (Milliken 2014; Vira *et al.* 2014).

Illegal harvest can also occur when harvesters break the rules associated with legal harvest systems (rule abuser).

Figure 1. *Diverse types of IWT harvesters. (a) Subsistence harvester with porcini mushroom (*Boletus edulis*) collected without permits in Forli Province, Italy. (b) African elephant (*Loxodonta africana*), widely targeted for ivory across its range by specialist commercial harvesters, often with support of local guides. (c) Inspection of a fishing vessel in the Gulf of Guinea suspected of abusing fishing rules (engaging in illegal, unreported, and unregulated fishing).*

For example, the abuse of allocated harvest quotas in the fishing and timber sectors, the use of illegal technologies such as snares or dynamite fishing, and hunting or collection within protected area boundaries can convert otherwise legal harvest into illegal goods (Hatcher and Gordon 2005; Radjawali 2011). Similarly, accidental bycatch of protected species (eg in snares or nets) can represent illegal takes.

Illegal harvest can also be associated with recreational activities, or can represent a defensive response to conflict with wildlife, such as crop raiding that affects rural livelihoods, or opposition to conservation policies (reactionary harvester; Muth and Bowe 1998; Oldfield 2003).

Trade intermediaries

Supplying wildlife or associated products to consumers typically relies on actors generically described as "middlemen", although intermediaries in illegal networks can serve diverse and complex roles (UNODC 2002). Working as logisticians involved in moving goods in ways that require specific contacts, networks, and skills (Warchol 2004; Wyatt 2009), such intermediaries may be directly involved in ordering and handling illegal goods, or may be more distantly associated through financial links or by coordinating logistics for others (Milliken and Shaw 2012; Milliken 2014). Because accessing markets for illegal products can be challenging and risky, intermediaries are often critical in facilitating access across international borders (specialized smuggler), for instance by bribing or working with government agents (government colluders; eg Figure 2; Pires 2012; Vira *et al.* 2014). In some instances, intermediaries may be third parties that are unaware of their roles, as in the case of airlines or bus companies (TRAPS 2015).

Intermediaries may also engage in physical transformation of wildlife, such as cleaning, butchering, skinning, or preparing medicines (processors; eg Vira *et al.* 2014), which may require specialized skills or infrastructure, such as sawmills for timber. In addition, intermediaries may provide laundering services that integrate illegal products into mainstream legal value chains (launderers), as has been documented among farms that claim to raise porcupines for meat (Brooks *et al.* 2010), reptiles and birds for pets (Lyons and Natusch 2011; Shepherd *et al.* 2012), and at lumber mills processing timber for furniture (GP 2014). Most visibly, intermediaries also include consumer-facing vendors and their associated platforms (eg public markets, online platforms).

Wildlife consumers

Consumer uses of wildlife are as diverse as the taxa illegally traded (Table 1). Public attention is largely on the medicinal use of charismatic taxa in Asia. However, thousands of other species are also used as medicines globally (Laird *et al.* 2010; Nijman *et al.* 2012a), and many taxa have other, complex social meanings and diverse uses (Courchamp *et al.* 2006; Truong *et al.* 2015). Wildlife and their parts can have ornamental uses, including as pets (Wyatt 2009; Pires 2012), can serve as cultural objects (De Angelis 2012), and/or represent high-value gifts or investments (eg Gao and Clark 2014; Truong *et al.* 2015). Wildlife may be involved in activities where harvest itself is a recreational or cultural act (Muth and Bowe 1998). Some wildlife are used as animal food to feed captive domesticated animals (Naylor *et al.* 2000), for construction materials, and as fuel (eg charcoal;

Wyatt 2013). Importantly, many taxa are used for food, both to meet basic nutritional requirements and as luxury products to satisfy a range of consumer preferences (eg Example 3, below).

Consumers may be present anywhere along the market chain, including at or near the point of harvest, in association with transport, or at defined end-markets, restaurants, or online portals. Illegal transactions may occur in open markets or in secret, including through clandestine transactions, through the anonymity of online sales, or through the laundering of wild products (eg Figure 4). Importantly, downstream consumers are not necessarily aware of the origins of such products (eg Figures 2 and 4) or of related regulations (GP 2014).

