Ribosome stalling and neurodegeneration *p. 378*

Hiding an object's shadow in the fog *p. 384*

CONSERVATION POLICY

Wildlife decline and social conflict

Policies aimed at reducing wildlife-related conflict must address the underlying causes

By **Justin S. Brashares**[1]*, **Briana Abrahms**[1], **Kathryn J. Fiorella**[1], **Christopher D. Golden**[2], **Cheryl E. Hojnowski**[1], **Ryan A. Marsh**[1], **Douglas J. McCauley**[3], **Tristan A. Nuñez**[1], **Katherine Seto**[1], **Lauren Withey**[1]

Children enslaved for fishing labor in the Brong Ahafo region of Ghana, 2010.

PHOTO: LISA KRISTINE/LISAKRISTINE.COM

U.S. President Obama's recent creation of an interagency task force on wildlife trafficking reflects growing political awareness of linkages between wildlife conservation and national security (*1*). However, this and similar new initiatives in Europe and Asia promote a "war on poachers" that overlooks the ecological, social, and economic complexity of wildlife-related conflict. Input from multiple disciplines is essential to formulate policies that address drivers of wildlife decline and contexts from which associated conflicts ignite.

POLICY

The harvest of wild animals from land and sea provides more than $400 billion annually, supports the livelihoods of 15% of the global population, and is the main source of animal protein for more than a billion of Earth's poorest inhabitants (*2*, *3*). Humans have always depended on wildlife, but the contemporary depletion of wildlife, combined with unprecedented market globalization, has heightened the economic stakes and desperation of consumers. The consequences of wildlife declines are severe and include regional destabilization and the proliferation of terrorism.

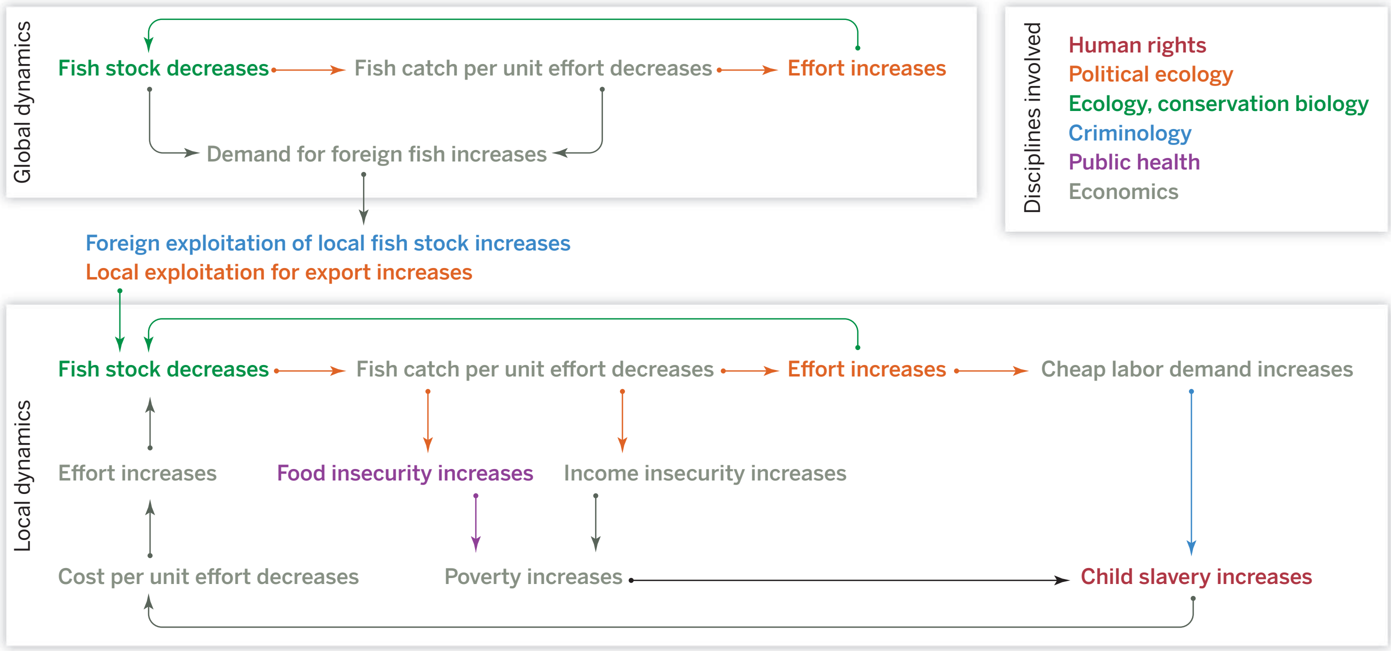
Here, we illustrate how wildlife decline may give rise to exploitative labor practices, empower profiteering groups who use violence to control illicit wildlife trades, and promote vigilante resource management. We also describe cases where incorporating interdisciplinary perspectives has improved policy outcomes.

