



Edited by Jennifer Sills

Ivory crisis: Growing no-trade consensus

In their Perspective, “Breaking the deadlock on ivory” (15 December 2017, p. 1378), D. Biggs *et al.* propose steps to enhance unity around the African elephant poaching crisis. We support their recommendations for dialogue among African elephant range states. However, the Perspective misrepresents the evidence-driven rationale of the no-trade approach to ivory, promotes a counterproductive geographically divided approach to wildlife trade, and understates the growing world-wide policy consensus to end ivory trade.

By asserting that a no-trade approach is motivated by “sacred” values and misidentifying animal rights as central to this position, Biggs *et al.* imply that the no-trade approach is not pragmatic. In fact, the no-trade position and the pro-trade position differ not only in core values or objectives, but in interpretations of evidence on the relative usefulness of improved governance, markets, and sociocultural change in addressing poaching. It would be ideal if only ivory from naturally deceased elephants could be used to fund conservation sustainably. However, the evidence suggests that this cannot be practically achieved for elephants. Economic models supporting ivory sales ignore elephants’ low population and productivity (1). Thus, new demand for ivory will likely outpace new legal supply, increase black market prices (2), and further incentivize elephant poaching in countries struggling to patrol vast areas (3). Legal trade also makes it more difficult to detect contraband (4) and fails to address the escalating levels of criminality driving

most ivory shipments over the past decade (5). A one-time legal ivory sale to China and Japan permitted by the Convention on International Trade in Endangered Species (CITES) in 2008 corresponded with an abrupt increase in poaching (2). In contrast, the 1989 ban on international ivory trade and decisions to restrict legal domestic trade from 2015 onward were each accompanied by at least a halving of the price of ivory (6, 7).

Elephant conservation would suffer under Biggs *et al.*’s proposal for further regional differentiation of ivory trade policies. Any legal trade in ivory undermines efforts to reduce elephant poaching everywhere (2). All 37 African elephant range states have expressed shared conservation objectives in the 2010 African Elephant Action Plan (8) and should be regarded as equal stakeholders. That 76% of African elephants live in transboundary populations (9) necessitates cooperation between neighbors and continent-wide management approaches. These approaches could include identifying revenue sources to replace ivory sales for pro-trade countries, as Biggs *et al.* suggest. CITES’ legitimacy would be undermined by devolving its authority or making decisions “outside of the public’s view,” as proposed by Biggs *et al.* Decreasing public scrutiny during negotiations could increase vulnerability to commercial interests or assertive governments focused on short-term benefits (10).

In contrast to the “deadlock” portrayed by Biggs *et al.*, a global consensus is growing for a complete ban on trade in ivory to combat elephant poaching. Biggs *et al.* themselves recognized current near-total domestic bans on ivory trade (in the United States, China, and the United Kingdom) and the motion to stop all legal domestic sales adopted at the 2016 IUCN World Conservation Congress. Additionally, since

Elephant tusks in Kenya.

2010, Parties to CITES have dismissed proposals for sales of stockpiled ivory and rejected a decision-making mechanism that could reestablish trade (11).

Instead of perpetuating demand for ivory through sales, we suggest that demand be minimized through a combination of regulatory instruments (domestic trade bans) and sociocultural interventions (behavior change campaigns). Other strategies include dismantling supply chains using intelligence-driven law enforcement; strengthening judicial systems; and encouraging cross-border cooperation, human-elephant coexistence projects, and alternative economic opportunities for poachers and traders. Combining nature-compatible livelihoods with strengthened revenue streams from elephant-oriented tourism could—if well-governed—promote equitable development and participatory conservation across rural Africa (12).

Nitin Sekar,^{1*} William Clark,² Andrew Dobson,¹ Paula Cristina Francisco Coelho,³ Phillip M. Hannam,¹ Robert Hepworth,⁴ Solomon Hsiang,^{5,6} Paula Kahumbu,⁷ Phyllis C. Lee,^{8,9} Keith Lindsay,⁹ Carlos Lopes Pereira,¹⁰ Samuel K. Wasser,^{11,12} Katarzyna Nowak^{13,14}

¹Princeton University, Princeton, NJ 08544, USA.

