LETTER



REPLY TO VERBEECK AND KEARSLEY:

# Addressing the challenges of including lianas in global vegetation models

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Verbeeck and Kearsley (1) rightfully point out that global vegetation models would greatly benefit from implicitly including the effects of lianas. Recent experimental evidence that lianas substantially reduce the capacity of tropical forests to uptake and store carbon is compelling (2, 3). Furthermore, lianas are increasing relative to trees rapidly in many neotropical forests (4), which will further change the way that forests uptake, cycle, and store carbon.

We agree that lianas should be incorporated in global vegetation models; however, to do so accurately several important challenges must be overcome. First, we desperately need experimental data on the effects of lianas on tropical forest carbon dynamics from additional geographic regions. Experimental data on the effects of lianas on carbon uptake, cycling, and storage currently come from studies conducted in one secondary forest in central Panama (2, 3). Liana abundance and biomass, however, is highly variable across the tropics, and lianas may have a much greater effect in secondary forests and highly seasonal tropical forests, where they are particularly common (4). Second, experimental studies will need to be conducted for long enough to capture important long-term community dynamics and to integrate annual variation in the effect of lianas on carbon dynamics. Lianas affect the growth and mortality of tree species (5), possibly changing tree community composition, which could significantly change forest carbon dynamics. Additionally, the strength of liana competition may vary annually with mean annual precipitation, the severity of seasonal drought, and other factors, and this type of variation must be quantified to provide a more accurate integrated estimate of the effects of lianas on tropical forest carbon dynamics. Third, the increase in lianas relative to trees is probably not uniform throughout the tropics. Although we have evidence that lianas are increasing in many neotropical forests, there is little evidence that this is a pantropical phenomenon, and we have little knowledge of the conditions where they are increasing the fastest (4). Understanding the causes of liana increases and where lianas are increasing most rapidly will become crucial for modeling future effects of lianas on forest carbon dynamics. Finally, global vegetation models themselves will benefit from further development and refinement. The inclusion of a greater diversity of plant functional traits in global models (6), for example, may be critical to improving these models and for predicting how lianas affect future carbon dynamics and storage in tropical forests.

The best way to address the challenges of incorporating lianas in global vegetation models is to establish a network of observational and experimental studies on the effects of lianas in a variety of forest types throughout the tropics. Although empirical data from recent experimental studies (2, 3) can certainly provide initial parameter estimates for refined global vegetation models, long-term data from across the tropics will provide a much more robust solution to the current challenges of accurately parameterizing global vegetation models.

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1 Verbeeck H, Kearsley E (2016) The importance of including lianas in global vegetation models. *Proc Natl Acad Sci USA* 113:E4.
2 van der Heijden GMF, Powers JS, Schnitzer SA (2015) Lianas reduce carbon accumulation and storage in tropical forests. *Proc Natl Acad Sci USA* 112(43):13267–13271.

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