

atmospheric transport of nitrogen from the Midwest to upland forest regions in the North-East, such as the western Adirondack region of New York, where  $\text{NH}_4^+$  constitutes 38% of the total wet deposition of N. © 2000 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Through human activities, the deposition of nitrogen from the atmosphere has increased to rates that are of the same magnitude as rates of natural fixation of  $\text{N}_2$  (Vitousek et al., 1997). Atmospheric deposition of nitrogen has been recognized as a major factor in the nitrogen saturation of forest ecosystems, in the acidification of freshwater lakes and streams (Stoddard, 1994; Aber et al., 1995; Fenn et al., 1998), and in the eutrophication of coastal waters (Muller and Helsel, 1996). Atmospheric deposition in the Mississippi River Basin also has been identified as a contributor to nitrogen loads in the Mississippi River that are discharged into the Gulf of Mexico (Dinnel, 1998). Eutrophication and hypoxia of an extensive area of the Gulf of Mexico has been linked to nitrogen inputs from the Mississippi River (Turner and Rabalais, 1991).

As part of an effort to determine the primary cause of hypoxia in the Gulf of Mexico, a working group under the direction of the National Science and Technology Council's Committee on the Environment and Natural Resources (CENR) was established in 1997 to quantify the nitrogen budget of the Mississippi River Basin. This task required that all inputs of N, including those from atmospheric deposition, be quantified as accurately as possible. A comprehensive assessment of atmospheric deposition of nitrogen within the Mississippi River Basin was, therefore, conducted. The objectives of this assessment were to: (1) evaluate the forms in which nitrogen is deposited from the atmosphere; (2) quantify the spatial distribution of atmospheric nitrogen deposition throughout the basin; and (3) relate locations of emission sources to spatial deposition patterns to evaluate atmospheric transport. This paper presents the methods and results of this assessment.

## 2. Methods

### 2.1. Data acquisition

In general, measurements of atmospheric deposition of nitrogen can be categorized as wet deposition (which falls as rain or snow) or dry deposition (particles or vapor deposited from the atmosphere primarily during periods without precipitation).

Wet deposition is monitored year-round at over 200 sites in the United States through the inter-agency-supported National Atmospheric Deposition Program/National Trends Network (NADP/NTN). The distribution of these sites is approximately uniform, nationwide, with additional sites located in regions of high-deposition gradients. At each site precipitation is collected for chemical analysis by an automated wet-only deposition collector that remains covered except when precipitation is falling. Through this method, wet deposition of  $\text{NO}_3^-$ ,  $\text{NH}_4^+$  and other constituents are determined at weekly intervals. Wet-deposition data used in this report were collected from 1988 through 1996. These data and further information on the NADP/NTN program are available on the World Wide Web (<http://nadp.sws.uiuc.edu>; accessed for this paper in 1998–1999).

Dry deposition is monitored at approximately 60 sites nationwide through several programs that operate under the US Environmental Protection Agency Clean Air Status and Trends Network (CASTNet; Clarke et al., 1997). Two-thirds of these sites are located east of the Mississippi River; all but three of the remainder are located from the Rocky Mountains to the West Coast. Dry deposition is determined at these sites by measurements of air concentrations taken 10 m above the ground and an inferential model of deposition velocities, as described in Hicks et al.