LETTERS

Indigenous peoples in Brazil's Amazon region are at increased risk in a COVID-19 outbreak.

PHOTO: LUCAS FERRANTE

Edited by **Jennifer Sills**

Protect Indigenous peoples from COVID-19

As coronavirus disease 2019 (COVID-19) spreads through Brazil, President Jair Bolsonaro has repeatedly denied the severity of the pandemic and broadcasted misleading information and mixed messages about how to respond, advocating for hydroxychloroquine use and the end of the country's quarantine (*1*). Current scientific evidence contradicts these recommendations (*2*, *3*), and the president's speech puts the population of Brazil at risk. The public health system in Brazil's state of Amazonas has already "collapsed," according to a statement by the mayor of the state's capital city (*4*). The Bolsonaro administration must immediately reverse its current posture of minimizing the threat of COVID-19 and take steps to protect Brazil's vulnerable populations, including its Indigenous and traditional peoples.

The standard risk groups for COVID-19 are elderly people and those with comorbidities (*3*), but in Brazil it makes sense to expand the risk group designation to include Indigenous peoples. Pathogens have historically been one of the most powerful factors in decimating Indigenous peoples in South America (*5*, *6*). COVID-19 poses a particular threat to these communities given that Brazil's federal government has marginalized and neglected Indigenous peoples even when their rights are guaranteed by law or by international agreements (*7*, *8*).

Indigenous and traditional peoples can be expected to be especially vulnerable to severe acute respiratory syndrome–coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19. In addition to their history of susceptibility to epidemics (*6*), many of these isolated communities lack medical posts, doctors, and basic medications, to say nothing of the ventilators that would be needed to treat a COVID-19 outbreak. Bolsonaro's administration recently dismissed 8000 Cuban doctors who served small communities in the country's interior (*9*), which has been especially harmful to Indigenous and traditional communities in the Amazon region.

Brazil's government must take action in the Amazon to protect these people. Instead of allowing evangelical missionaries to enter into contact with isolated Indigenous groups (*10*), all means of transport to these areas should be restricted. The first Indigenous case of the disease was confirmed on 1 April (*11*). In line with international guidelines (*11*), Brazil's government should ensure isolation and monitoring in Indigenous areas as well as for all those who have contact with them. The government must act quickly to provide doctors, personal protective equipment, and testing capabilities in these areas. On the national scale, Brazil must maintain a nationwide quarantine to mitigate the disease's impact. Measures favored by Brazil's president, such as "vertical isolation" or a partial breach of isolation (*1*), conflict with World Health Organization recommendations and scientific studies (*3*, *12*), thereby putting Brazil's entire population at risk. The effectiveness of hydroxychloroquine has not been confirmed, although its risks have been (*2*). Protecting Indigenous and traditional peoples from COVID-19 by acknowledging their increased risk and acting accordingly will protect public health for all Brazilians as well as safeguard the sustainability of the Amazon.

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Ecosystem aridity and atmospheric CO_2

In their Report "Global ecosystem thresholds driven by aridity" (14 February, p. 787), M. Berdugo *et al.* found that more than 20% of the land surface is projected to cross an aridity threshold by 2100, which could lead to widespread desertification ("Crossing thresholds on the way to ecosystem shifts," M. Hirota and R. Oliveira, Perspectives, 14 February, p. 739). Efforts to identify robust thresholds are essential to guide effective policy (*1*). Such efforts, however, commonly overlook two important aspects of vegetation-water relations: the effect of CO_2 on the efficiency with which plants use water and the effect of CO_2 on potential evapotranspiration, and thus aridity.

Under elevated CO_2, plants increase the efficiency with which they use water (*2*). In water-limited regions, this has an outsized impact, leading to dryland ecosystems becoming less water-limited, with an increased number of leaves and/or increased photosynthesis per leaf (*3*). Aridity thresholds are thus projected to shift as a function of CO_2 (*4*, *5*). In addition, although large future increases in aridity are commonly projected using drought indices (*6*), these projections do not account for the direct effect of CO_2 on vegetation. When the effect of CO_2 on plant water use is included, projected increases in aridity are greatly decreased (*7–10*).

