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Carbon Dynamics of Forest Recovery under a Changing Climate: Forcings, Feedbacks, and Implications for Earth System Modeling

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Forests recovering from disturbance are strong carbon (C) sinks that play an important role in climate regulation through their influence on the global C cycle. Climate change is likely to alter forest recovery dynamics or even prevent recovery, and changes in disturbance-recovery dynamics will impact the global C cycle. We are using a combination of modeling and data synthesis to understand how and why C cycling in forests varies as a function of ecosystem age, how these patterns vary globally with respect to climate, and how expected changes in atmospheric CO_2 and climate will affect patterns of forest recovery. We are using the Ecosystem Demography model (ED2) to characterize how the physiological and successional mechanisms that regulate the C cycle are altered by elevated CO_2 and climate change. Specifically, we are projecting how forest demography and C cycling will react to elevated CO_2, using data from the Duke Free Air CO_2 Enrichment (FACE) experiment and a nearby chronosequence for model evaluation. The model predicts that elevated CO_2 will alter C cycling directly through ecophysiological effects and indirectly through altered community dynamics (e.g., relative increase in late successional hardwoods). Current work is focused on quantifying and identifying sources of uncertainty in total impacts of elevated CO_2 on forest C cycling, and future plans include examining responses to climate change and modeling forests in other parts of the world. In addition, we are building a database of C cycling dynamics in secondary forests of known age, which is incorporated into the BETY-db database framework for integration with models (including ED2). The database now contains >5,000 records from >150 sites around the world and includes >50 C cycle variables. All elevated CO_2 and warming experiments to date are included. These data are being used to characterize age- and climate-related patterns in C cycling in global forests, to evaluate model runs, and to analyze forest C cycle responses to warming and elevated CO_2.