INSIGHTS

PERSPECTIVES

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BRIDGE – CONSERVATION AND IVORY TRADE

Breaking the deadlock on ivory

An iterative process that recognizes different value systems may help to protect elephants

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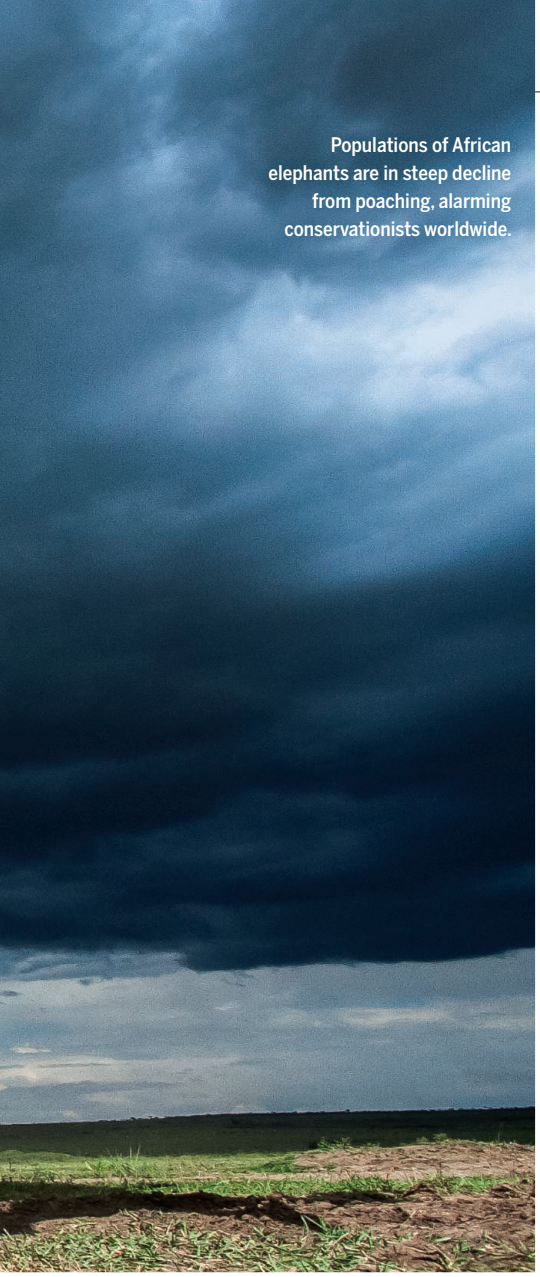
Poaching for ivory has caused a steep decline in African elephant (*Loxodonta africana*, see the photo) populations over the past decade (*1*). This crisis has fueled a contentious global debate over which ivory policy would best protect elephants: banning all ivory trade or enabling regulated trade to incentivize and fund elephant conservation (*2*). The deep-seated deadlock on ivory policy consumes valuable resources and creates an antagonistic environment among elephant conservationists. Successful solutions must begin by recognizing the different values that influence stakeholder cognitive frameworks of how actions lead to outcomes ("mental models") (*3*), and therefore their diverging positions on ivory trade (*4*). Based on successful conflict resolution in other areas, we propose an iterative process through which countries with wild elephant populations may be able to understand their differences and develop workable solutions in a less confrontational manner.

CONFLICTING VIEWS

Many argue that prohibiting all trade in ivory will reduce poaching and protect elephants (*5*). Stakeholders who support ivory bans also advocate the destruction of ivory



Populations of African elephants are in steep decline from poaching, alarming conservationists worldwide.

stockpiles and steps to reduce demand for ivory. Kenya and most west and central African countries with wild elephant populations subscribe to this approach. Critics of the prohibition approach argue that trade bans and stockpile destruction have the perverse effect of increasing the ivory price through perceived scarcity, thereby incentivizing further poaching, and that there is limited evidence of successful demand reduction from these actions (*6*). Trade bans are also difficult to enforce in countries with poor governance, carry high social costs of enforcement, and limit opportunities to use sustainably managed elephant populations and their ivory to generate funds for conservation and community benefits (*2, 6, 7*).

An alternative approach proposed for elephant conservation is to allow legal ivory trade through regulated markets, with ivory harvested from animals that die naturally or are killed for other reasons, such as problem animal control (*7*). Revenue from ivory can be used to provide income to rural communities that bear the costs of living with elephants (such as crop raids or attacks on humans), and to fund conservation and development programs. The southern African countries that advocate this approach—such as South Africa, Namibia, and Zimbabwe—have large elephant populations and lower rates of poaching than other African nations (*8*). Critics of a use-based approach argue that legal sales stimulate demand by implying that purchasing ivory is socially acceptable. Legalized trade can also facilitate laundering of illegal ivory, particularly in countries with high levels of corruption that would struggle to regulate a legal trade (*5*).

