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THROUGHFALL MONITORING AT 4 SITES IN THE NETHERLANDS FOR 2002

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Abstract

During one year throughfall was measured in four Level II forest sites in the Netherlands as part of the PAN European monitoring programme for the Intensive Monitoring of Forest Ecosystems. The data for the monitoring year 2002 are reported and a canopy exchange model was applied to estimate the atmospheric deposition to these sites. Further evaluation of the results including comparison with previous years will be reported with the results of the project concerning throughfall measurements 2003-2005. In this project also in a fifth forest site throughfall will be monitored.

CONTENTS

SUMMARY

The Pan-European Programme for the Intensive Monitoring of Forest Ecosystems is the so-called Level II Programme of the International Co-operative Programme on Assessments and Monitoring of Air Pollution Effects on Forests (ICP Forests of UN/ECE). It provides the framework in which analysis of the effects of atmospheric loads and its temporal variation is investigated. The current monitoring programme of ICP Forest at the so-called ‘Intensive Monitoring’ (Level II) plots in the Netherlands includes deposition measurements at four sites. Throughfall is measured by the Energy research Centre of the Netherlands at Dwingelo, Hardenberg, Speuld and Zeist. Bulk deposition is measured close to the Hardenberg site. For the other three sites bulk deposition data are obtained from the National Air Quality Monitoring Network by the National Institute of Public Health and Environment.

This report describes the measurements made in 2002 and the results of the quality checks performed on the data. The total nitrogen deposition in 2002 varied between 1100 and 2500 mol ha^{-1} y^{-1}. Lowest nitrogen deposition is measured at Zeist, the other sites showing about the same inputs. Potential acid deposition is highest at Speuld and amounts to 3700 mol ha^{-1} y^{-1}. The other sites show comparable inputs except Zeist with 2100 mol ha^{-1} y^{-1}.
Further evaluation of the results will be reported with the results of the throughfall measurements 2003-2005. In this following project also in a fifth forest site throughfall will be measured.

1. INTRODUCTION

The Pan-European Programme for the Intensive Monitoring of Forest Ecosystems is the so-called Level II Programme of the International Co-operative Programme on Assessments and Monitoring of Air Pollution Effects on Forests (ICP Forests of UN/ECE). It provides the framework in which analysis of the effects of atmospheric loads and its temporal variation is investigated. The current monitoring programme of ICP Forest at the so-called ‘Intensive Monitoring’ (Level II) plots in the Netherlands includes the yearly assessment of the forest condition, foliar composition and the soil solution since 1992 at 14 sites (12 before 1995) and the five-yearly assessment of a large number of more slowly changing parameters. The chemical composition of the groundwater has been measured three-monthly at the initial 12 sites during all years. In 1990 a national survey of the chemical composition of needles, litter, soil and soil solution was also conducted for 150 stands (De Vries and Leeters, 1996), which has been repeated in 1995 for 200 stands, including the 14 intensive monitoring plots. A new assessment is foreseen in the year 2005. Up until now throughfall (or atmospheric deposition) was not measured at the 14 plots.

IKC-Natuur co-ordinates the Dutch contribution to ICP Forest. ECN performed throughfall measurements at the 4 Level II plots in the Netherlands between January 2000 and December 2000 using the method recommended by Draaijers et al., (1996). The research was financed by the EC through IKC-Natuur and by the Ministry of Housing, Physical Planning and the Environment (VROM).

This report is a intermediate publication of the results for the 4 plots in 2002. This report first gives a description of the sites and the measurement methods. The results of the measurements are described in chapter 3. The report ends with short conclusions. Further evaluation of the results will be reported with the results of the throughfall measurements 2003-2005.

2. EXPERIMENTAL

The current monitoring programme of ICP Forest at the Level II plots in the Netherlands includes the yearly assessment of the forest condition, foliar composition and the soil solution since 1992 at 14 sites. At these sites throughfall gutters were installed in 1995 and for one year data were collected (Erisman et. al., 1997). In October 1997 the measurements were continued at four of the 14 sites. The sites, stand characteristics, the co-ordinates and the dominant tree species are given in Table 2.1. Figure 2.1 shows the location of the sites in a map of the Netherlands. The plots are located in the main forested areas in the country: in Overijssel (1), the Utrechtse Heuvelrug (2), the Veluwe (3) and in Drenthe (4).