Understanding IWT networks

Actors in IWT are arranged into diverse network configurations (UNODC 2002; Kenney 2007), of which we identify seven common structures (Table 2). Their architecture ranges from simple relationships – such as the subsistence and local use relationship, or a structure that links harvesters directly to consumers (Table 2, a and b) – to configurations that involve multiple intermediaries (Table 2f). Much of this complexity arises from restrictions to access, whether to the resource itself, to transport routes, or to consumers, including to distant urban or international markets willing to pay higher prices.

A network configuration restricted by resource access is defined by trade structured around a specific geographic area and/or limited set of harvesters (Table 2c). For example, the Lao newt (*Laotriton laoensis*) is endemic to high-elevation streams in a small area within northern Laos. As a result, international collectors have relied on local residents with species knowledge and access to harvest newts for the pet trade (Phimmachak *et al.* 2012).

Gatekeeper configurations arise when a limited number of intermediaries control market access, based on the provision of pivotal services, contacts, or capital that enable them to overcome transport, enforcement, or technical barriers (Table 2d). For instance, the illegal timber trade in Pará, Brazil, relies on central mills that provide timber processing and avenues through which to launder illegal timber into legal supply chains (GP 2014). Similarly, the Indonesian reptile trade requires specialized knowledge, contacts, and access to

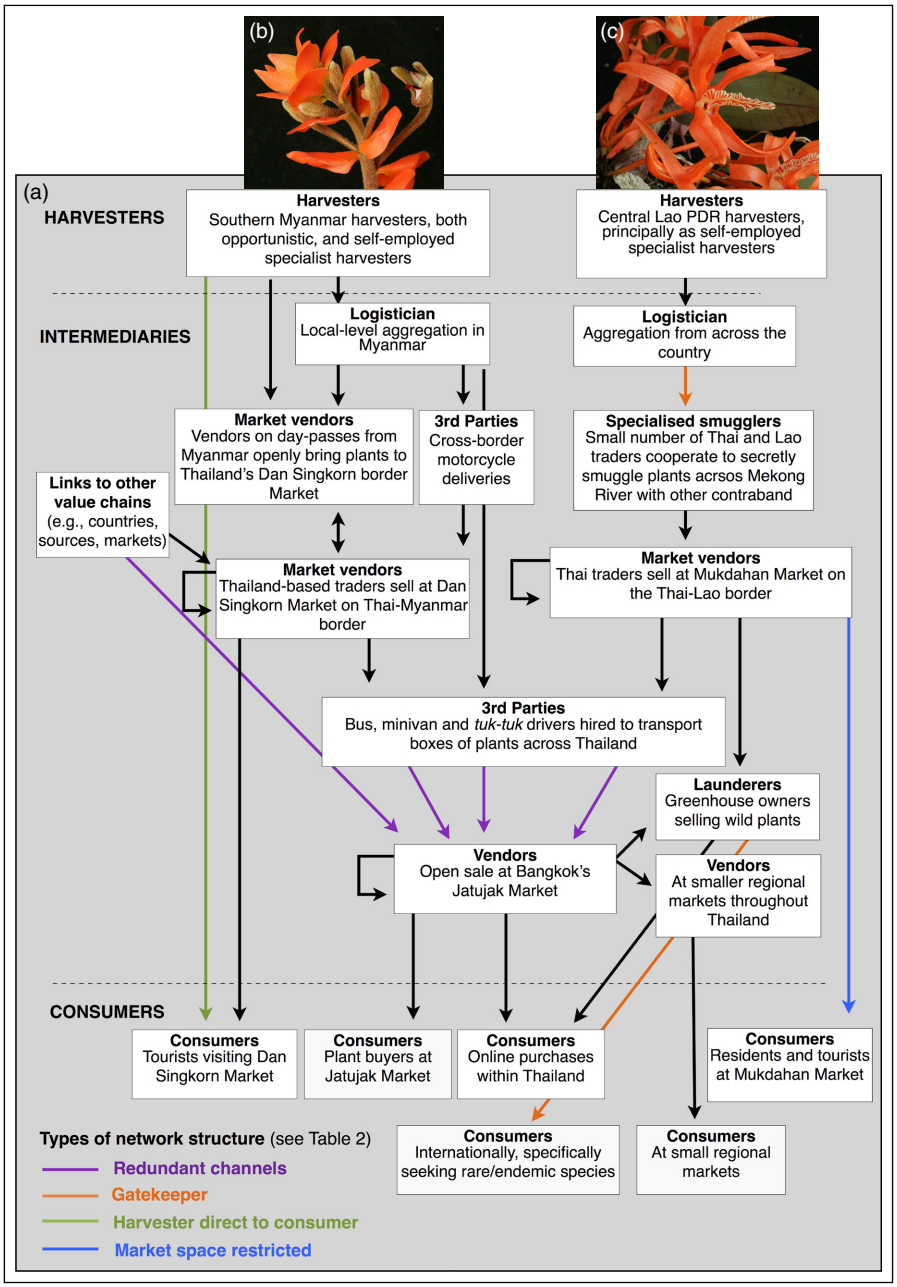
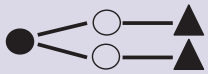
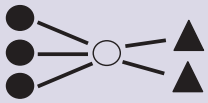
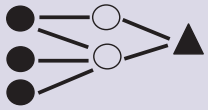
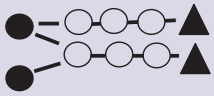
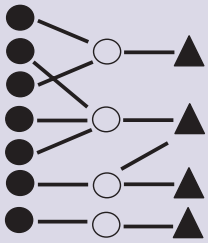