²Great Falls, VA 22066, USA. ³Ministry of Environment,

Luanda, Angola. ⁴David Shepherd Wildlife Foundation,

Shalford, Guildford, Surrey, GU4 8JU, UK. ⁵Global

Policy Laboratory, Goldman School of Public

Policy, University of California, Berkeley, Berkeley,

CA 94720, USA. ⁶National Bureau of Economic

Research, Cambridge, MA 02138, USA. ⁷WildlifeDirect,

Nairobi, Kenya. ⁸Behaviour and Evolution Research

Group, Faculty of Natural Sciences, University of

Stirling, Stirling FK9 4LA, UK. ⁹Amboseli Trust for

Elephants, Nairobi, Kenya. ¹⁰National Administration

of Conservation Areas, Ministry of Land, Environment

and Rural Development, Maputo, Mozambique.

¹¹Center for Conservation Biology, University of

Washington, Seattle, WA 98195, USA. ¹²Conservation

Science Group, University of Cambridge,

Cambridge, CB2 3QZ, UK. ¹³Department of Zoology

and Entomology, University of the Free State,

Phuthaditjhaba, 9866, South Africa. ¹⁴The Safina

Center, Setauket, NY 11733, USA.

*Corresponding author. Email: nitin.sekar@gmail.com

REFERENCES

1. D. Lusseau, P. C. Lee, *Curr. Biol.* **26**, 2951 (2016).
2. S. M. Hsiang, N. Sekar, “Does legalization reduce black-market activity? Evidence from a global ivory experiment and elephant poaching data,” *National Bureau of Economic Research (Working Paper no. 22314)*, 2016.
3. S. K. Wasser *et al.*, *Science*, **349**, 84 (2015).
4. Environmental Investigation Agency, “Vanishing Point” (2014); <https://eia-international.org/wp-content/uploads/EIA-Vanishing-Point-lo-res1.pdf>.
5. C. May, “Transnational crime and the developing world,” *Global Financial Integrity* (2017); www.gfintegrity.org/report/transnational-crime-and-the-developing-world/.
6. M. O’Connell, M. Sutton, “The effects of trade moratoria on international commerce in African elephant ivory: A preliminary report,” *TRAFFIC USA (WWF and the Conservation Foundation)*, 1990.
7. L. Vigne, E. Martin, “Decline in the legal ivory trade in China in anticipation of a ban” (Save the Elephants, 2017); www.savetheelephants.org/wp-content/

uploads/2017/03/2017_Decline-in-legal-ivory-trade-China.pdf.

8. CITES, "African elephant action plan" (2010); www.iucn.org/sites/dev/files/import/downloads/e15i_68.pdf.
9. K. Lindsay *et al.*, *Biol. Conserv.* **215**, 260 (2017).
10. A. Gupta, *Glob. Environ. Polit.* **8**, 1 (2008).
11. S. Korwin, K. Lindsay, R. Reeve, *Pachyderm* **58**, 140 (2017).
12. R. Naidoo *et al.*, *Nat. Commun.* **7**, 13379 (2016).

10.1126/science.aat1105

Ivory crisis: Role of bioprinting technology

We agree with D. Biggs *et al.* ("Breaking the deadlock on ivory," Perspectives, 15 December 2017, p. 1378) that to prevent the extinction of elephants, we must recognize that different values influence stakeholders' perspectives. Poaching is increasingly driven by demand from China, with its growing number of wealthy consumers and investors and its traditions of ivory usage (1). Moreover, ivory prices have increased considerably since 2000 (1–3), indicating that it is a good investment. Altering consumer preferences alone through changing mental models, as Biggs *et al.* propose, is unlikely to reduce the demand for ivory and prevent the killing of elephants. Policy-makers must take a broader systems-thinking approach, whereby they consider not only how people value ivory psychologically but also how technology can be used to influence underlying economic demand and supply levers of the ivory trade, and ultimately its price.

