Nitrogen deposition limits climate change impacts on carbon sequestration

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Forests are important in reducing the green house gas CO2. For the period 2000-2007, it has been estimated that from the 8.9 billion ton of carbon released by man, approximately 46% is found back in the atmosphere. The removed 54% is due to an estimated equal amount absorbed in oceans and taken up by forests and other natural vegetations. The role of forest growth is assumed to increase in the future due to climate change and increasing CO2 concentrations.

The role of forest growth is assumed to increase in the future due to climate change and increasing CO2 concentrations. So-called Earth System Models, making predictions for the globe, estimate that this effect can be very large. Research results, based on measurements at hundreds of European forest monitoring plots, however, indicate that the

effects of climate change and CO2 increase are overestimated when neglecting the limitation induced by low nitrogen availability. Low availability of other nutrients, such as calcium and magnesium, can also limit the growth. Overall, nutrient limitation may reduce the estimated forest growth increase by a factor of more than two. This is one of the results of a study published in a special issue of Forest Ecology and Management of September, with Wim de Vries of Alterra, part of Wageningen University (The Netherlands), being the editor.

Despite nutrient limitation, it is expected that future environmental change up to 2100 may lead to an average increase in carbon pool changes in trees of 35-40%. It should be noted says Wim de Vries that this is an average value with large regional variations. Climate change will not lead to an increase in carbon sequestration all over Europe. An increased growth is specifically expected in boreal climates due to the dominating effect of an increase in temperature, but in large parts of Southern Europe, the effect is opposite due to increased drought stress. Research at the forest monitoring plots has also shown that for 1 kilogram of nitrogen deposited from the atmosphere, approximately 30-70 kg of carbon will be sequestered in both forests and forest soils. Multiplying this range by an estimated global N deposition, this corresponds to an annual global carbon sink of 0.15 - 0.35 billion ton, being 2-4 % of the estimated release by man.

Major debate on reactive nitrogen among scientists

A major debate is emerging among scientists regarding the environmental impact of reactive nitrogen. Although the atmosphere contains nearly 80% nitrogen as N2, this cannot be used by most plants and animals. The result is that trace amounts of reactive nitrogen (Nr) make a huge difference to life on earth. The big issue is that humans have roughly doubled global production of reactive nitrogen compared with the natural cycle. This extra nitrogen provides important fertilizers

for crops, but at the same time results in losses into the atmosphere and water courses, leading to a web of pollution effects through the environment, such as loss of plant diversity both in terrestrial and aquatic systems, eutrophication of fresh and marine aquatic ecosystems and adverse effect on human health. However, nitrogen deposition on ecosystems also increases their productivity and thereby captures CO2 from the atmosphere.

The disagreement emerging among the scientists is how large this contribution of nitrogen is with respect to carbon sequestration. The discussion started since the controversial findings of Magnani (University of Bologna) and his team who claim that for every 1 kilogram of nitrogen deposited from the atmosphere, 400 kg of carbon would be absorbed by forests. If this were true, it would imply a global CO2 sequestration in forest ecosystems due to N deposition near 2.0 Pg.yr-1, being 30 % of the estimated 7.1 Pg C yr-1 release by man. This could lead to the argument to abandon policies on the reduction in the emission of ammonia and nitrous oxides, as this reduces nitrogen deposition and thereby greenhouse gas concentrations. One might even argue to increase the emissions as a climate change mitigation policy while accepting the known adverse effects of nitrogen on biodiversity and water pollution.

Hundreds of forests contradict large role of nitrogen on carbon sequestration

Against this position, de Vries and his team used amongst others the analysis of approximately 400 European forest plots at individual tree species level and stand level to show that the overall ratio of carbon to nitrogen is 30-70 kilograms of carbon per kilogram of nitrogen, around one tenth of that claimed by Magnani et al. A summary of the results of this empirical research has been published in Nature last year (De Vries

et al., 2008) while details of the results of the empirical studies are published in the special issue of Forest Ecology and Management. The innovative field study combines measured growth data for the period 1994-1999 from intensive monitoring plots from the ICP Forests network in Europe, ranging from northern Finland to Spain and southern Italy, in combination with measurements of nitrogen, sulphur, and acid deposition, climatic data and site factors, such as tree competition data. The results also in accordance with N fertilization experiments, 15N experiments on the fate of N in trees and soil and various process based model applications, as shown by de Vries et al (2009). This much smaller response of carbon sequestration to N deposition, combined with the effect that N use also causes nitrous oxide emission in both agricultural and non- agricultural systems, implies that the potential benefits of N deposition do not outweigh the negative effects.

More information:

• Special issue of Forest Ecology and Management of September

• Major relevant publications

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of atmospheric deposition and climate on forest growth in European monitoring plots: An empirical tree growth model. Forest Ecology and Management 258: 1751-1761.
Solberg, S., M. Dobbertin, G.J. Reinds, K. Andreassen, H. Lange, P. Garcia Fernandez, A. Hildingsson and W. de Vries, 2009. The impact of changes in atmospheric deposition and climate on forest growth in European monitoring plots: An empirical stand growth model. Forest Ecology and Management 258: 1735-1750.
Wamelink, G.W.W., R. Wieggers, G.J. Reinds, J. Kros, J. P. Mol-Dijkstra, M. van Oijen and W. de Vries, 2009. Modelling impacts of changes in carbon dioxide concentration, climate and nitrogen deposition on growth and carbon sequestration of Intensive Forest Monitoring plots in Europe. Forest Ecology and Management 258: 1794-1805.

Provided by Wageningen University

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