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The Global Emergence of Hotter-Drought Drivers of Forest Disturbance Tipping Points

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Current research is presented on global-scale patterns and trends of forest responses to increasingly hotter droughts, particularly extensive tree mortality and forest die-offs involving a range of interactive disturbances (e.g., water stress, insect outbreaks, high-severity wildfire), illustrating emerging ecological changes and growing tipping-point risks to forests worldwide from hotter-drought extremes. Cross-scale observations and empirical findings – ranging from controlled experiments in pots and local plot-level vegetation data, to networks of carbon flux monitoring sites and globally synoptic remote-sensing data – increasingly indicate that amelioration of hotter-drought stress via fertilization of photosynthesis from elevated atmospheric CO₂ concentrations may soon be overwhelmed by heat and accelerated atmospheric drought. These findings highlight some current challenges in realistically projecting the future of global forest ecosystems (and their associated carbon pools and fluxes) with process-based Earth system models. In particular there is substantial evidence that ‘historical forests’ – established by circa 1880 and dominated by larger, older trees – may be disproportionately vulnerable to increased growth stress and mortality under hotter-drought conditions from ongoing anthropogenic climate change. The fates of the world’s biggest, oldest trees and historical forests in response to global change are of vital importance, given that they are essential as: a) disproportionately large carbon sinks; b) among the most biodiverse and rare terrestrial ecosystems; c) irreplaceable archives of environmental history; and d) venerated for many spiritual, aesthetic, and other cultural reasons. Key scientific uncertainties that impede modeling progress are outlined, and examples of promising empirical modeling approaches are illustrated.