Unexpected Responses of an Oak Forest to Nitrogen Amendment
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Abstract
Excess nitrogen deposition can have multiple effects on forests, including alteration of growth, nutrition and carbon allocation by trees and increased leaching of nitrate through the ecosystem. Nitrate leaching can cause depletion of base cations in the soil such as calcium (Ca), magnesium, potassium, and sodium and lead to soil acidification and increased aluminum (Al) concentration and mobility. Experimental addition of nitrogen (N) to an upland oak-hickory forest near Millbrook, New York has revealed several unexpected results. First, nitrate leaching began to increase within a year after the start of N fertilization, before there was evidence of increased nitrification. Control plots showed little N leaching. Second, the fertilized plots experienced significant tree mortality, especially after two summers of moderate drought. The mortality appears to be associated with soil acidification. Third, surviving trees in the fertilized plots had higher relative growth rates than those in the control plots, indicating that the fertilization and N saturation effects of excess N deposition can occur simultaneously in the same forest stand.

Nitrogen Amendment Experiment
The site is a ridgetop oak-hickory forest with thin soil over glacial till and shale bedrock. This forest was selectively cut until about 70-80 years ago but was never used for agriculture.

There are six pairs of plots. One plot of each pair is fertilized with NH₄NO₃ in May, June, July and August each year, and the other plot is a control.

100 kg N/ha/yr added each year 1996 – 1999
50 kg N/ha/yr added each year 2000 – present
Measurements included foliar N, tree growth, soil C, N and exchangeable cations, soil solution chemistry, N mineralization and nitrification (14-day lab assay). Leaching losses were estimated from B-horizon soil solution chemistry and water fluxes calculated from the BROOK90 model.

Unexpected Response #1: Nitrate leaching was observed after 1 year of fertilization, before nitrification increased.

Unexpected Response #2: Tree mortality was severe in some of the fertilized plots, especially after two summers of moderate drought. Mortality appeared to be related to soil acidification.

Unexpected Response #3: Surviving trees in fertilized plots had higher relative growth rates than trees in control plots. Thus, the fertilization and N saturation effects of N addition occurred simultaneously.

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