LETTERS

The indigenous Yanomami people of Venezuela are facing a public health crisis.

Edited by **Jennifer Sills**

Venezuela's upheaval threatens Yanomami

The collapse of the Venezuelan economy has caused the country's health system to crumble, leading to the interruption of major vaccination and vector control programs (*1*, *2*) and putting the country's indigenous people at risk. Inhabiting the Venezuelan Amazon forest, the Yanomami people are now confronted with an unfolding, complex, and potentially catastrophic health situation. The rampant and uncontrolled epidemics of measles (*1*), malaria (*2*), and other infectious diseases (*1*, *2*) that sweep the country threaten the existence of these vulnerable Amerindian populations.

Relative isolation and low population density have made the Yanomami immunologically vulnerable to foreign diseases such as measles (*1*). In February 2018, the first cases of measles in 40 years were reported among Yanomami of the Upper Orinoco area (Amazonas State, Venezuela) (*1*, *3*). In 4 months, the disease spread to 126 people and caused 53 deaths (a 42% mortality rate) (*3*, *4*). From 2017 to 2018, the mortality rate among indigenous populations was 18%, 150 times as high as the rate in the general population (0.12%) (*1*, *3*, *4*). Measles vaccination coverage in accessible areas of the Venezuelan Amazon region has progressively decreased since 2010 in all municipalities, barely attaining 40% in the Upper Orinoco (*1*), thus making further spread of the epidemic even more likely.

The Yanomami, who live under high levels of exposure to vector-borne tropical infections in the best of circumstances (*5*, *6*), are now experiencing an unprecedented increase in malaria cases as well (*7*). The ongoing malaria epidemic in Venezuela, which could be approaching a million cases per year, led to 32,293 Venezuelan Amazon cases in 2016 and an increase to 67,387 cases in 2017 (*2*, *7*). The municipality of Alto Orinoco, which harbors most of the Yanomami settlements, exhibited a 41% increase in cases between 2016 and 2017 (*7*). Like measles, the increase of malaria could be fueled by the intensification of illegal gold mining (*2*).

The Yanomami face these threats of disease in the context of cultural changes that also affect public health (*5*). The seminomadic nature of these populations is giving way to a more settled way of life, in areas where they live in contact with other populations (*8*). These changes have led to poor nutrition, overcrowding, poorer sanitation, and increased forest clearing (*8*, *9*). Although artisanal small-scale mining has been a traditional practice among other indigenous groups, such as the Ye'kwana (*9*), it has only recently been adopted by the Yanomami, and the expansion of illegal gold mining by outsiders in their territory is an unfolding reality (*5*). Because gold isolation and recovery require substantial amounts of elemental mercury, the increase in mining pollutes the Yanomami people's land and waters with a chemical that takes 500 years to dissipate (*9*).

The Yanomami's vulnerability to measles, malaria, malnutrition, and mercury pollution is both an environmental disaster and an ethnocide in progress. The future of the Yanomami hangs in a delicate balance. Their immense and ancestral journey as guardians of the Amazon deserves our highest recognition and respect.

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No inflation of threatened species

In the global assessment recently produced by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), we reported that human-caused drivers have been reducing biodiversity and many of its contributions to people and that these downward trajectories can be reversed only by transformative change (*1*). Among many other statistics reflecting the current state of nature, the assessment estimated that 1 million animal and plant species are threatened with extinction and that extinction rates are already at least tens to hundreds of times higher than the average over the past 10 million years (*1*). In his Letter "Unhelpful inflation of threatened species" (26 July, p. 332), M. J. Costello critiques these estimates and argues that, rather than being helpful to conservation, they may even be counterproductive. We disagree: The estimates are not inflated, and we were right to report them.

As we acknowledged fully (*1*), the current global number of animal and plant species is a key uncertainty when estimating how many are threatened. Costello implies a consensus that this number is at most 2.7 million, citing four of his recent papers as evidence. However, estimates have not converged over recent decades (*2*), and Costello's low estimates have themselves been criticized; for example, they are based on analysis of the taxonomic history of unusually completely described groups (*3*), and they overlook how species descriptions have become increasingly complex over time (*4*). Faced with very divergent estimates from different researchers using well-reasoned approaches, we used a transparent and non-extreme recent estimate [8.1 million animal and plant species (*5*)] but also spelled out how the number of threatened species depends on the estimate used and, given that insects may have a lower prevalence of extinction risk, how many are insects (*1*). The estimate of 5.5 million insects that we used (*1*) has since been supported by a focused review (*3*). Costello's criticisms of the extinction rate comparisons in the Global Assessment are also wrong: Contrary to his suggestion, the comparisons were matched by taxonomic group and considered the effect of time scale (*1*), whereas the cause of extinction is irrelevant to rate comparisons.

We agree with Costello that expanded knowledge of species status will be immensely helpful for conservation action; however, we disagree entirely with his suggestion that the Global Assessment should have focused on how many species have been documented as threatened (about 27,000) rather than estimating the global total (about 1 million), for fear of inducing "compassion fade." Effective policy and action surely need estimates of the true state of nature, not numbers chosen for their political or social acceptability. The Global Assessment therefore took the view that it should estimate the true state of nature, acknowledging the uncertainties, rather than only report numbers of documented extinctions and threatened species (which, although important and more precisely known, conflate the state of nature and the state of knowledge). As Tukey (*6*) wrote, "Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise."