Table 2.1 *Sites, stand characteristics their co-ordinates*

No.	Plot	Locatie	Lon	Lat	Species	Distance to forest edge (m)	Tree height (m)	Crown coverage (%)	Bulk deposition site
1	106	Hardenberg-DG	06° 33' 00"	52° 32' 42"	Douglas fir	>100	>20	50-75	Rheezerveen
2	1040	Zeist-EI	05° 13' 50"	52° 06' 32"	Oak	20-40	15-20	50-75	628 Bilthoven
3	2084	Speuld-DG	05° 44' 17"	52° 16' 03"	Douglas fir	>100	10-15	>75	732 Speulder Veld
4	2085	Dwingelo	06° 26' 45"	52° 50' 20"	Scots pine	>100	15-20	>75	928 Witteveen

Figure 2.1 *Location of the throughfall monitoring sites*

2.1 Sampling and analysis

The sampling was done according to the descriptions in the Submanual on deposition on ICP Forests Level 2 plots (ICP Forest Expert Panel on Deposition, 1994, updated 06/1999) and data was handled according to the *Basic documents for the implementation of the intensive monitoring programme of forest ecosystems in Europe* (EC, VI/3908/95-EN). An extensive description of the methods is given in the Data Accompanying Report on Deposition Monitoring as available at the FIMCI data centre (Alterra, Wageningen) and as appendix A in Erisman et. al. (1997). Bulk deposition (open field measurements) were only made at plot Hardenberg (106). For all other locations bulk precipitation was obtained from wet-only measurements made by RIVM at the sites indicated in Table 1. The data from the Air Quality Monitoring Network were kindly being made available by RIVM (RIVM, 1999; 2000). Open field precipitation is measured as two-weekly averages, which are combined in the lab to obtain monthly samples.

At each plot 10 gutters were used in two parallel lines with 5 collectors, each at distances of 1-2 m. The gutters are 4 m long and have a collecting area of about 400 cm^2. They are placed with an angle of 150^o, about 1.5 m above the surface. Sample bottles were placed below the surface and $CHCl_3$ was added as a preservative. The samples were kept in the dark at temperatures between 4 and 8 ^oC. Sample bottles were collected two-weekly and the gutters were rinsed with demi-water. Five samples were combined into one sample. Weekly samples were combined in the lab to obtain monthly samples.

In the lab the monthly sample was split, one half was acidified with HNO_3 to pH 1 for analyses of metals. These were determined by atomic absorption spectroscopy (ICP-AES). Ions determined were: K, Ca, Mg, Na, Al, Mn and Fe. The other sample was used to determine conductivity, pH (potentiometric), Cl, NO_3, SO_4 by ionic chromatography, N_{total} by Kjeldahl analysis and NH_4 by Flow Injection Analysis, FIA/conductivity. Before sending the data to FIMCI data checks were performed, as described in de Vries et. al., (1999) and outlined in the next paragraph.

2.2 Quality checks

Several criteria were met to safeguard the quality and to estimate the uncertainty. First of all the measurement set-up, conservation and handling of samples was done according to the recommendations in Draaijers et al, (1996) and the Mapping Manual (UN/ECE, 1996). Gutters were used instead of open samplers. The number of gutters was 10. Secondly, sample analysis was performed according to and with methods certified by STERLAB. Finally, samples were collected and stored in light-tight bottles at low temperatures. $CHCl_3$ was added as a preservative to prevent biological conversion. Additional quality checks can be done after sampling and are described in Erisman et. al. (2001).

3. RESULTS

In this chapter the results of the monitoring of throughfall and bulk precipitation at the four sites are given. First the results of the quality checks are discussed. Then the results of the year 2002 are given.

3.1 Quality checks

The quality checks were done as previously reported by Erisman et al. (2001). About 10% of the data show discrepancies from the acceptable ranges in ionic balances, conductivity and/or Na-Cl ratio. Errors could be identified based on the interpretation of the three criteria and in few cases they were corrected for. Examples of errors that were encountered were dilution factor not taken into account and missing values. Samples were reanalysed or, if no explanation could be found, only one of the duplo samples was taken into account. The data after corrections are shown in Figure 3.1 to 3.3. These figures show the comparison of the cations versus the anions (3.1), the measured versus the calculated conductivity (3.2) and the Na-Cl ratio versus the deviation of the ionic balance (3.3).

