



Some forest soils still to recover from acidification by air pollutants

Sulphur and nitrogen emissions have been significantly reduced across Europe in recent decades, but a recent study from Sweden finds that some forest soils are still struggling to recover from the acidifying effects of the pollutants. Some areas are also at risk of nitrogen leaching from soils into surface waters.

When the air pollutants sulphur dioxide and nitrogen oxides are deposited back to the ground, they contribute to acidification of soils and surface water, damaging terrestrial and aquatic ecosystems. Sweden produces relatively little air pollution itself, but is on the receiving end of long-range transport of emissions from the UK and the European continent (in addition to ship emissions from the North Sea and Baltic Sea). Efforts to reduce air pollution in Europe have resulted in a decrease of sulphur and nitrogen oxide emissions over the period 1997-2008. Air concentrations of these pollutants in Sweden have fallen in line with reductions of European emissions.

In this study, records of over 50 forest monitoring sites across Sweden were examined to determine air pollutant concentrations, deposition of sulphur and nitrogen and soil water chemistry over time, concentrating on the period 1996-2008.

For both sulphur dioxide and nitrogen dioxide, air concentrations decreased. The total deposition of sulphur declined in the majority of the forest monitoring sites during the 12 year period 1997-2008, and rates varied between north and south. Deposition was greatest in the southwest, and gradually diminished towards the northeast.

Over the study period, sulphur deposition rates decreased the most in southwest Sweden where they were highest at the start of the period. Between 1997 and 2008, sulphur deposition decreased between 22% and 67% for different forest sites, which is in line with the 49% reduction in European sulphur dioxide emissions during this time.

Patterns of nitrogen deposition, measured on open field, were similar to that of sulphur deposition across Sweden, with highest levels recorded in the southwest decreasing towards the northeast. Analysis of the trends of nitrogen deposition on open field between 1997 to 2008 demonstrated that although the concentration of nitrogen dioxide in the air had dropped substantially, there was no significant decline in the deposition of nitrogen.

The concentration of sulphur in soil water tended to be higher in the south of Sweden compared with the north of the country, although there were considerable differences locally, particularly in the south. Sulphur in soil water was reduced significantly on more than half the sites during 1997-2008. Measurements revealed that soil water was more acidic in the southwest but showed decreasing acidity along a gradient towards the north. Several sites in the south had extremely acidic soil water towards the end of the time period (during 2006 to 2008).

Despite the reduction of sulphur in soil water and although some southern sites showed recovery from acid conditions during the period 1996/97- 2007/08, many other sites showed little change in acidity, indicating slow progress in recovery and return to less acidic soil conditions.

The increased levels of nitrogen deposition have resulted in higher levels of nitrogen found in soil water. The southwest of Sweden is particularly at risk of nitrogen leaching from soils into surface waters as levels of nitrogen reach saturation point.

Source: Karlsson, G.P., Akselsson, C., Hellsten, S., Karlsson, P.E. (2011) Reduced European emissions of S and N - Effects on air concentrations, deposition and soil water chemistry in Swedish forests. *Environmental Pollution*. 159: 3571-3582.

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