Integrating the evidence for a terrestrial carbon sink caused by increasing atmospheric CO 2

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Atmospheric carbon dioxide concentration ([CO2]) is increasing, which increases leaf-scale photosynthesis and intrinsic water-use efficiency. These direct responses have the potential to increase plant growth, vegetation biomass, and soil organic matter; transferring carbon from the atmosphere into terrestrial ecosystems (a carbon sink). A substantial global terrestrial carbon sink would slow the rate of [CO2] increase and thus climate change. However, ecosystem CO2 responses are complex or confounded by concurrent changes in multiple agents of global change and evidence for a [CO2]-driven terrestrial carbon sink can appear contradictory. Here we synthesize theory and broad, multidisciplinary evidence for the effects of increasing [CO2] (iCO2) on the global terrestrial carbon sink. Evidence suggests a substantial increase in global photosynthesis since pre-industrial times. Established theory, supported by experiments, indicates that iCO2 is likely responsible for about half of the increase. Global carbon budgeting, atmospheric data, and forest inventories indicate a historical carbon sink, and these apparent iCO2 responses are high in comparison to experiments and predictions from theory. Plant mortality and soil carbon iCO2 responses are highly uncertain. In conclusion, a range of evidence supports a positive terrestrial carbon sink in response to iCO2 , albeit with uncertain magnitude and strong suggestion of a role for additional agents of global change.
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