Despite this lack of agreement, the first approach has more policy momentum. Stockpile destruction has increased more than sixfold since 2011. There have been substantial efforts to criminalize trade, including commitments to near-total domestic bans on commercial ivory trade in the United States, China, and the United Kingdom, and a motion to stop all legal domestic ivory sales passed at the 2016 IUCN (International Union for Conservation of Nature) World Conservation Congress. However, the polarization continues as pro-trade countries and nongovernmental organizations (NGOs) disagree with the current policy direction.

A HISTORY OF POLARIZED DEBATES

Heated debates about elephants and ivory have dominated meetings of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Conference of the Parties (CoP) for nearly 30 years (table S1). For example, following fierce debate at the October 2016 CoP, a proposal by Namibia and Zimbabwe to trade ivory was defeated. CITES debates are influenced by the positions of NGOs that mobilize media and public attention, lobby signatories, and provide technical advice and support (*2*). Because all signatory countries have an equal vote on proposals to CITES, some range states (countries with wild elephant populations) have expressed frustration that they have limited influence in CITES negotiations despite bearing the costs of resulting decisions (*2*).

There have been several efforts to find common ground. For example, the African Elephant Range States Dialogues were initiated in 1996 to bring nations together to discuss relevant conservation and trade issues (*9*). In a series of African Elephant Meetings, range states developed the African Elephant Action Plan, which expressed support for securing sustainable elephant populations throughout their present and potential range in Africa and for realizing elephants' potential to provide cultural and socioeconomic benefits. In 1997, parties to CITES established two global monitoring systems—MIKE (Monitoring the Illegal Killing of Elephants) and ETIS (the Elephant Trade Information System)—for collecting and analyzing data on poaching, mortality, and illegal ivory trade and providing evidence for decision-making.

"Similarly polarized arenas ...have made progress using approaches that allow for structured, iterative trust-building..."

Despite these efforts and the evidence available through MIKE and ETIS, the polarization on ivory trade persists. There is no consensus on which ivory policy options could resolve the crisis (*2, 5, 7*).

THE IMPORTANCE OF VALUES

We contend that the continued polarization stems from a failure to recognize the different moral perspectives of stakeholders ("values"), which contribute to their contrasting mental models of how elephant conservation can be achieved (*4*). Mental models influence the interpretation of evidence: People are more likely to unconsciously challenge the credibility of information that deviates from their mental models (confirmation bias). For example, values (as captured by political affiliation) predict alternative interpretations of climate change and gun control policy among respondents in the United States better than scientific or mathematical literacy (*10*).

Values also affect how stakeholders perceive trade-offs, thus contributing to positions that appear irreconcilable despite agreement about the overarching goal of elephant conservation. Three types of trade-off can be identified when sacred values (such as human rights, nature, and justice) and secular values (such as cost effective-

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ness) are involved (see the figure) (*4, 11*).

Routine trade-offs pit secular values against each other and can be acceptably evaluated using rational cost-benefit logic (e.g., whether ground-based or aerial patrols are more cost-effective in deterring poachers). Tragic trade-offs involve trading one sacred value against another (e.g., investing to secure elephant populations in one national park, while sacrificing others elsewhere). Taboo trade-offs pit a secular value against a sacred value. Debates over ivory trade pitch the sacred value of the moral unacceptability of trade in any elephant-derived product (*12*) against the secular value that ivory is a source of conservation revenue. Taboo trade-offs are inherently uncomfortable and generate both moral outrage and a reluctance to deal with the issue (*4*).

BEYOND THE CURRENT IMPASSE

Conflict over the trade in ivory is emblematic of the impasses that have characterized international decision-making around trade in iconic taxa, including elephants, rhinos, sea turtles, and tigers (*2*). Similarly polarized arenas, such as negotiations to end armed conflicts (*13*) and address climate change (*14*), have made progress using approaches that allow for structured, iterative trust-building, as part of evaluating policy options among parties. Iterations of face-to-face interaction and discussion help stakeholders to better understand each other's perspectives and build the necessary trust to overcome impasses (*13*, *14*).

Drawing from these successful precedents, we propose a process that incorporates five components aimed at overcoming the impasse on ivory. The order is not prescriptive and can be adapted through iterations of the process if required.

First, a reconfirmation by the range states, as part of their ongoing dialogues on elephant conservation, of the conservation objectives that they aim to achieve and a discussion of the values associated with elephant conservation will serve as a platform for collective deliberation (*15*).