Figure 2. *Network of illegal trade in protected ornamental orchids harvested in Southeast Asia. (a) Overview of trade network of plants from Lao PDR (People's Democratic Republic) and Myanmar for sale in Thailand and internationally, including the roles of harvesters, intermediaries, and consumers (Phelps 2015; Phelps and Webb 2015). Colored lines illustrate selected examples of trade network structures (see Table 2). (b) Ornamental orchid* (Eria ornata) *commonly harvested in Myanmar. (c) Ornamental orchid* (Dendrobium lamyaiae)*, a narrowly distributed (possibly endemic) species harvested in Lao PDR.*

Table 2. Typology of common IWT network configurations

Type of network	*Illustrative architecture: harvesters (black circles) – intermediaries (white circles) – consumers (triangles)*	*Explanation*
(a) Subsistence and local use		Harvest principally for household or very local use
(b) Harvester directly to consumer		Harvesters have direct market access, usually due to geographic proximity
(c) Restricted access		Resources access at source is limited by species distribution, required harvest technology, user group rights and/or enforcement
(d) Gatekeeper		Market access is limited by a small number of intermediaries, potentially because of their ability to circumvent legal restrictions, access to technology, or market monopolization.
(e) Market space restricted		Market access relies on a limited number of sites or platforms (eg markets, Internet sites)
(f) Multiple barriers to market		Market access limited by multiple barriers, such as geographic distance, high enforcement and/or processing demands
(g) Redundant channels		There are few barriers to participation in illegal trade, potentially because resource is abundant or widely distributed, and/or enforcement is low

Notes: The network types listed (a–g) can refer to either the structure of entire networks or to the "building blocks" of more complex, compound networks.

permits to enable international trade (Figure 4). The live reef fish trade uses expensive technologies to keep fish healthy and attractive until they reach overseas restaurants (Radjawali 2011). Such centralized structures are also likely where criminal syndicates exclude other participants through force (Bennett 2011; Milliken 2014).

Trade networks can also be restricted by market access that mediate consumer access (Table 2e), such as specific stores, neighborhoods, markets, or online portals to which trade is restricted, forcing or enabling certain patterns of trade interactions. Restrictions may require several linked intermediaries (Table 2f) to enable transport, evade enforcement, pay bribes, and/or leverage social networks to facilitate trade across protected area boundaries, police checkpoints, or international borders (Radjawali 2011; Vira *et al.* 2014; Phelps 2015).

