Nitrogen deposition on the Western Alps: long-term trends and present status in relation to critical loads

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Atmospheric input of nitrogen compounds may have an impact on both terrestrial and aquatic ecosystems in the Alpine area. Nitrogen (N) can act as a fertilizer for forest ecosystems, enhancing forest growth. On the other hand, high N loads can determine nutrient imbalances, changes in the composition of ground vegetation, and increased sensitivity to other stress factors (Dise and Wright 1995; Gundersen *et al.* 1998). The Western European Alps are affected by high N deposition (usually above 15 kg N ha^{-1} y^{-1} as the sum of ammonium and nitrate). Some long-term studies at the catchment scale in the Alps showed increasing evidence of soil N saturation with consequent leaching of nitrate to surface water (Rogora *et al.* 2001).

Several research programs for the monitoring of atmospheric deposition in the Alpine countries have been launched in the last few decades. To monitor the atmospheric deposition onto forests, national programs in many European countries sample and analyze bulk and throughfall deposition as part of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) (EC-UN/ECE 1998). Results form the ICP Forests networks of Italy, Switzerland and France are gathered in this paper in order to:

(i) investigate geographical variability in the deposition of nitrogen compounds;
(ii) assess temporal trends of N deposition in response to changes in the atmospheric emission;
(iii) discuss the potential relationship between the status of N deposition and its effects on forest ecosystems in the alpine and subalpine areas.

No obvious gradients were identified in N deposition in relation to geographical attributes such as altitude or latitude. The highest loads were recorded in areas in the foothills of the Alps, such as the pre-alpine area in North-Western Italy and the area of Canton Ticino, Switzerland.

Nitrate in atmospheric deposition has not decreased significantly in last decade, both as concentration and flux. Ammonium deposition has slightly decreased at a few sites. The deposition of N is still well above the estimated critical loads of nutrient N at most of the sites.

Present N deposition were compared to estimates of deposition reduction by 2010 according to the Gothenburg Protocol (UN-ECE 1999). Beside the reduction of NO_3 deposition envisaged by the Protocol, a sharp decrease of N input also in reduced form will be needed to reach the goal of critical loads.

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