HUMAN TRAFFICKING, ORGANIZED CRIME, AND VIGILANTE GOVERNANCE. Wildlife declines often necessitate increased labor to maintain yields. Harvesters of wildlife resort to acquiring trafficked adults and children to capture ever-scarcer resources while minimizing production costs. A vicious cycle ensues, as resource depletion drives harvesters to increase their use of forced labor to stay competitive.

Human trafficking associated with declining fishery harvests is increasing across the globe, exposing connections between fishery decline, poverty, and human exploitation (see the chart and figure) (*4*). Many fishers must travel farther, endure harsher conditions, search deeper, and fish for longer to obtain the types of harvests more readily available a generation ago (*2*). In Thailand, for example, Burmese, Cambodian, and Thai men are increasingly sold to fishing boats, where they may remain at sea for several years without pay, forced to work 18- to 20-hour days (*4*). Starvation, physical abuse, and murder are common on these vessels.

Connections between wildlife depletion and labor injustice are not limited to fisheries. Terrestrial wildlife declines in West Africa have led to exploitative child labor practices (*5*). Communities that for thousands of years met their dietary needs by hunting in neighboring forests must now travel for days to find prey. The region's main source of animal protein, fish, has declined, increasing reliance on terrestrial wildlife (*6*). Cheap child labor enables hunters to extract wildlife from areas that would otherwise be too costly to harvest.

Wildlife-related conflict is not limited to labor injustice. Scarce wildlife species used



Global and local drivers. The growth of child slavery in fisheries provides an example of the complex linkages between wildlife decline and social conflict, as well as the multidisciplinary insights necessary to inform policy. In practice, interdisciplinary engagement cannot be easily parsed among simplistic categories, and many perspectives inform each step. Policy action must integrate disciplines to address feedbacks among failing fish stocks, weak governance, uncertain resource tenure, and pressure from international demand.

as luxury goods can draw extraordinary prices. For example, high demand and reduced supply have contributed to record prices in elephant and rhino products, with ivory recently sold for $3000/kg and rhino horn fetching $60,000 to $100,000/kg (*1*, *7*). As in the drug trade, such concentrations of value promote a cascade of social consequences. Huge profits from trafficking luxury wildlife goods have attracted guerilla groups and crime syndicates worldwide. In Africa, the Janjaweed, Lord's Resistance Army, al-Shabab, and Boko Haram poach ivory and rhino horn to fund terrorist attacks (*7*).

Conservationists have lamented the endangerment of species targeted by luxury trades. Yet disciplines beyond conservation biology—such as political science, economics, and international law—must be integrated with ecological perspectives to understand and address feedbacks between wildlife depletion and organized crime (*8*).

Conflict resulting from wildlife scarcity is not always catalyzed by organized crime. When governments lack the political will or capacity to defend access to declining wildlife, local stakeholders may take the job into their own hands, sometimes resorting to violence. These vigilante defense actions often escalate into broader social unrest.

For example, lacking an effective central government since 1991, Somalia's coast guard ceased to defend the country's exclusive economic zone. As foreign fishing vessels proliferated in Somali waters, local fishers seized offending boats and demanded payment. As the number of foreign fishers increased, violence escalated (*9*). Dozens of boats are now ransomed annually by well-armed pirates (many supported by foreign cartels), who long ago traded nets for heavy weaponry. Pirates have justified their actions as necessary to protect their sovereignty over offshore fishing grounds (*9*).

> ***"wildlife decline may give rise to exploitative labor practices, empower profiteering groups who use violence to control illicit wildlife trades, and promote vigilante resource management."***

This path from resource defense to violent conflict, facilitated by weak governance, seems to be repeating itself in Benin, Senegal, and Nigeria, which are all witnessing increasing rates of piracy. In the words of a Senegalese fisherman, "in 10 years' time people will go fishing with guns.... We will fight for fish at sea. If we cannot eat, what do you expect us to do?" (*10*).

