C. Potter
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State of the Carbon Cycle - Consequences of Rising Atmospheric CO_2

The rise of atmospheric CO_2, largely attributable to human activity through fossil fuel emissions and land-use change, has been dampened by carbon uptake by the ocean and terrestrial biosphere. We outline the consequences of this carbon uptake as direct and indirect effects on terrestrial and oceanic systems and processes for different regions of North America and the globe. We assess the capacity of these systems to continue to act as carbon sinks. Rising CO_2 has decreased seawater pH; this process of ocean acidification has impacted some marine species and altered fundamental ecosystem processes with further effects likely. In terrestrial ecosystems, increased atmospheric CO_2 causes enhanced photosynthesis, net primary production, and increased water-use efficiency. Rising CO_2 may change vegetation composition and carbon storage, and widespread increases in water use efficiency likely influence terrestrial hydrology and biogeochemical cycling. Consequences for human populations include changes to ecosystem services including cultural activities surrounding land use, agricultural or harvesting practices. Commercial fish stocks have been impacted and crop production yields have been changed as a result of rising CO_2. Ocean and terrestrial effects are contingent on, and feedback to, global climate change. Warming and modified precipitation regimes impact a variety of ecosystem processes, and the combination of climate change and rising CO_2 contributes considerable uncertainty to forecasting carbon sink capacity in the ocean and on land. Disturbance regime (fire and insects) are modified with increased temperatures. Fire frequency and intensity increase, and insect lifecycles are disrupted as temperatures move out of historical norms. Changes in disturbance patterns modulate the effects of rising CO_2 depending on ecosystem type, disturbance frequency, and magnitude of events. We discuss management strategies designed to limit the rise of atmospheric CO_2 and reduce uncertainty in forecasts of decadal and centennial feedbacks of rising atmospheric CO_2 on carbon storage.

Authors

David J Moore
- University of Arizona

Sarah R Cooley
- Ocean Conservancy Inc.

Simone R Alin
- NOAA

Molly Elizabeth Brown
- University of Maryland College Park

David E Butman
- University of Washington Seattle Campus

Nancy H F French
- Michigan Technological University

Zackary I Johnson Duke
- Duke University

Gretchen Keppel-Aleks

- University of Michigan Ann Arbor

Steven E Lohrenz

- University of Massachusetts Dartmouth

Ilissa Ocko

- Environmental Defense Fund Boulder

Elizabeth H Shadwick

- Virginia Institute of Marine Science

Adrienne J Sutton

- Joint Institute for the Study of the Atmosphere and Ocean

Christopher S Potter

chris.potter@nasa.gov

- NASA Ames Research Center

Rita M.S. Yu

- University of Washington Seattle Campus