Structures with redundant pathways are characterized by complex web-shaped configurations, which are the result of few barriers to participation in harvest and/or access to market (Table 2g). These networks involve widespread participation and exchanges among a larger number of individuals and are more likely where enforcement is weak.

Trade frequently involves compounded networks that integrate multiple configurations (Table 2). For example, Southeast Asia's trade in wild, ornamental orchids affects hundreds of species and involves unexpectedly complex trade networks (Figure 2; WebPanel 1).

Beyond actor and network mapping, understanding IWT requires evaluation of the contexts that shape actors' decisions – determining actual and perceived rewards, effort, preferences, and risks associated with illegal behavior (eg WebPanel 2; Ostrom 2011). These contextual factors include biological characteristics (species abundance, distribution, fecundity) and physical variables (topography, seasonality, infrastructure), which affect access to wildlife as well as effort and profitability from IWT. Decisions are further shaped by governance context, such as the legal–regulatory framework and the effectiveness of enforcement, which influence the secrecy and effort involved in harvest, processing, and transport; the penalties associated with getting caught; and the perceived legitimacy of the rules (South and Wyatt 2011; Moreto and Lemieux 2014). Decisions are also defined by social context, including individual agency (Duffy *et al.* 2015), relationships to specific wildlife products

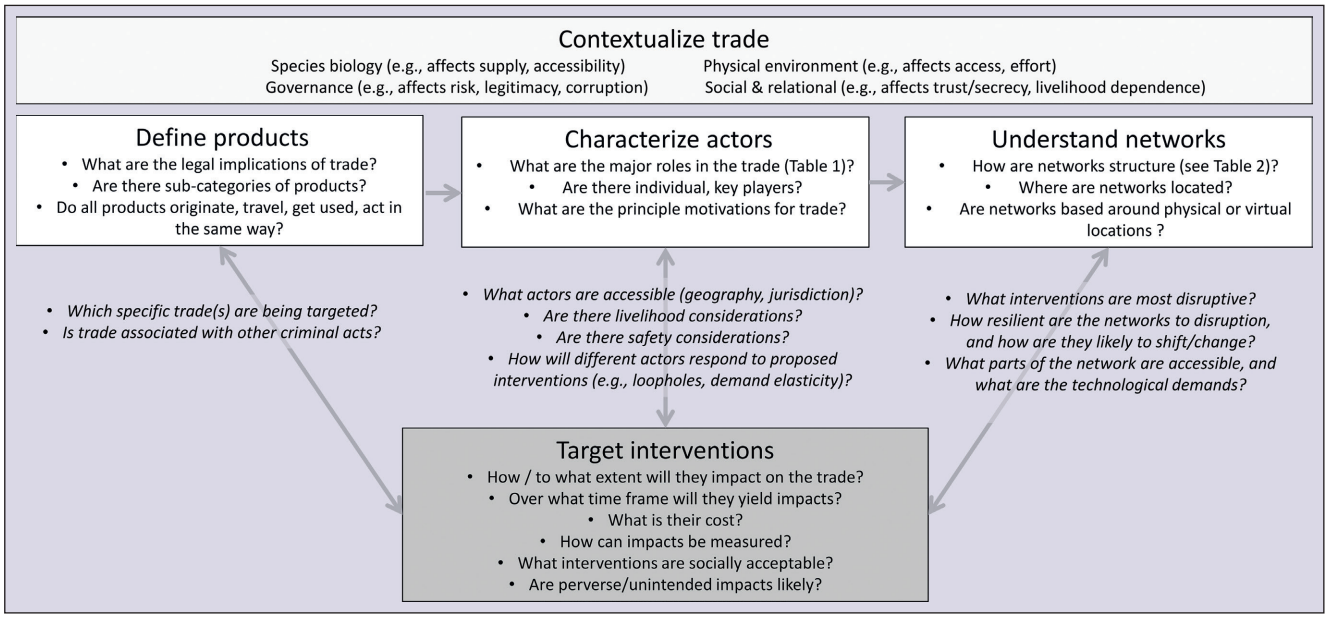


Figure 3. *Framework for evaluating IWT interventions to consider contextual parameters, products, actors (Table 1), networks (Table 2), and their relationships to conservation interventions. The framework is expanded in WebTable 1.*

(Gao and Clark 2014), knowledge about where to find wildlife, and levels of trust, fidelity, transparency, and benefit sharing among actors (McGloin and Kirk 2010; Radjawali 2011).