Second, eliciting and sharing considerations of other threats to elephants (such as habitat loss) will clarify the differences and commonalities in stakeholder views of policy interventions (*3*). Identification of areas of common ground between stakeholders can inform the development of policies that have broad stakeholder support.

Such sharing of mental models can also foster the emergence of innovative solutions (*3*). For example, tension between wool-producing farmers and conservationists in New South Wales, Australia, involved fundamental differences about the perceived impacts of expanding conservation areas on the farming industry's survival. Through a process that revealed and explored stakeholders' conflicting mental models, it became apparent that farmers had the capacity to manage land for conservation, enabling conservation stewardship to become established on pastoral land (table S2) (*3*). A similar process may, for example, highlight that pro-trade countries view ivory as an essential, sustainable source of revenue for conservation. In this case, a commitment to provide other, equally valuable revenue sources to replace ivory sales could potentially be an acceptable alternative. In addition, discussion of mental models will expose specific areas of disagreement about the impacts of policy interventions and thereby reveal which aspects of the evidence must be most carefully examined.

Third, evaluation and synthesis of evidence to assess the consequences of different policies can be carried out using a structured approach that minimizes bias and is considered legitimate by all participants. If existing evidence is not sufficient to make these assessments and additional data collection is necessary, evidence that is collected through credible mechanisms that participants agree to accept will increase the uptake of new information.

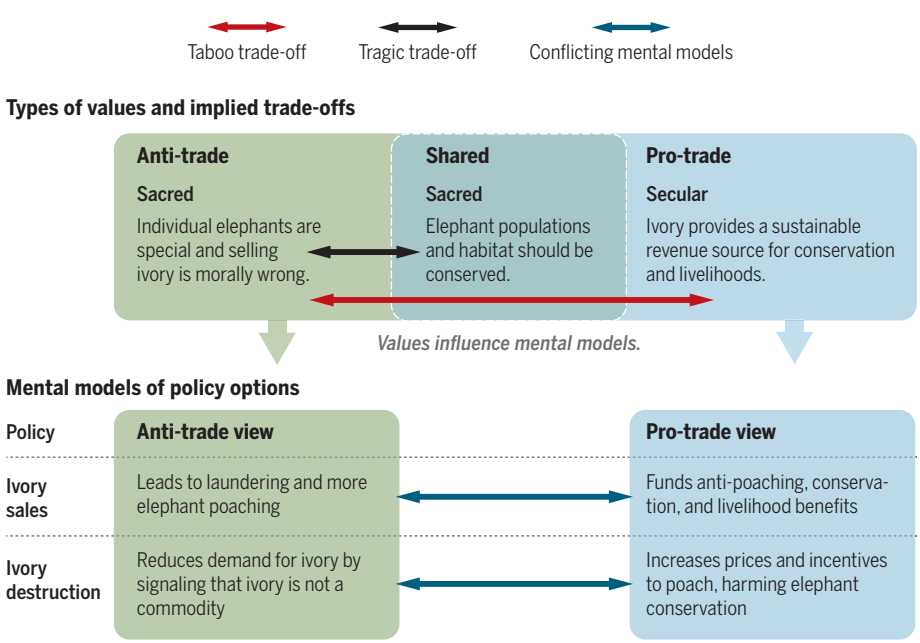
Fourth, discussion among stakeholders about the trade-offs involved in achieving their shared conservation objectives will help to identify policies and interventions that are acceptable to a wider group of stakeholders. Such discussion may, for example, reveal that trade-offs perceived as taboo by some stakeholders (such as the morality of selling ivory versus secular benefits of money from ivory) are viewed as tragic trade-offs by others (such as the morality of selling ivory versus the morality of conserving elephant populations and supporting poverty alleviation through a sustainable nature-based revenue source) (see the figure) (*4, 11, 12*).

Finally, agreement among range states on how this process feeds into decision-making at different levels, including via proposals and votes at CITES CoPs, will reduce one source of dissent. Circumstances vary widely among range states, making a single continent-wide policy unlikely and inappropriate; but if this process is successful, it could lead to range states supporting each other on locally appropriate policy proposals at CITES, defusing long-term debates.

Our proposed process differs from previous efforts to bring diverse stakeholders together on ivory trade in that it is structured and is explicit in its recognition of the values and mental models underlying different positions. We propose that this process be initiated, spearheaded, and owned by African range states. It will require frequent, iterative discussions that include NGOs, conservation donors, and other key stakeholders at appropriate times, with input from technical experts where needed.

How values and mental models affect views of ivory trade

Stakeholders in the ivory trade debate hold different values that affect how they perceive trade-offs. These values influence their mental models of how different policy options will lead to successful elephant conservation. The examples shown are illustrative and not comprehensive.



