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Vegetation out of Balance

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Time lags in responses to environmental changes are very common in natural systems. Given the projected high rates of climate change over the 21st century, many land ecosystems will be poorly adapted to the new conditions. We assess the magnitude of this adaptation deficit by comparing transient ecosystem state under given climate trajectories with optimally adapted state ("equilibrium state" in the following), both simulated with the dynamic global vegetation model LPJmL under WCRP CMIP3 climate projections.

We show large differences between actual and equilibrium ecosystem state in key variables such as tree cover, vegetation carbon stocks and NPP. The gap between transient and equilibrium state increases throughout the 21st century, indicating modelled ecosystem adaptation rates below climate change rates. At the end of the 21st century relaxation times to reach carbon-equilibrium are as high as >1000 years in boreal regions.

Time lags in ecosystem responses and resulting suboptimal growing conditions have a potentially destabilising effect: non-adapted vegetation is more susceptible to stress and could decline very rapidly in some regions; replacement by better adapted species is usually slow. The risk of such catastrophic ecosystem collapses is especially high in regions with structural differences between transient and equilibrium vegetation. But even where changes in vegetation are gradual, ecosystems in many regions will stay behind their carbon sequestration and carbon storage potential for centuries.