IWT actors and networks are dynamic; they adjust to changes in biophysical parameters (seasonality, weather, abundance), market pressures (price increases), and governance contexts. For instance, some consumers' preferences for rarity can simultaneously increase harvest pressure and increase rarity (Courchamp *et al.* 2006). Changes in enforcement actions can yield novel interactions (Williams 1998). For example, increased enforcement apparently led to new configurations in Russia's falcon trade (Wyatt 2009) and to a shift to online sales in China's ivory trade (Gao and Clark 2014).

Implications for conservation

Trade dynamics are a function of interactions among actors, networks, and products, which are themselves embedded in a range of biological, physical, governance, and social contexts (Figure 3). These factors not only interact but also shape how different conservation interventions play out, including likelihood of success and unintended outcomes.

Faced with this complexity, a typological approach has the potential to help conservation practitioners consolidate vocabulary and concepts across taxa and contexts. It is particularly useful with regard to limited ecological data, conservation resources, uncertainty, and contention over the most appropriate interventions, to facilitate policy debates, inform research, and craft more nuanced, socially appropriate, fair, and effective interventions. The following examples highlight parts of a typology-based framework (see also WebPanel 3) and how it can be used to inform interventions, with each species also benefitting from full evaluation (eg WebPanel 1).

Example 1: Defining products – Southeast Asian orchid products

Commercial trade is an intense, targeted threat to many Southeast Asian orchid species (Figure 2; Phelps 2015; Phelps and Webb 2015). Conservation efforts have traditionally focused on restricting international trade, although these rules are widely disregarded (Phelps and Webb 2015). Structured IWT analysis (Figure 3) highlights opportunities for strengthened interventions, including those based on an improved understanding of orchid products themselves.

There are important differences (in consumer preferences, prices, and networks) between the trade of relatively common ornamental species and that of rare and endemic species targeted by specialist consumers (Hinsley *et al.* 2015; Phelps 2015). Moreover, the trade in ornamental orchids exists alongside a trade in medicinal species. Although both involve similar geographic areas and even some of the same species (eg *Dendrobium nobile*), these transactions generally involve separate actors and networks, and are largely decoupled from trade in other wildlife (Phelps 2015).

Conservation interventions must therefore define which subset of orchid products they target. For example, while conservation actions have primarily focused on

overseas markets, much trade is regional (Phelps and Webb 2015). Moreover, despite considerable sales activity at public markets, this predominantly involves ornamental species (Phelps 2015); interventions focused on these markets would largely overlook the region's growing trade in medicinal orchids. Differences among products also shape consumer-oriented interventions, and must distinguish between informal gardeners who might unintentionally buy wild ornamental plants and specialists who may be aware of, but unconcerned about, the conservation implications of their purchases (Phelps *et al.* 2014). Raising awareness through targeted outreach and offering improved access to sustainable greenhouse-grown plants can effectively change behavior in informal gardeners, but may fail to influence specialists, who might be more motivated by enforcement.

Example 2: Characterizing actors – South African rhinoceros horn harvesters

South Africa, home to over 80% of the world's remaining white rhinos (*Ceratotherium simum*), saw a tenfold increase in poaching between 2007 and 2014, principally to supply the East Asian medicinal trade (Milliken and Shaw 2012). Conservation efforts focus on strengthening trade bans through anti-poaching efforts at the point of harvest and enhanced enforcement efforts along the supply chain (Biggs *et al.* 2013; Milliken 2014). However, effective interventions must also recognize that rhino poaching involves a diversity of harvester types and contexts.

