LETTERS

The Brumadinho, Brazil, dam rupture, which caused the mudslide and rail bridge damage shown here, may have been preventable.

Edited by **Jennifer Sills**

Brazil's policies stuck in the mud

In 2015, the rupture of a dam in Mariana, Brazil, caused a massive mudslide from iron ore mining to flow downriver, severely affecting more than 1 million people living downstream along the most important river basin for biodiversity conservation in southeastern Brazil (*1*). This tragedy was directly linked to negligence and monitoring failures by the Samarco mining company (co-owned by the Brazilian Vale and Australian BHP Billiton) (*1*). Less than 4 years later, a similar tragedy has happened once again: A large broken dam in Brumadinho generated a mudslide avalanche, severely flattening the landscape and leaving hundreds of people missing (*2*). This tragedy occurred despite warnings in Brazil, where some 23,000 mining dams are exposed, 45 of which are under threat of imminent collapse (*3*). Meanwhile, the government proposed a new plan to boost mining activities and fast-track poorly executed environmental licensing to rubber-stamp mineral exploitation (*4*). Even more alarming are the new Bolsonaro administration's plans to roll back environmental protection, starve federal science programs, and implement an aggressive pro-development agenda to facilitate agricultural, industrial, and mineral expansion (*5*).

Propelled by economic growth, emergent tropical economies such as Brazil, Guiana, and Congo have historically allowed extractive industries, including mining, to generate jobs and tax revenues at great risk to the environment and local communities (*6*–*9*). Governmental environmental agencies in developing countries, especially Brazil, are relaxing licensing laws and penalties (*5*, *10*, *11*). Instead, these governments should be striving to incorporate better environmental performance, strong regulatory measures, comprehensive impact assessments, and risk monitoring into all major government plans (*1*). Civil societies and policy-makers in development-ravenous emergent economies must rethink their strategies to reconcile the imperatives of development with environmental sustainability.

João Vitor Campos-Silva[1]* and Carlos A. Peres[2]
[1]Programa de Pós-Graduação em Diversidade Biológica e Conservação nos Trópicos, Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Alagoas, Tabuleiro dos Martins, Maceió, Alagoas, Brazil. [2]School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK.
*Corresponding author. Email: jvpiedade@gmail.com

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Broadly defining "working lands"

In their Review "Landscapes that work for biodiversity and people" (19 October, p. eaau6020), C. Kremen and A. M. Merenlender emphasize the importance of "working lands" in preventing biodiversity loss, mitigating climate change, and sustainably providing resources for humanity. We agree with the authors' assertions, but we believe that their restriction of "working lands" to those that produce food, water, fiber, and fuel is far too limited to address the threats of the Anthropocene and achieve conservation goals.

Landscapes that support the infrastructure that provides services such as transportation, energy, and water make up a substantial proportion of managed land (*1*). If designed properly, this land can support biodiversity (*2*) and serve as viable corridors to connect protected and sustainably managed areas (*3*), while still providing important products and services for humans. Some types of sustainable and green infrastructure development have the potential to support biodiversity and ecosystem function as well as play an important role in urban biodiversity conservation and climate change adaptation (*4*).

Given the escalating threats to and dominance of the oceans in our global ecosystem, we also suggest an expansion of this conceptual framework to include "working seascapes." Working seascapes include coastlines, near- and offshore waters, estuaries, and open ocean, all of which have been transformed by humans for millennia (*5*). Working seascapes provide livelihoods, food security, and cultural identity to millions globally (*6*) through wild-caught fisheries, aquaculture, tourism, recreation, and infrastructure. Working lands and working seascapes face many similar challenges to balancing resource exploitation with biodiversity conservation, although the necessary strategies, scales, and tools required to address these issues may differ substantially (*7*).

Jessica L. Deichmann[1,2]* Steven W. J. Canty[1,3], Thomas S. B. Akre[1,2], Melanie McField[1,3]
[1]Working Land and Seascapes, Conservation Commons, Smithsonian Institution, Washington, DC 20013, USA. [2]Smithsonian Conservation Biology Institute, Washington, DC 20560, USA. [3]Smithsonian Marine Station, Fort Pierce, FL 34949, USA.
*Corresponding author. Email: deichmannj@si.edu

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Response

In our Review, we carefully defined working lands conservation as systems that simultaneously provide resources to support biodiversity and rely on biodiversity, in the form of ecosystem service providers, for sustainable production. Although Deichmann *et al.* rightly point out the large land area taken up by burgeoning energy, water, and transportation infrastructure and thus the importance of mitigating its impacts on biodiversity, built infrastructure does not rely on biodiversity to supply services to humanity. Thus, it does not have the reciprocity that we see as critical for advancing conservation objectives in working lands. On the other hand, green infrastructure—i.e., ecosystems engineered to deliver certain services (*1*)—could both support and rely on some biodiversity (*2*), aligning with our working lands conservation concept. In some cases, green infrastructure may also promote habitat connectivity [e.g., (*3*)].

Despite green infrastructure's potential, we should focus above all on limiting infrastructure to improve conservation outcomes. For example, in the tropics, many roads developed at high economic and environmental cost quickly degrade. Thus, road development should be strategically limited to those most likely to endure while maximizing biodiversity-sensitive road-free areas (*4*). Similarly, working lands conservation and green infrastructure projects should be applied only on already-converted landscapes, rather than expanding into primary or advanced secondary habitats, as we explained in our Review.

We agree with Deichmann *et al.* that conservation of working seascapes is a natural analog to working lands conservation. Marine management systems exist that fit with our concept of supporting biodiversity by providing critical resources, while relying on biodiversity for sustainable production of various ecosystem goods and services. For example, techniques that operate outside of marine protected areas (MPAs), such as incentive-based fisheries management and ecosystem-based management, are recognized by marine biologists as providing some of the most promising opportunities for conserving both fish stocks and marine ecosystems overall, in combination with MPAs (*5*).

In their Letter "Working governance for working land" (14 December 2018, p. 1257), D. Brockington *et al.* responded to our Review by pointing out the critical role of effective governance systems and how they must be tailored to the specific socioecological context of each working land or working seascape, whether private, communal, or state-managed. The paucity of information available on this critical topic limits the ability to predetermine which governance systems are likely to be most effective in which contexts. Two things are clear. First, it is critical to co-create conservation projects with diverse stakeholders and build community support, from conception to implementation (*6*, *7*). Second, we must study both failure and success systematically, so we can learn and improve conservation outcomes using evidence-based approaches (*8*–*10*).

Claire Kremen[1,2]* and Adina Merenlender[2]
[1]Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, BC V6T 1Z4, Canada. [2]Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720, USA.
*Corresponding author. Email: claire.kremen@ubc.ca

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Response

Jennifer SillsClaire KremenAdina Merenlender

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