Developments in three-dimensional (3D) bioprinting have made it possible to produce an indistinguishable substitute of elephant ivory and rhino horn. Using a small sample of tissue, the machine can replicate the species' DNA precisely in the printed version (4–6). Bioprinting offers several potential options for substantially reducing the market price for ivory. For example, if large volumes of bioprinted ivory were successfully introduced into African ivory markets (mixed, without detection, with the genuine ivory), then this ivory would likely pass further through the supply chain and into the black markets of Asia. A recent experiment shows that such an intervention is indeed possible (7). Mixing substantial volumes of bioprinted ivory into the supply chain, would not only increase supply and reduce the price, but also create information uncertainty among investors as to whether they are buying genuine ivory. This strategy has been shown to be effective in combating the shark fin trade (8).

Magdalena Lenda,^{1,2,3*} **Piotr Skórka**,² **Błażej Mazur**,⁴ **Adrian Ward**,^{1,3} **Kerrie Wilson**^{1,3}
¹School of Biological Sciences, The University of Queensland, Brisbane, QLD, 4072, Australia.

²Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, 31-120 Kraków, Poland.
³ARC Centre of Excellence for Environmental Decisions, The University of Queensland, St. Lucia, Brisbane, QLD, 4072, Australia.
⁴Cracow University of Economics, Rakowicka 27, 31-510 Kraków, Poland.
 *Corresponding author. Email: m.lenda@uq.edu.au

REFERENCES

1. Y. Gao *et al.*, *Biol. Cons.* **180**, 23 (2014).
2. G. Wittemyer *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **111**, 13117 (2014).
3. M.† Sas-Rolfes, B. Moyle, D. Stiles, *Pachyderm* **55**, 62 (2014).
4. A. Klarmann, "3D printed rhino horns to deter ivory poaching?," All3DP (2017); <https://all3dp.com/3d-printed-rhino-horns-poaching/>.
5. S. V. Murphy, A. Atala, *Nat. Biotechnol.* **32**, 773 (2015).
6. Z. Corbyn, "Can we save the rhino from poachers with a 3D printer?," *The Guardian* (2015); www.theguardian.com/environment/2015/may/24/artificial-3d-printed-fake-rhino-horn-poaching.
7. B. Christy, "How killing elephants finances terror in Africa," *National Geographic* (2015); www.nationalgeographic.com/tracking-ivory/article.html.
8. M. Fabinji, N. Liu, *Cons. Soc.* **12**, 218 (2014).

10.1126/science.aat0925

Response

Sekar *et al.* argue that there is unequivocal evidence that ivory trade bans are necessary for conserving elephants, and that a growing consensus removes the need to consider or incorporate alternative values in this debate. In doing so, they overlook relevant literature [e.g., (1–3)] and do not account for marginalized voices from key range states (4). Their response illustrates why the current impasse is unlikely to be resolved without a new structured process, underpinned by recognition that interpretation of scientific information on both sides of any contentious debate is influenced by values (5, 6).

Sekar *et al.* describe apparently compelling evidence for the consequences of different policies relating to ivory, but there is much literature that contests their conclusions (1–3, 7). For example, before the 17th Conference of the Parties (CoP), a technical advisory group of the Convention on International Trade in Endangered Species (CITES) took the unusual step of issuing a formal statement about the methodological shortcomings of one of the key working papers Sekar *et al.* cite (3, 8). Sekar *et al.* also cite the motion adopted at IUCN's 2016 World Conservation Congress to prohibit legal domestic ivory sales as illustrating consensus. However, this debate was so adversarial that a diverse group of 30 prominent individuals, spanning 20 countries and including people from eight nongovernmental organizations and seven governments, publicly highlighted its pitfalls and urged for this approach to be avoided in the future (9).