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Experience from other apparently intractable issues, such as negotiating the end to armed conflict in Colombia and apartheid in South Africa (*13*) and international climate change negotiations (*14*), suggests that such frequent, iterative interactions among a small group of key parties are more likely to engender trust and agreement than an international vote open to the media and campaigning pressures. For example, the success of the 2016 Paris climate agreement built on a prior bilateral agreement between the United States and China. This agreement stemmed from a working group that met several times outside of the public's view over more than 2 years (*14*). Experience from the African Elephant Range States Dialogues also suggests that concordance on ivory policy may best be found outside the public and adversarial environment of CITES CoPs (*9*).

The next CITES CoP is less than 2 years away. We recognize that the politics around ivory policy are challenging, but urge range states to begin a structured process to negotiate the diverse perspectives in this contentious debate as soon as possible, supported by organizations committed to elephant conservation. Successful navigation of different mental models and the associated values, and the trade-offs they imply, will not only enable greater collective action on elephant conservation, but also provide an example of how to enhance the structured use of evidence in CITES decision-making on other iconic species. ■

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SUPPLEMENTARY MATERIALS

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CELL BIOLOGY

Closing the tubulin detyrosination cycle

Enzymes that detyrosinate the microtubule cytoskeleton are identified

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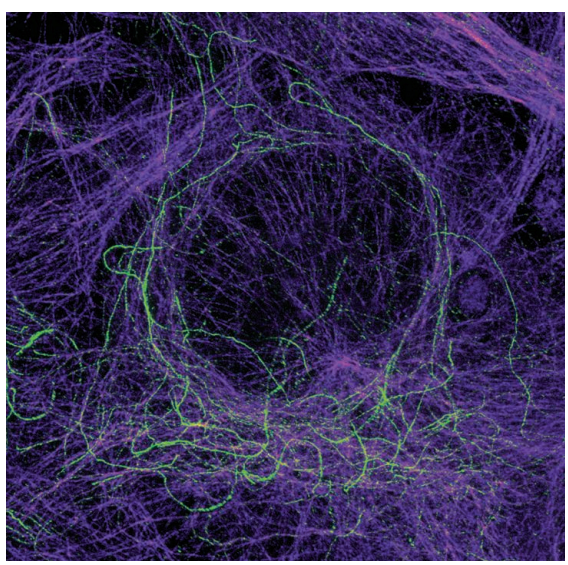
Microtubules are cytoskeletal filaments that drive chromosome segregation during cell division, control cell shape and motility, and serve as rails for motor protein–based intracellular transport. Microtubules are polymers built of highly conserved subunits, α- and β-tubulin, which contain a globular core and more variable C-terminal tails that are exposed at the microtubule surface. Although microtubules are structurally uniform, they display functional specialization due to the combination of different tubulin isoforms and multiple posttranslational modifications (*1*). Many of these modifications occur within the C-terminal tails and affect microtubule interactions with motor proteins or regulatory factors. The first tubulin modifications were discovered more than 40 years ago and consist of the catalytic removal and reincorporation of the C-terminal tyrosine, an amino acid residue that is present in most α-tubulin isotypes (see the figure) (*2*–*4*). Whereas retyrosination of soluble tubulin is known to be mediated by tubulin-tyrosine ligase (*5*), α-tubulin detyrosination, which occurs preferentially on microtubules, is mediated by an unknown carboxypeptidase activity. On pages 1448 and 1453 of this issue, Aillaud *et al.* (*6*) and Nieuwenhuis *et al.* (*7*) report the identification and characterization of vasohibins as long-sought tubulin carboxypeptidases.



Stable detyrosinated microtubules are highlighted in green, revealing microtubule diversity in human cells.

Vasohibins were originally identified as regulators of new blood vessel formation (angiogenesis) (*8*) and have a predicted protease fold with a noncanonical catalytic triad consisting of cysteine, histidine, and serine or threonine (*9*). Mammalian genomes encode two vasohibin paralogs, vasohibin-1 and vasohibin-2, but their proteolytic activity and molecular function had never been explored. Importantly, vasohibins form a complex with the chaperone-like peptide small vasohibin binding protein (SVBP), which is required for vasohibin stability and function (*10*). This might explain why previous attempts to identify the tubulin carboxypeptidase have failed, because standard purification assays could result in dissociation of SVBP from vasohibins, compromising their catalytic activity.

The two groups seeking the elusive tubulin carboxypeptidase converged on vasohibins using different unbiased approaches. Aillaud *et al.* used chemical proteomics; they developed a potent irreversible inhibitor of tubulin carboxypeptidase and combined it with mass spectrometry–based analysis of fractionated mouse brain lysates to identify vasohibin-1 as the stron-

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