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Shifting terrestrial feedbacks from CO_2 fertilization to global warming

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Humans are increasingly fertilizing the planet. Our activities are increasing atmospheric concentrations of carbon dioxide, nitrogen inputs to ecosystems and global temperatures. Individually and combined, they lead to biospheric availability of carbon and nitrogen, enhanced metabolic activity, and longer growing seasons. Plants can consequently grow more and take up more carbon that can be stored in ecosystem carbon pools, thus enhancing carbon sinks for atmospheric CO_2. Data on the increased strength of carbon sinks are, however, inconclusive: Some data (eddy covariance, short-term experiments on elevated CO_2 and nutrient fertilization) suggest that biospheric carbon uptake is already effectively increasing but some other data suggest it is not, or are not general and conclusive (tree-ring, forest inventory). The combined land–ocean CO_2 sink flux per unit of excess atmospheric CO_2 above preindustrial levels declined over 1959-2012 by a factor of about 1/3, implying that CO_2 sinks increased more slowly than excess CO_2. We will discuss the available data, and the discussion will drive us to revisit our projections for enhanced carbon sinks. We will reconsider the performance of the modulators of increased carbon uptake in a CO_2 fertilized and warmed world: nutrients, climate, land use and pollution. Nutrient availability in particular plays a crucial role. A simple mass-balance approach indicates that limited phosphorus availability and the corresponding N:P imbalances can jointly reduce the projected future carbon storage by natural ecosystems during this century. We then present a new paradigm: we are shifting from a fertilization to a warming era. Compared to the historical period, future impacts of warming will be larger than the benefits of CO_2 fertilization given nutrient limitations, management and disturbance (which reduces C stocks and thus sequestration potential) and because CO_2 will decrease by 2050 in RCP2.6, meaning loss of CO_2 fertilization, and CO_2 stabilizes by 2060 in RCP4.5. So in light of the Paris agreement, it is more important to investigate climate change impacts on carbon stocks than to expect a continuation of increasing sink due to CO_2 fertilization, which will have only a small role or disappear in RCP2.6 during this century.