This lack of consensus explains why different range states, all of which are committed to conserving elephants and all

with access to the same data sets, continue to take opposing positions, illustrating how interpretation of evidence often reflects underlying assumptions, value systems, and mental models (10, 11). Our paper acknowledged that there is policy momentum toward a trade ban, but called for a new process because polarized debates persist between and among range states and researchers. If this polarization continues, it will undermine policy implementation.

Despite Sekar *et al.*'s claim, our proposals would not undermine the legitimacy of CITES. Instead, we highlighted that experience from other contentious issues, such as negotiating climate change policy and the end to armed conflict, shows that progress is more likely through iterations of discussion in small groups by key stakeholders, rather than in adversarial public environments such as CITES CoPs (12, 13). Such an approach could be facilitated by CITES and feed into CITES processes, as happened with the African Elephant Range State Dialogues (14). We also reiterate that range states, which are the ultimate custodians of Africa's elephants, should own and lead this process to develop policies that navigate the trade-offs their societies face.

We did not advocate a particular policy position, but instead called for a structured process to overcome the barriers to evidence-based decision-making. This should account for the different values and mental models that influence this debate, building consensus on how the available evidence is interpreted and what research is needed to tackle uncertainties and data gaps.

We agree with Sekar *et al.* that any process to build consensus must incorporate the need for sustainable financing to protect elephants from poaching and other threats like habitat loss. Such financing also needs to provide economic benefits to communities that live with elephants. Critically, to strengthen sustainability, policy processes on ivory must give more of a voice to those responsible for and affected by policy decisions than to those who suffer none of the costs of living with elephants. Overcoming this long-standing deadlock requires a new approach; conservation can learn from successes in other polarized debates to achieve lasting positive outcomes for elephants and other iconic taxa threatened by illegal trade.

We agree with Lenda *et al.* that synthetic ivory might provide new solutions, but it could also have unintended negative consequences by changing the nature and size of the ivory trade in unpredictable ways. There is already an effort within CITES to address the issue of synthetically produced wildlife products (15), which would benefit from

adopting the structured process we propose.

Duan Biggs,^{1*} Robert J. Smith,² Vanessa M. Adams,³ Henry Brink,² Carly N. Cook,⁴ Rosie Cooney,⁵ Matthew H. Holden,⁶ Martine Maron,⁶ Jacob Phelps,⁷ Hugh P. Possingham,⁸ Kent H. Redford,⁹ Robert J. Scholes,¹⁰ William J. Sutherland,¹¹ Fiona M. Underwood,¹² E. J. Milner-Gulland¹³

¹Griffith University, Nathan, QLD 4111, Australia.

²University of Kent, Canterbury, CT2 7NR, UK.

³Macquarie University, Sydney, NSW 2109, Australia.

⁴Monash University, Clayton, VIC 3800, Australia.

⁵IUCN SULI, 1196, Gland, Switzerland. ⁶University of Queensland, St. Lucia, QLD, 4072, Australia.

⁷Lancaster University, Lancaster, UK. ⁸The Nature Conservancy, Arlington, VA 22203, USA. ⁹Archipelago Consulting, Portland, ME 04112, USA. ¹⁰University of Witwatersrand, Johannesburg, South Africa.

¹¹University of Cambridge, Cambridge, CB2 3EJ, UK.

¹²Taunton, UK. ¹³Oxford University, Oxford, OX2 6GG, UK.