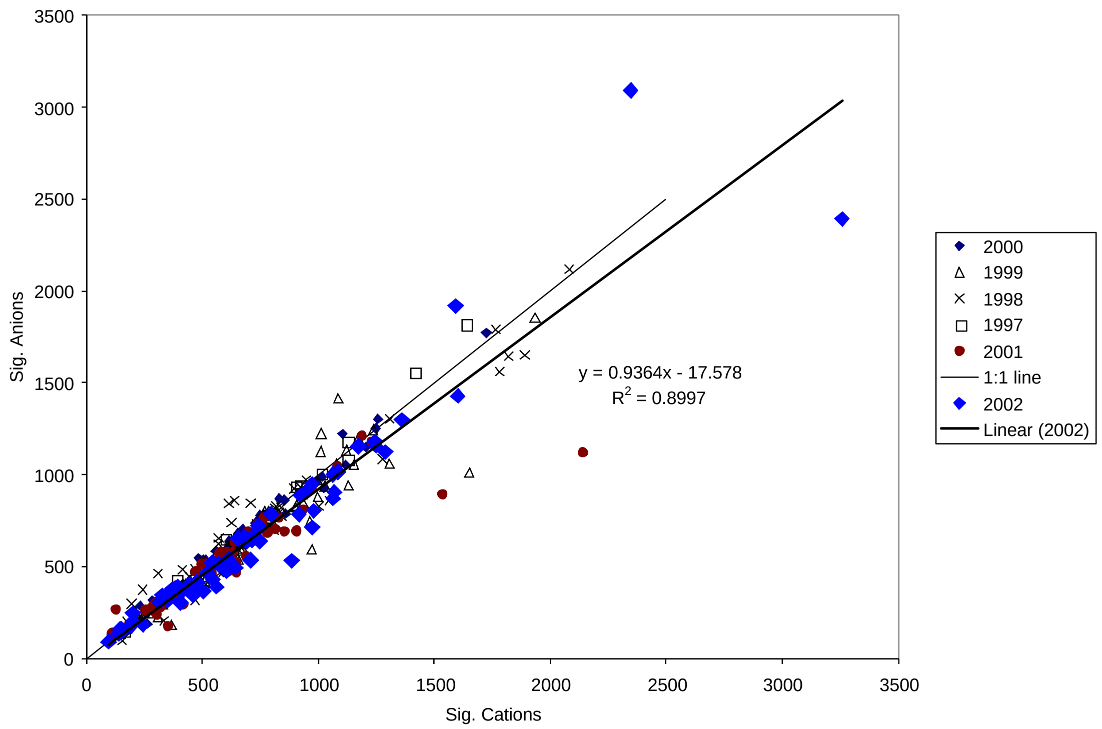

Figure 3.1 *Cations versus the anions for monthly samples for 2002 (mmol$_c$ m^{-3}).*

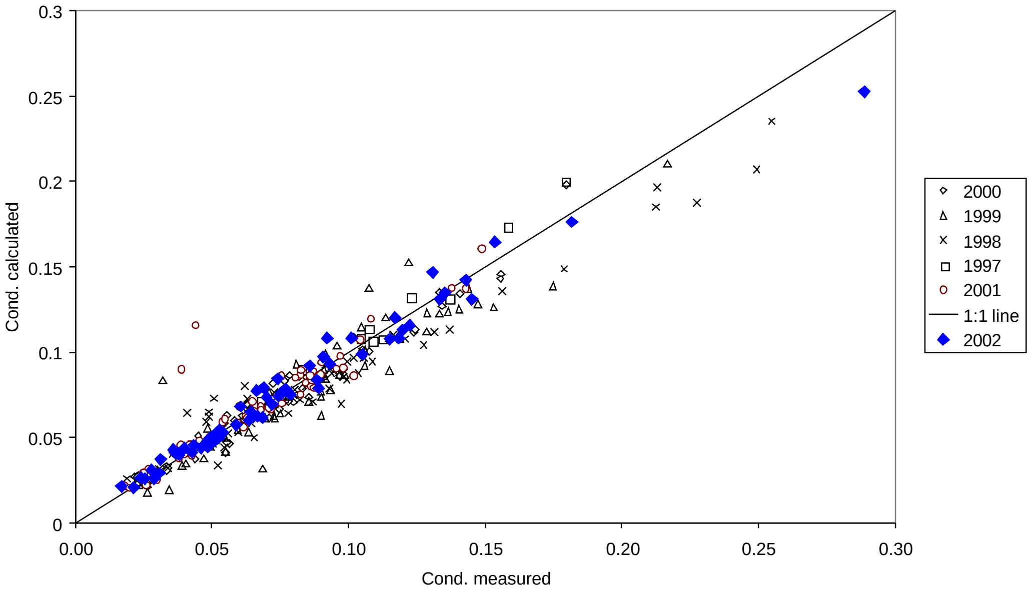

Figure 3.2 *Calculated conductivity versus the measured conductivity (mS cm^{-1}).*