TOWARD INTEGRATED POLICY. Initiatives like President Obama's wildlife task force, the International Consortium on Combating Wildlife Crime, and the new UN Office on Drug and Crime anti–wildlife trafficking program emphasize enforcement of antipoaching and antitrafficking laws. Such steps are useful but their reach is limited because they target outcomes rather than factors that underlie demand for wildlife. Combating trafficking should only be one part of integrative programs that consider ecological, socioeconomic, and institutional contexts in which wildlife conflict occurs (see the chart).

Several models already exist for such programs. At a global scale, the Intergovernmental Panel on Climate Change has brought together academics, government practitioners, and seasoned policy-makers. The formation of a similarly inclusive and far-reaching problem-based working group is long overdue for addressing the global decline of wildlife.

The Millennium Ecosystem Assessment provides a multidisciplinary platform on which such a working group could be built. The new United for Wildlife collaboration, led by the Duke of Cambridge, offers an organizational framework for integrating law

---

*[1]Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720, USA. [2]Wildlife Health & Health Policy, Health and Ecosystems: Analysis of Linkages (HEAL) Program, Wildlife Conservation Society, Bronx, NY 10460, USA. [3]Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara, CA 93106, USA. *Corresponding author. brashares@berkeley.edu*

enforcement with biodiversity and livelihood conservation. However, such global efforts will only be sustained if the policies they create are enacted with strong funding and unfaltering political engagement.

At local and regional scales, policies that strengthen resource tenure may address both causes and consequences of wildlife conflict. Local governments have headed off social tension created by uncertain resource tenure by giving fishers and hunters exclusive rights to harvest grounds. Fiji's fishery, structured around territorial use rights, offers one example of effective management (*11*). Locally controlled management zones in Namibia have also demonstrated the ability of proactive policies to reduce poaching, stem wildlife decline, and improve local livelihoods (*12*). Government willingness to allow stakeholders to retain the bulk of revenues from harvests has been critical to the persistence of these programs.

Reducing or preventing wildlife conflict by strengthening local resource tenure has broad application but requires strong governance and an international commitment to recognize user rights. Organizations working to stem social conflict must address wildlife decline as a possible driver. Similarly, policies aimed at addressing wildlife decline must consider the social context of wildlife use and the feedbacks between wildlife scarcity and social conflict. Leadership must move beyond superficial reactions to elephant and rhino poaching and consider the complicated fate of the billions of people who rely on our planet's rapidly disappearing wildlife for food and income. ■

REFERENCES AND NOTES

1. Office of the President, *National Strategy for Combating Wildlife Trafficking* (U.S. Office of the President, Washington, DC, 2014).
2. Fisheries and Agriculture Department, *The State of World Fisheries and Aquaculture 2012* (Food and Agriculture Organization of the United Nations, Rome, 2012).
3. J. E. Fa, S. F. Ryan, D. J. Bell, *Biol. Conserv.* **121**, 167 (2005).
4. U.N. Office on Drugs and Crime, *Transnational Organized Crime in the Fishing Industry* (UNDOC, Vienna, 2011).
5. U.S. Department of Labor, Findings on the Worst Forms of Child Labor (2012); www.dol.gov/ilab/reports/child-labor/findings/.
6. J. S. Brashares *et al.*, *Science* **306**, 1180 (2004).
7. L. R. Douglas, K. Alie, *Biol. Conserv.* **171**, 270 (2014).
8. M. L. Gore, *Conserv. Biol.* **25**, 659 (2011).
9. J. Bahadur, *The Pirates of Somalia* (Pantheon Books, New York, 2011).
10. J. Vidal, "Will overfishing by foreigners drive Senegalese fishermen to piracy?" [blog], *The Guardian*, 3 April 2012.
11. R. Weeks, S. D. Jupiter, *Conserv. Biol.* **27**, 1234 (2013).
12. Namibian Association of Community-Based Natural Resource Management Support Organizations, *The State of Community Conservation in Namibia, Annual Report 2012* (NASCO, Windhoek, Namibia, 2013).