*Corresponding author. Email: ancientantwren@gmail.com

REFERENCES

1. M. 't Sas-Rolfes, B. Moyle, D. Stiles, *Pachyderm* **55**, 62 (2014).
2. R. B. Martin *et al.*, "Decision-making mechanisms and necessary conditions for a future trade in African elephant ivory" (CITES, 2012).
3. CITES, "A statement from the MIKE and ETIS Technical Advisory Group on recent claims that the CITES-approved ivory sales in 2008 caused a spike in poaching levels" (2017); <https://cites.org/sites/default/files/eng/cop/17/InfDocs/E-CoP17-Inf-42.pdf>.
4. R. Duffy, *Environ. Planning C Gov. Pol.* **31**, 222 (2013).
5. D. Kahan, *Nature* **463**, 296 (2010).
6. D. M. Kahan *et al.*, *Nat. Clim. Change* **2**, 732 (2012).
7. B. Moyle, *Ecol. Econ.* **107**, 259 (2014).
8. S. M. Hsiang, N. Sekar, "Does legalization reduce black-market activity? Evidence from a global ivory experiment and elephant poaching data," National Bureau of Economic Research (Working Paper no. 22314, 2016).
9. S. N. Stuart *et al.*, *Oryx*, 10.1017/S0030605317001557 (2017).
10. CITES, "Closure of domestic markets for elephant ivory" (COP17 Doc 57.2, 2016); <https://cites.org/sites/default/files/eng/cop/17/WorkingDocs/E-CoP17-57-02.pdf>.
11. CITES, "Consideration of proposals for amendment of Appendices 1 and 2" (2016); <https://cites.org/sites/default/files/eng/cop/17/E-CoP17-Prop-14.pdf>.
12. A. Kahane, K. Van Der Heijden, *Transformative Scenario Planning: Working Together to Change the Future* (Berrett-Koehler Publishers, 2012).
13. D. H. Cole, *Nat. Clim. Change* **5**, 114 (2015).
14. CITES, "African range States agree a restricted ivory trade from four southern African countries" (2002); https://cites.org/eng/news/pr/2002/021102_eledialogue.shtml.
15. CITES 17.89-17.91, "Specimens produced from synthetic or cultured DNA" (2017); www.cites.org/eng/dec/valid17/81839.

10.1126/science.aat1596

Insurance coverage for genomic tests

On 16 March, the Centers for Medicare and Medicaid Services (CMS) announced that Medicare will cover Food and Drug Administration (FDA)-approved or cleared genomic tests that encompass broad gene

panels for advanced cancer patients (1). The final policy does not include the initial draft's proposed "coverage with evidence development" (CED)—i.e., coverage of tests run as part of clinical trials and registries—which some had argued should be applied to develop a stronger evidence base for these tests (2). Instead, tests not already approved in the national coverage determination can be reviewed for coverage by local Medicare Administrative Contractors (MACs). The new policy reflects a substantial shift in determining how genomic tests are evaluated for coverage, which provides a needed "roadmap" for coverage. However, to develop effective and efficient policies, stakeholders should support further research to address how the new policy will affect ongoing cancer research as well as the access to and affordability of next-generation sequencing testing for cancer patients.

The new policy has the potential to increase access to testing, but it may remain out of reach for many patients. Private payers may not follow the CMS policy for covered tests, as there are myriad reasons that payers have limited their coverage for broad genomic tests

(3), and private payers often do not use Medicare policies as precedents (4). The tests that remain uncovered by CMS may not be covered by local MACs either (5). The numerous laboratories that offer their own tests that do not currently meet the coverage requirements in the new policy may have trouble finding the trial participants and funding they need to obtain the evidence required. Although CMS's policy may spur these laboratories to develop evidence even without a CED requirement, this process may take several years, and its outcome is uncertain (4). The CMS policy is binding only on Medicare; it is uncertain whether states will cover these tests for Medicaid patients (6).

Likewise, the policy may increase affordability and equity for these tests, but with caveats. Benefit-cost tradeoffs were not examined as they are outside the scope of CMS. CMS is caught in an ongoing dilemma: Coverage policies are determined irrespective of cost, yet there is a constant drumbeat of calls to reduce Medicare expenditures (7). Lastly, it will be important to understand the implications of the new policy for genomic tests for patients with other types of cancer and with other

conditions, which face similar challenges to coverage (8).

Given today's challenging health policy environment, CMS should work with stakeholders, including other federal agencies, to carefully evaluate the benefits and risks of this novel coverage approach and to consider what additional policy mechanisms will be needed to ensure that the necessary evidence is generated. We must address the substantial uncertainty about the impact of coverage policies on the health outcomes of Medicare beneficiaries.

