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Two decades of forest monitoring shows instability in the rainforests

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The tropical terrestrial ecosystems naturally exist as alternative stable states, commonly referred to as forest and savanna ecosystems. However, these ecosystems, especially forests, are currently threatened by the risk of drought-induced forest-to-savanna transitions across the tropics and subtropics. Therefore, a better understanding of ecosystem dynamics and characteristics behind these alternative stable states is crucial in predicting their response to future hydroclimatic changes. Previous studies have analyzed these alternative stable states against precipitation predominantly based on space-for-time substitution. However, such a substitution provides a partial picture of ecosystem adaptation dynamics and associated ecosystem structural change over time.

Here, we empirically study the transient state of tropical ecosystems and their hydroclimatic adaptations by examining remotely sensed tree cover and root zone storage capacity over the last two decades in South America and Africa. Tree cover represents the above-ground ecosystem structure's density, and is derived directly from MODIS satellite data. Whereas root zone storage capacity is the maximum amount of soil moisture that the vegetation can access for transpiration is derived using daily precipitation and evaporation data.

We found that ecosystems at high (>75%) and low (<10%) tree cover adapt to changing precipitation by instigating considerable subsoil investment while experiencing limited tree cover change over time. For these ecosystems, the below-ground investment does not come at the cost of changing the above-ground ecosystem structure. Thus, we deem these ecosystems as stable since ecosystems' adaptive dynamics keep the structural characteristics intact. In contrast, unstable ecosystems at intermediate (30-60%) tree cover were unable to exploit the same level of adaptation as stable ecosystems, thus showing considerable changes to their above-ground ecosystem structure. We also found that ignoring this adaptive capacity of the ecosystem can underestimate the resilience of the forest ecosystems, which we find is largely underestimated in the case of the Congo rainforests. The results from this study emphasize the importance of the ecosystem's temporal dynamics and adaptation in inferring and assessing the risk of forest-savannah transitions under rapid hydroclimatic change.