Substantial illegal harvest takes place within Kruger National Park by residents of neighboring, generally impoverished communities, some of whom may work for or with organized criminal syndicates (Milliken 2014). Illegal harvest also occurs on privately owned land, where landholders can collect horns from rhinos that die naturally or that are de-horned to minimize poaching risk (Biggs *et al.* 2013). Horns are stored in guarded vaults but have recently been subject to theft by organized criminal groups (Herskovitz 2013). Faced with this dilemma, some farmers have reportedly colluded to have horns stolen from their property for financial gain.

These distinct roles and contexts may merit different interventions. For instance, South African landowners can legally own and harvest wildlife on their property. Legalizing the international trade of sustainable, non-lethally harvested horn could create incentives for these actors to engage in conservation and sustainable use (Biggs *et al.* 2013). Nevertheless, interventions necessarily differ in contexts where wildlife is owned by the state and where hunting is illegal, such as in national parks or in Kenya. These contexts may require enforcement alongside alternatives, such as poverty reduction and/or payments to local communities as incentives to reduce poaching. Conservation practitioners must also be capable of crafting nuanced responses, such as distinguishing between local actors contending with poverty and non-resident actors affiliated with criminal enterprises (Roe *et al.* 2015).

Example 3: Characterizing actors – Amazonian wild meat consumers

Ecuador's Yasuní Biosphere Park and Reserve is a biodiversity hotspot, home to Waorani indigenous communities, and subject to IWT for wild meat. The commercial bushmeat trade – dominated by paca (*Cuniculus paca*), collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*), and woolly monkeys (*Lagothrix poeppigii*) – expanded in the mid-1990s and tripled between 2005 and 2007, due to increased demand and improved road access (Suarez *et al.* 2009). While interventions have traditionally focused on opportunistic enforcement against harvesters and transporters, IWT involves a much broader range of actors, including distinct types of consumers.

Local communities have ancestral rights to legally hunt for subsistence household use (Suarez *et al.* 2009). Their consumption is distinct from the illegal trade to satisfy demand among shift workers visiting the region (eg those from the petroleum industry), rural-to-urban migrants seeking wild meat in the city, and domestic tourists interested in sampling traditional cuisine (Suarez *et al.* 2009; Poats *et al.* 2011).

A collaboration among TRAFFIC, the Ministry of Environment, and local communities has tailored interventions to each consumer group (A Puyol, B Ortiz, SV Poats, pers comms; Poats 2011). Local residents dependent on legal subsistence harvest were engaged via incentives, negotiation, and enforcement to conduct more selective harvest, avoid hunting in core protected areas, and reduce their participation in commercial IWT. In contrast, low- and middle-income urban consumers were targeted with educational messaging – presented by a popular mayor via the regional bus network – in an effort to diminish consumption. Shift workers were pursued via messaging displayed by the principal regional airline used by industry; in addition, restaurants frequented by these workers were offered culinary training to serve alternative dishes and asked to post signs advertising that they no longer served wild meat. Likewise, domestic tourists were targeted through higher-end restaurants and with national television spots.

Example 4: Understanding networks – Indonesian pet reptiles

Indonesia is a leading source in the global trade of pet reptiles, most of which are wild-caught (Figure 4; Lyons and Natusch 2011; Nijman *et al.* 2012b; Natusch and Lyons 2012). Although often poorly designed and ignored, harvest quotas have traditionally been relied on to regulate international trade of these species (Lyons