Kathryn A. Phillips,^{1,2,3} Julia R. Trosman,⁴ Patricia A. Deverka,^{1,5} Bruce Quinn,⁶ Sean Tunis,⁷ Peter J. Neumann,⁸ James D. Chambers,⁸ Louis P. Garrison Jr.,⁹ Michael P. Douglas,¹ Christine B. Weldon⁴

¹Department of Clinical Pharmacy, Center for Translational and Policy Research on Personalized Medicine (TRANSPERS), University of California San Francisco, San Francisco CA 94143, USA. ²Philip R. Lee Institute for Health Policy, San Francisco, CA 94118, USA. ³Helen Diller Family Comprehensive Cancer Center, University of California, San Francisco, San Francisco, CA 94143, USA. ⁴Center for Business Models in Healthcare, Northwestern University Feinberg School of Medicine, Chicago, IL 60611 USA. ⁵American Institutes for Research, Chapel Hill, NC 27517, USA. ⁶Bruce Quinn Associates, Los Angeles, CA 90036, USA. ⁷Center for Medical Technology Policy (CMTP), Baltimore, MD 21202, USA. ⁸The Center for

the Evaluation of Value and Risk in Health, Institute for Clinical Research and Health Policy Studies, Tufts Medical Center, Boston, MA 02111, USA. ⁹The Comparative Health Outcomes, Policy, and Economics (CHOICE) Institute, Department of Pharmacy, University of Washington, Seattle, WA 98195, USA.

*Corresponding author. Email address: kathryn.phillips@ucsf.edu

REFERENCES

1. CMS, Decision Memo for Next-Generation Sequencing (NGS) for Medicare Beneficiaries with Advanced Cancer (CAG-00450N) (2018); www.cms.gov/medicare-coverage-database/details/nca-decision-memo.aspx?NCAId=290&DocID=CAG-00450N&bc=AAAAAAAQAAA&.
2. R. Eisenberg, H. Varmus, *Science* **358**, 1133 (2017).
3. K. A. Phillips *et al.*, *Nat. Biotechnol* **35**, 614 (2017).
4. J. D. Chambers *et al.*, *Health Aff. (Millwood)* **34**, 1376 (2015).
5. D. R. Levinson, "Local coverage determinations create inconsistency in Medicare coverage" (2014); <https://oig.hhs.gov/oei/reports/oei-01-11-00500.pdf>.
6. E. Schattner, "Medicare will cover genetic cancer testing, with caveats," *Forbes* (2018); www.forbes.com/sites/elaineschattner/2018/03/16/medicare-will-cover-genetic-cancer-testing-with-caveats/#d78931d9e556.
7. P. J. Neumann, J. D. Chambers, *N. Engl. J. Med.* **367**, 1775 (2012).
8. J. R. Trosman *et al.*, *J. Natl. Compr. Canc. Netw.* **15**, 219 (2017).

ACKNOWLEDGMENTS

This letter was funded by grants from the National Human Genome Research Institute (R01HG007063 and U01HG009599) and by the Helen Diller Family Comprehensive Cancer Center Support Grant of the National Institutes of Health under Award Number P30CA082103-18.

10.1126/science.aas9268

Ivory crisis: Role of bioprinting technology

Magdalena Lenda, Piotr Skórka, Blazej Mazur, Adrian Ward and Kerrie Wilson

Science **360** (6386), 277.

DOI: 10.1126/science.aat0925

ARTICLE TOOLS

<http://science.sciencemag.org/content/360/6386/277.1>

RELATED CONTENT

<http://science.sciencemag.org/content/sci/360/6386/277.2.full>
<http://science.sciencemag.org/content/sci/358/6369/1378.full>

REFERENCES

This article cites 5 articles, 1 of which you can access for free
<http://science.sciencemag.org/content/360/6386/277.1#BIBL>

PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. 2017 © The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works. The title *Science* is a registered trademark of AAAS.