LETTER

# Smaller human population in 2100 could importantly reduce the risk of climate catastrophe

In PNAS, Bradshaw and Brook (1) report that even the most aggressive population policies would be unlikely to reduce the 2100 human population below 7 billion, and that more realistic measures would be unlikely to reduce the population by more than 1 billion people less than it otherwise would be. They conclude that "the result would be ineffective in mitigating the immediately looming global sustainability crises." Their research conducts persuasive demographic projections of population size but does not estimate the possible magnitude of any effect of population size on climate outcomes.

Would the effects of a counterfactual reduction in the size of the 2100 population by 1 billion have important consequences for well-being because of effects on climate change? One way to answer—without denying more likely costs of climate change—is to focus on small risks of an extreme catastrophe, which Weitzman (2) has argued are important to climate policy decision making. For example, Sherwood and Huber (3) compute that the 10 °C warming that Weitzman considers could make the places where most people now live effectively uninhabitable due to heat stress.

The Intergovernmental Panel on Climate Change's "business as usual" representative concentration pathway (RCP) 8.5 scenario projects that the human population will reach about 12 billion in 2100. O'Neill et al. (4) review 14 cross-country econometric studies, which collectively suggest that the elasticity of $CO_2$ emissions with respect to population size is about 1 or more; this means that a 1% decrease in the population would cause a 1% decrease in emissions. The RCP8.5 path projects a mean and SD of 7.8 °C and 2.9 °C for temperature change by 2300. If a population path that results in 1 billion fewer people in 2100 (a reduction of 8%) reduces this mean and SD by 5%, then the probability of a dichotomized 10 °C Weitzman-type extreme disaster may be reduced by about five percentage points (which is about 20%), if the world were on an RCP8.5 economic and political trajectory. This approximate, illustrative large effect is because 10 °C has a $z$ score of 0.76, so the cumulative distribution function of temperature change is relatively steep. Of course, if the world develops on a lower emissions path than RCP8.5, then the effect of population on the probability of such a disaster could be much lower, even if the effect of population on emissions is large.

Whether or not pursuing a smaller 2100 human population than otherwise would occur is, on net, a recommended policy goal depends critically on alternatives, on costs, and on the nature of the population policy. Some historical efforts to reduce population size have caused considerable harm (5). Moreover, many of the present-day high-emissions populations have comparatively lower fertility. Human development—such as improving health, education, and women's social status—could encourage parents to freely choose to reduce population size while improving average well-being, and could therefore be an exception to the standard claim that development is in conflict with climate policy.

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**1** Bradshaw CJA, Brook BW (2014) Human population reduction is not a quick fix for environmental problems. *Proc Natl Acad Sci USA* 111(46):16610–16615.
**2** Weitzman ML (2009) On modeling and interpreting the economics of catastrophic climate change. *Rev Econ Stat* 91(1):1–19.
**3** Sherwood SC, Huber M (2010) An adaptability limit to climate change due to heat stress. *Proc Natl Acad Sci USA* 107(21): 9552–9555.
**4** O'Neill BC, et al. (2012) Demographic change and carbon dioxide emissions. *Lancet* 380(9837):157–164.
**5** Connelly M (2008) *Fatal Misconception: The Struggle to Control World Population* (Harvard Univ Press, Cambridge, MA).

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