Magnani et al. reply


Nitrogen (N) deposition alters ecosystem function in several ways, with important effects on N leaching and water quality, as well as on interspecific competition and biodiversity. These changes have been attributed to ecosystem N saturation, defined as the alleviation of N limitations on rates of biological function1. After an initial fertilization effect, N saturation has also been suggested to reduce plant function and growth2, eventually leading to forest dieback. Although our observation of a substantial positive effect of N deposition on forest carbon (C) sequestration3 does not imply the absence of nitrate losses or other negative effects, as rightly stressed by De Schrijver et al.4, the sustained response observed demonstrates that the fear of a generalized forest decline in response to N fertilization might be overstated, at least within the rather broad N deposition range explored in our analysis. The nature of the observed response of forest C sequestration to N deposition, however, has been questioned outright by de Vries et al.5, who suggested that it could be an artefact resulting from the covariation between N deposition and other environmental variables. The arguments proposed against an overwhelming N effect, however, do not seem to stand up to close scrutiny.

We agree that ecosystem gross primary production (GPP) and plant growth are, to a large extent, controlled by local climate, drought and fertility (that is, N mineralization associated with soil organic matter decomposition), although fertility could be itself influenced by current and past N deposition6. However, the same environmental factors would modulate in parallel ecosystem respiration, and as a result do not seem to affect net ecosystem production (NEP), which is the difference between GPP and ecosystem respiration and is the subject of our analysis7. Both components of NEP seem to be also affected by N deposition, but in opposite directions: apart from the positive effects on plant growth considered by de Vries et al.5, respiration is known to be significantly reduced by N fertilization, as demonstrated by manipulation experiments8,9, as well as regional transect studies8. The combined effect at the ecosystem level is largely missed when focusing on tree growth alone.

The question remains of the magnitude of the observed response to N deposition. Assuming a linear relationship between NEP and N deposition, a slope of 445 ± 38 kg C per kg of wet N deposition can be inferred from our entire data set (n = 20, rather than the sub-sample of 8 data points in the analysis by de Vries et al.10). If we assume, rather conservatively, that wet deposition constitutes 40–50% of total N deposition11, this would imply a NEP sensitivity to total N deposition of approximately 175–225 kg C per kg N, which is consistent with the stoichiometry of plant tissues and soil organic matter. Although it is true that fine roots account for a significant fraction of forest growth, it should be noted that one of the main effects of increased N availability is an increased allocation to woody tissues (with a high C:N ratio of up to 500:1) away from fine roots11. This mechanism could indeed represent an important component of the observed response to N deposition.

Far from implausible, a 200:1 sensitivity is nevertheless higher than suggested by long-term forest fertilization experiments12,13. Potential problems with N manipulation studies have already been discussed13. In particular, they overlook the role of canopy N uptake, which enables plants to absorb a relevant fraction of incoming N without any competition from soil microbes. Canopy N uptake amounts to up to 70% of N deposition, providing as much as one-third of tree N requirements14,15. The critical comparison of results from ecosystem manipulation and observational studies could be providing a rare, unforeseen insight into the key factors controlling C–N relations in forest ecosystems.

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**doi**10.1038/nature06580