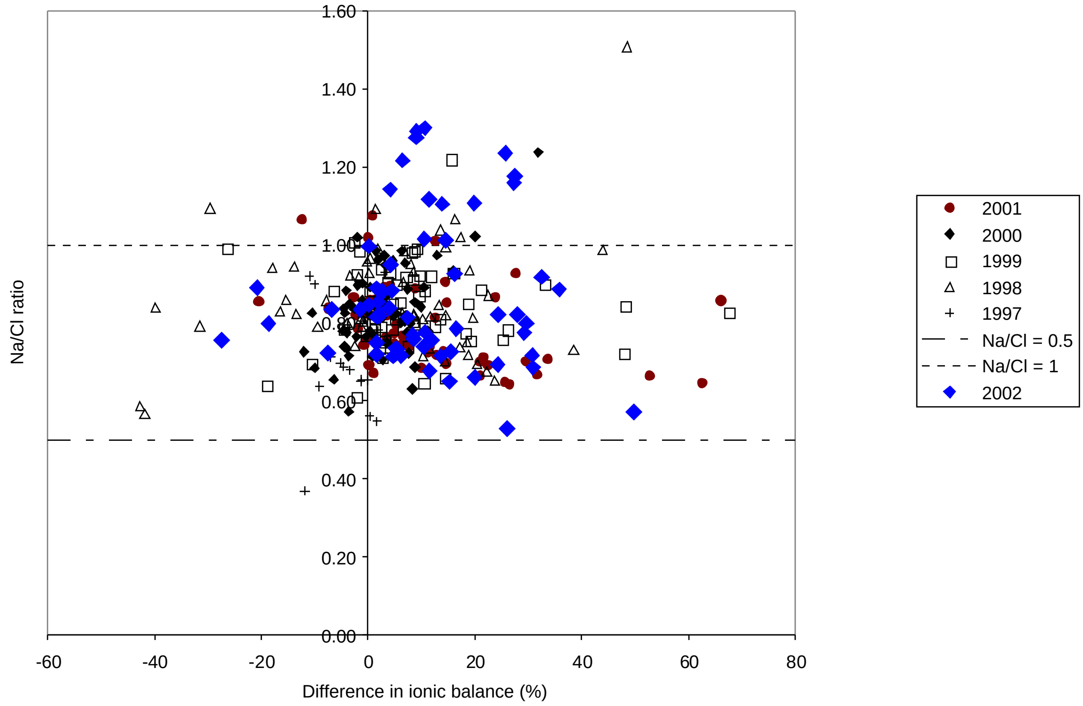

Figure 3.3 *Molar Na-Cl concentration ratio versus the deviation of the ion balance (%).*

As can be seen from the figures, most of the data fall within the acceptable ranges. However, several data are rejected when using the FIMCI software to evaluate the data using the above described data checks, especially related to the conductivity test. It is suspected that the FIMCI software uses more stringent criteria for rejecting data then listed in de Vries et. al. (1999). Organic compounds might also cause the data that are outside the limits.

Annual fluxes were calculated by averaging the concentrations for those periods, which fulfilled either the ion-balance or conductivity criteria, or both. This concentration was multiplied by the total amount of throughfall or precipitation over the whole year, including also the rejected periods.

