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Potential roles of CO_2 fertilization, climate warming, nitrogen deposition, and land use and land cover change on the global terrestrial carbon uptake in the 21st century

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Terrestrial ecosystem sequesters atmospheric CO_2 through photosynthesis and thus moderates the growth of CO_2 in the atmosphere. Assessment of land carbon stocks in the future and quantification of dominant factors contributing to it are required for guidance on future emission policies. We assess the relative importance of CO_2 fertilization, nitrogen deposition, climate warming, and land use and land cover changes (LULCC) on land carbon uptake in three future scenarios (specified by the representative concentrations pathways -RCP) used extensively in phase 5 of the Coupled Model Intercomparison Project (CMIP5). Our simulations using Community Earth System Model (CESM) show that CO_2 fertilization continues to be the primary driver of increases in net primary production (NPP) and total ecosystem carbon (TEC) in the RCP2.6, RCP4.5, and RCP8.5 scenarios. LULCC is a major driver for increases in NPP in the future scenarios due to post-harvest regrowth in the RCP2.6 and RCP8.5 scenarios, and due to afforestation in RCP4.5. Climate warming leads to a small increase in NPP in RCP4.5 and RCP8.5, but it also leads to loss of TEC in the future scenarios because of an increase in heterotrophic respiration. The effect of nitrogen deposition on NPP and TEC in the future scenarios is smaller than the historical period (years 1850 to 2005), where it was one of the major drivers. Our simulations further show that land is a source of carbon in the RC8.5 and RCP2.6 scenarios mainly because of LULCC and climate warming, but afforestation and CO_2 fertilization in RCP4.5 facilitate the land to be a sink. Our findings, albeit from a single model, are in broader agreement with other studies that highlight the need for better land management practices and a moderation in climate warming for a continued land carbon sink.