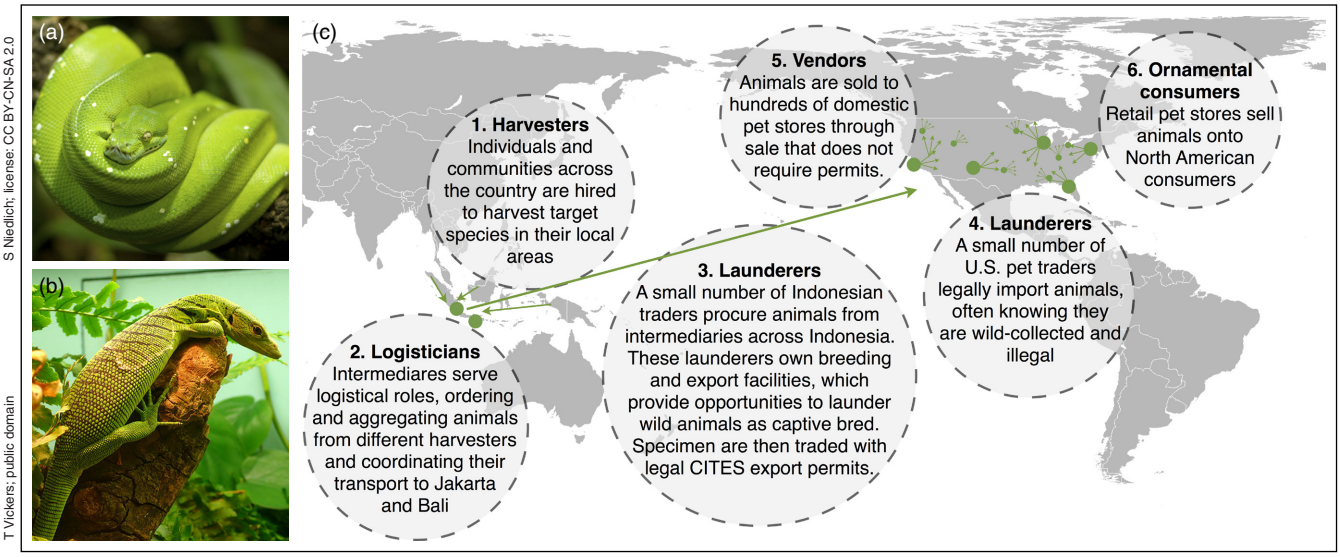


Figure 4. *Overview of the illegal trade of wild, protected, Indonesian reptiles for the North American exotic pet market. (a) Green tree python* (Morelia viridis)*, a CITES Appendix II species, and one of the most common python species in international trade, the conservation impacts of which remain unknown. (b) Emerald tree monitor* (Varanus prasinus)*, a species traded as a pet and restricted to New Guinea and adjacent islands. (c) Overview of the illegal trade network and key actor roles (C Shepherd and S Stoner, pers comms; Natusch and Lyons 2012).*

and Natusch 2011). Trade analysis specifically highlights opportunities for strategic interventions at key points of the network (Figure 4).

The US is a leading market for wild-collected Indonesian pet reptiles. This trade relies on a small group of gatekeepers (Table 2d), including intermediary logisticians who coordinate harvest across the archipelago, launderers who integrate wild-caught individuals into legal breeding facilities (Lyons and Natusch 2011; Natusch and Lyons 2012), and a few US intermediaries (Table 1). Given the challenges associated with implementing conservation interventions against harvesters distributed across hundreds of Indonesian islands, it would be more efficient and feasible to instead target the US and Indonesian gatekeepers, whose behavior could be shaped through international monitoring and enforcement, and/or new legislation requiring that US importers obtain proof of parentage to demonstrate animals are indeed captive bred (C Shepherd and S Stoner, pers comms).

Conclusion

The complexity of IWT precludes simple or standardized solutions, yet our policy debates and tools – including narrow approaches to enforcement and interventions (through CITES) – are often very coarse (Challender 2015). The typologies we present enable more structured analyses of products, actors, networks, and contexts that can help guide conservation actions and research inquiry. For example, clarification of diverse actor roles that moves beyond caricatures of wildlife poachers will facilitate closer examinations of the relative economic benefits from trade, as well as the non-economic motivations that drive different actors to participate in IWT (Duffy *et al.* 2015); this can, in turn, inform more appropriate, fair, and effective conservation actions. Similarly, recognition of different types of products and consumers can guide more detailed research on motivations and uses (Hinsley *et al.* 2015; Truong *et al.* 2015).

The typologies can also assist with determining which types of interventions are most appropriate under different conditions, such as for geographically restricted versus widely distributed species; species for which consumers are, or are not sensitive to changes in price; and IWT involving local residents versus non-resident harvesters. More thorough analyses will be critical to designing strategic, targeted, and appropriate interventions for reducing IWT. Efforts to improve policy responses, however, first require the terms and tools to articulate and distinguish among diverse IWT actors and phenomena.

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