Observed dynamics of natural dryland vegetation (*4*, *11*) and experimental evidence (*12*) support these conclusions and suggest that elevated CO_2 improves the resilience of semi-arid ecosystems, which is often accompanied by substantial greening (*4*, *11*). Rising CO_2 has thus already led to a shift in the relationship between ecosystem function and water resources. Understanding the extent to which this direct effect of CO_2 offsets the indirect effect of increased potential evapotranspiration driven by atmospheric warming remains an important area of research. By omitting the direct influence of CO_2, however, projections of future aridity and the cascading effects on ecosystems overestimate the degree to which ecosystems will cross aridity thresholds this century.

Information on ecological thresholds is essential for understanding the limiting factors of future ecosystem function but requires a full consideration of ecophysiology. We agree with Berdugo *et al.* that immediate action is necessary to avoid the negative impacts of climate change and potential desertification, but such action will be most effective when informed by more comprehensive scientific projections.

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Response

We reported that increases in aridity observed across global drylands indicate that more than 20% of the Earth's surface will cross one or several of the aridity thresholds identified by 2100. Keenan *et al.* suggest that this proportion will be lower because a CO_2-enriched atmosphere will promote higher water-use efficiency of vegetation and affect potential evapotranspiration (*1*). However, Keenan *et al.* do not quantify how these CO_2-driven adjustments affect the nonlinear responses we reported (which are robust and constitute the core findings of our study), the aridity levels at which they occur, or the proportion of Earth's surface that will be affected.

Keenan *et al.* argue that plant water use will decrease estimated increases in aridity. Of course, the proportion of terrestrial surface affected by the thresholds identified would vary if aridity projections change. We used (but did not produce) one of the most accepted aridity projections available (*2*). However, we acknowledge that aridity projections are currently under debate. Once there is a global consensus on projections, the agreed-upon numbers could be used to refine the estimates provided in our study, which focused on identifying aridity thresholds, not questioning projections.

As we acknowledged in our Report's Methods section, there are limitations to our space-by-time substitution approach. In addition to water use efficiency changes described by Keenan *et al.*, factors such as species turnover, adaptation to the new climatic conditions, increasing albedo, topography (*3*), and potential legacy effects of current climatic and management conditions (*4*) could affect ecosystem responses to increases in aridity. The lack of global and consistent estimations of the effect of these processes on aridity projections, however, prevented us from considering them in our quantitative estimations.

Keenan *et al.*'s assumptions also have limits: Increases in soil temperature projected with climate change, and thus associated soil moisture losses, may be higher than previously reported (*5*), and increases in water use efficiency may not be compensated by enhanced dryness driven by ongoing warming (*6*). This, together with an increased frequency of extreme climatic events, could dampen or even reverse the positive effect of CO_2 fertilization on vegetation growth and evapotranspiration in the future (*7*), particularly in drylands (*8*). In addition, vegetation greening is not always related to increasing productivity (*9–11*). Thus, we cannot assume that the influence of CO_2 fertilization on vegetation observed in recent decades will be maintained in the future, which will likely be characterized by the rise of temperature-driven impacts of climate change, such as increases in aridity, on ecosystems (*12*). However, we agree with Keenan *et al.* on the importance of investigating the opposite effects of elevated CO_2 and increased atmospheric dryness on vegetation. We look forward to future research that will help elucidate these complex interactions and further hone aridity projections.

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TECHNICAL COMMENT ABSTRACTS

Comment on "Light-induced lattice expansion leads to high-efficiency perovskite solar cells"

Nicholas Rolston, Ross Bennett-Kennett, Laura T. Schelhas, Joseph M. Luther, Jeffrey A. Christians, Joseph J. Berry, Reinhold H. Dauskardt

Tsai *et al*. (Reports, 6 April 2018, p. 67) report a uniform light-induced lattice expansion of metal halide perovskite films under 1-sun illumination and claim to exclude heat-induced lattice expansion. We show that by controlling the temperature of the perovskite film under both dark and illuminated conditions, the mechanism for lattice expansion is in fact fully consistent with heat-induced thermal expansion during illumination.

Full text: dx.doi.org/10.1126/science.aay8691

Response to Comment on "Light-induced lattice expansion leads to high-efficiency perovskite solar cells"

Hsinhan Tsai, Wanyi Nie, Aditya D. Mohite

Rolston *et al*. suggest through a convective heating scheme that the mechanism of light-induced lattice expansion is from light-induced thermal heating. We bring out key differences in the physical observables that are not discussed and different from what is observed in the original paper by Tsai *et al*.

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