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Certification for gene-edited forests

Forest certification bodies were established to provide consumers with confidence that they are purchasing sustainably sourced wood products. Over 500 million hectares of forests, or about 13% of global forest area, are certified under the largest certification systems (*1–3*). However, certification bodies have consistently excluded all genetically engineered or gene-edited (GE) trees from certification, including from field research on certified lands that is essential for understanding local benefits and impacts (*4*). We, leading forest biotechnology scientists from around the world, with the support of more than 1000 globally diverse signatories to a recent detailed petition (*5*), call for all forest certification systems to promptly examine and modify these policies.

Forests face mounting stresses posed by invasive pests and climate change (*6*). Given the growing need for sustainable and renewable forest products and the increasing precision and safety record of biotechnologies, we believe that GE trees can make a substantial contribution to management of certified forests. To face the challenges of forest health, carbon sequestration, and maintenance of other ecological services, we must use all available tools. GE tree research should be allowed immediately on certified land, and GE trees proven by research to provide value should eventually be allowed in certified forests.

A variety of current biotechnologies—including grafting, in vitro propagation, breeding, hybridization, and cloning—have made tremendous impacts on tree health and productivity (*7*). Newer forms of biotechnology, specifically gene editing, can

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make substantial further contributions to forest management. Traits that have shown great promise based on field trials of GE trees are highly diverse and include those related to productivity, wood quality, pest and stress resistance, protection of endangered species, and reproductive control (*8*). Research results also suggest that there are no hazards unique to GE methods compared with conventional breeding; rather, it is the value and novelty of the specific traits imparted and how they interact with conventional breeding that are germane to safety and economic assessments (*9*, *10*). Instead of categorically excluding GE methods, each application of GE technology should be evaluated on its individual merits based on the trait and its mechanism.

Democratic and stakeholder-driven processes generally govern certification agencies in sustainable forest management systems. However, the Programme for the Endorsement of Forest Certification (PEFC) recently extended the GE tree ban through 2022 via editorial updates (*11*), an internal procedure that did not meet the standards of a rigorous, science-based, democratic, and transparent process. We urge in-depth discussion and decisions on this issue at the PEFC annual stakeholder meeting on 3 October and at the Forest Stewardship Council general assembly on 8 October.

The National Academies of Sciences, Engineering, and Medicine recently completed an in-depth study on forest health and biotechnology, concluding that the potential benefits are numerous and rapidly increasing (*12*). Our forests are in dire need of assistance, and GE trees hold tremendous potential as a safe and powerful tool for promoting forest resilience and sustainability.

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Gene-edited and genetically engineered trees, such as these poplars, should be allowed in certified forests.

PHOTO: STEVEN STRAUSS

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TECHNICAL COMMENT ABSTRACTS

Comment on "Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico"

Tristan C. Ballard, Anna M. Michalak, Gregory F. McIsaac, Nancy N. Rabalais, R. Eugene Turner

Van Meter *et al.* (Reports, 27 April 2018, p. 427) warn that achieving nitrogen reduction goals in the Gulf of Mexico will take decades as a result of legacy nitrogen effects. We discuss limitations of the modeling approach and demonstrate that legacy effects ranging from a few years to decades are equally consistent with observations. The presented time scales for system recovery are therefore highly uncertain.

Full text: dx.doi.org/10.1126/science.aau8401

Response to Comment on "Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico"

K. J. Van Meter, P. Van Cappellen, N. B. Basu

Ballard *et al.* argue that our prediction of a 30-year or longer recovery time for Gulf of Mexico water quality is highly uncertain and that much shorter time lags are equally likely. We demonstrate that their argument, based on the use of a two-component regression model, does not sufficiently consider fundamental watershed processes or multiple lines of evidence suggesting the existence of decadal-scale lags.

Full text: dx.doi.org/10.1126/science.aav3851

ERRATA

Erratum for the Research Article "Synthetic glycolate metabolism pathways stimulate crop growth and productivity in the field" by P. F. South *et al.*, *Science* **365**, eaay8818 (2019). Published online 2 August 2019; 10.1126/science.aay8818

Erratum for the Report: "Elevated *HLA-A* expression impairs HIV control through inhibition of NKG2A-expressing cells" by V. Ramsuran *et al.*, *Science* **365**, eaay7985 (2019). Published online 2 August 2019; 10.1126/science.aay7985

Erratum for the Report: "Efficient access to unprotected primary amines by iron-catalyzed aminochlorination of alkenes" by L. Legnani *et al.*, *Science* **365**, eaay8140 (2019). Published online 26 July 2019; 10.1126/science.aay8140

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Certification for gene-edited forests

Steven H. Strauss, Wout Boerjan, Vincent Chiang, Adam Costanza, Heather Coleman, John M. Davis, Meng-Zhu Lu, Shawn D. Mansfield, Scott Merkle, Alexander Myburg, Ove Nilsson, Gilles Pilate, William Powell, Armand Seguin and Sofia Valenzuela

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