Litterfall ^{15}N Abundance Indicates Declining Soil N Availability in a Free Air CO_2-Enrichment Experiment

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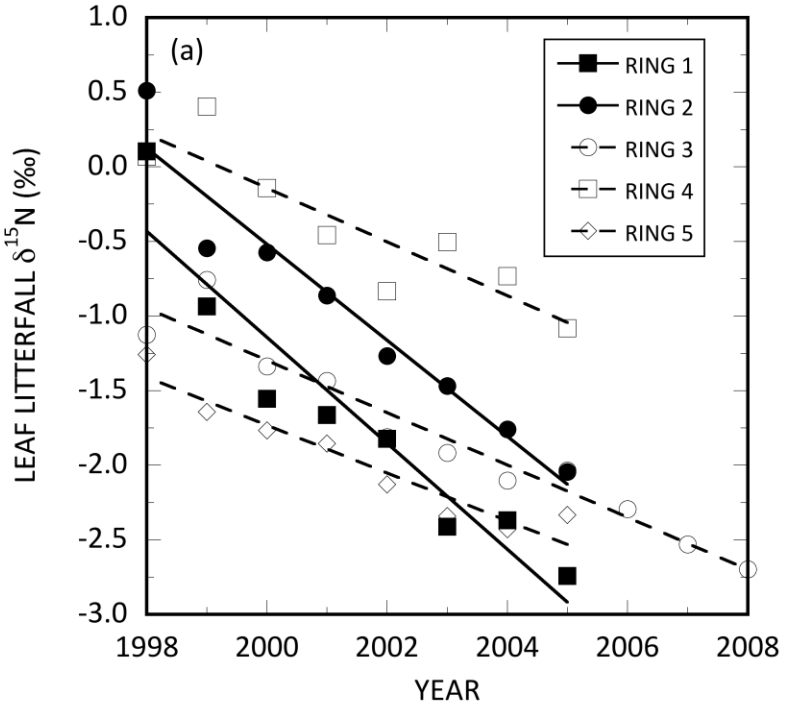
- The response of sweetgum (*Liquidambar styraciflua*) productivity to elevated CO_2 concentrations has declined over time in the ORNL FACE experiment, but documenting an associated change in soil N availability (which could be a cause of declining stand production) has been a difficult challenge.
- We show that ^{15}N abundance ($\delta^{15}N$) in leaf litterfall has declined over the course of the ORNL FACE experiment and the rate of decline is significantly faster under elevated atmospheric CO_2.
- Declining litterfall $\delta^{15}N$ is indicative of a tighter ecosystem N cycle and more limited soil N availability.
- This new analysis of soil N availability based on $\delta^{15}N$ abundance provided the missing evidence that progressive N limitation is behind declining tree productivity in the ORNL FACE experiment and that greater productivity under elevated CO_2 is constrained by soil N availability.



Change in leaf litterfall $\delta^{15}N$ over time in different treatment rings at the free-air CO_2 enrichment (FACE) experiment at Oak Ridge National Laboratory. Solid symbols designate measurements under elevated CO_2 (544 ppm) and open symbols designate measurements under ambient CO_2 (391 ppm).

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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Abstract:

Forest productivity increases in response to carbon dioxide (CO_2) enrichment of the atmosphere. However, in nitrogen-limited ecosystems, increased productivity may cause a decline in soil nitrogen (N) availability and induce a negative feedback on further enhancement of forest production. In a free-air CO_2-enrichment (FACE) experiment, the response of sweetgum (*Liquidambar styraciflua* L.) productivity to elevated CO_2 concentrations [CO_2] has declined over time, but documenting an associated change in soil N availability has been difficult. Here, we assess the time-history of soil N availability through analysis of natural ^{15}N abundance in archived samples of freshly fallen leaf litterfall. Litterfall $\delta^{15}N$ declined from 1998 to 2005, and the rate of decline was significantly faster in elevated [CO_2]. Declining leaf litterfall $\delta^{15}N$ is indicative of a tighter ecosystem N cycle and more limited soil N availability. Our new analysis of soil N availability based on leaf litterfall ^{15}N abundance, coupled with the decline in response of NPP to elevated [CO_2], provides the missing evidence that progressive N limitation is probably occurring in the ORNL FACE experiment and that the response of stand productivity to elevated [CO_2] is constrained by declining soil N availability. By integrating N availability over time and throughout the soil profile, temporal dynamics in leaf litterfall $\delta^{15}N$ provide a powerful tool for documenting changes in N availability and the critical feedbacks between C and N cycles that will control forest response to elevated atmospheric CO_2 concentrations.

Citation:

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