ACKNOWLEDGMENTS

This article was greatly improved by suggestions from four anonymous reviewers and supported by a NSF Dynamics of Coupled Natural and Human Systems grant.

10.1126/science.1256734

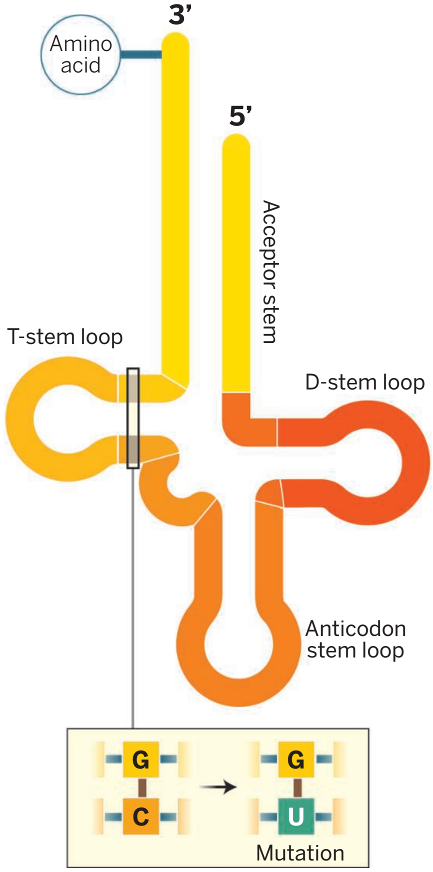
MOLECULAR BIOLOGY

Ribosome rescue and neurodegeneration

A mutation in a brain-specific tRNA reveals the link between ribosome maintenance and neuronal cell death

By **Jennifer C. Darnell**

Many human cognitive and neurodegenerative diseases are caused by alterations in the amounts of specific neuronal proteins, which are maintained at proper levels by regulation of their synthesis and turnover. For example, fragile X syndrome, a neurologic disease characterized by intellectual impairment and many behavioral symptoms including autism (*1*), results from loss of fragile X mental retardation protein (FMRP). FMRP normally reduces the synthesis of synaptic and other proteins (*2*). It achieves this by stalling ribosomes that are translating messenger RNA (mRNA) into protein. Aberrant protein synthesis that arises from the absence of FMRP is linked to neuron dysfunction. On page 455 of this issue, Ishimura *et al.* (*3*) reveal that loss of a protein that functions to release similar stalled ribosomes is linked to neuronal degeneration, but surprisingly, only in the presence of a second mutation in the protein synthesis machinery. This finding informs both critical translation mechanisms in the brain and the impact of modifying genes on disease symptoms. It thereby establishes a paradigm for understanding how a person's genetic makeup affects whether a specific mutation will lead to disease or be tolerated.



Isodecoder mutation. The predicted secondary structure of a brain-specific tRNA for arginine (in the mouse) is shown (*3*). The box indicates the mutation in the T-stem loop that is linked to neurodegeneration.

Ribosomes move along a strand of mRNA one codon at a time, decoding each group of three nucleotides into an amino acid that is added to a growing polypeptide chain. This decoding involves transfer RNA (tRNA) molecules that recognize a specific mRNA codon by base pairing through their "anticodon" loop. To mediate the translation of mRNA code into a protein, the tRNAs must be "charged" with the appropriate amino acid specified by the anticodon, a reaction catalyzed by very specific enzymes called tRNA synthetases. Neurodegeneration can result from mutation in the domain of a tRNA synthetase responsible for confirming the correct amino acid specified by the anticodon. Such mutations cause the incorporation of the wrong amino acids into neuronal proteins (*4*).

Ishimura *et al.* set out to identify the genomic mutation underlying a form of neurodegeneration. They discovered that neuronal death in mice resulted from a mutation that caused loss of the guanosine triphosphate–binding protein 2 (GTPBP2). GTPBP2 is similar to a class of proteins called ribosome release factors that free ribosomes from mRNA when they have stopped translating protein. Some of these release factors help terminate the newly synthesized protein when the ribosome reaches a codon instructing it to stop. Others rescue stalled ribosomes that have encountered aberrant early stop codons (*5*), have reached the 3′ end of mRNAs lacking a stop codon (*6*), or are stalled at codons

ILLUSTRATION: V. ALTOUNIAN/*SCIENCE*