State of the Carbon Cycle - Consequences of Rising Atmospheric CO₂

The rise of atmospheric CO₂, 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 CO₂ 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 CO₂ causes enhanced photosynthesis, net primary production, and increased water-use efficiency. Rising CO₂ 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 CO₂. 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 CO₂ 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 CO₂ depending on ecosystem type, disturbance frequency, and magnitude of events. We discuss management strategies designed to limit the rise of atmospheric CO₂ and reduce uncertainty in forecasts of decadal and centennial feedbacks of rising atmospheric CO₂ on carbon storage.

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