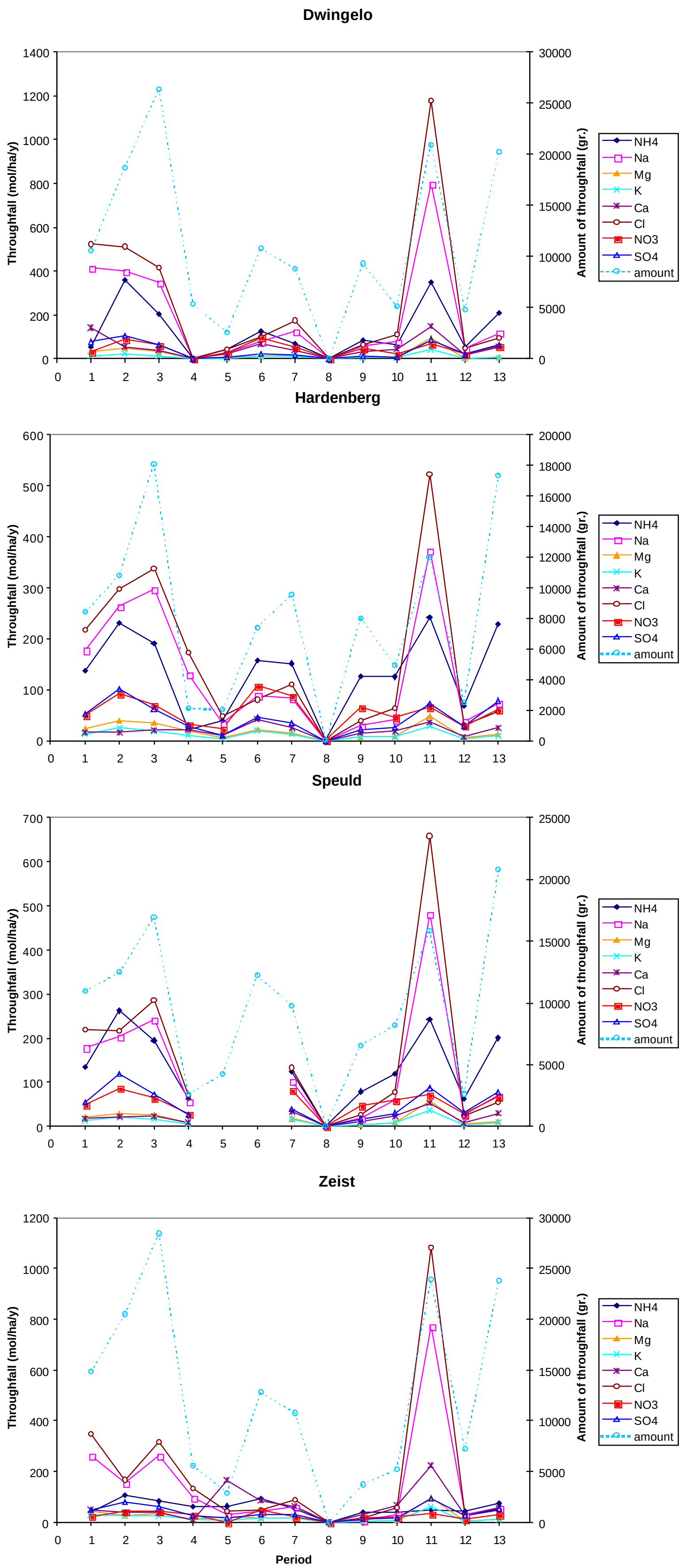

Figure 3.4 *Temporal variations in throughfall fluxes (mol ha^{-1} y^{-1}) and amount of throughfall (mm) in 2002*

3.2 Temporal variations in throughfall fluxes

The temporal variation as monthly averages in throughfall fluxes of K^+, Ca^{2+}, Mg^{2+}, Na^+, NH_4^+, Cl^-, NO_3^- and SO_4^{2-} is plotted in Figure 3.4 for the four sites. Generally the throughfall fluxes display the same pattern for all components. The temporal variation is primarily determined by the amount of precipitation for each month. Fluxes are low when the amount of precipitation is low. All sites show a distinct peak in the eleventh period of the year.

3.3 Annual average throughfall fluxes in 2002

The fluxes of throughfall and open field precipitation were calculated by multiplying the concentration with the amount of water and make the necessary conversions to express the flux in mol ha^{-1} y^{-1}. Table 3.1 gives the fluxes for the year 2002. Annual average fluxes were calculated as the sum of monthly fluxes. The total nitrogen flux is calculated as the sum of nitrate and ammonium fluxes, whereas the potential acid flux is estimated according to:

$$\textit{Potential acid} = NH_4^+ + NO_3^- + 2\,SO_4^{2-} \qquad [9]$$

Table 3.1 *Annual throughfall fluxes measured at the four sites and open field precipitation measured at Hardenberg in 2002 in mol ha^{-1} y^{-1}.*

site:	NH_4	Na	Mg	K	Ca	Cl	NO_3	SO_4	Tot N	Po. Acid
Dwingelo	1680	2606	282	151	689	3400	612	512	2292	3317
Hardenberg	1717	1632	238	160	255	1978	736	563	2453	3578
Speuld	1711	1666	216	153	262	2036	675	640	2386	3665
Zeist	746	1814	302	226	852	2374	328	501	1073	2076
bulk-Hardenberg	475	557	86	59	55	692	577	165	1052	1381

Throughfall fluxes of total nitrogen are lowest at Zeist, a plot relatively far away from livestock breeding areas. The northern sites and Speuld show about the same nitrogen loading of 30–35 kg N ha^{-1}. The potential acid fluxes are highest in Speuld (3700 mol ha^{-1} y^{-1}) and lowest in Zeist (2100 mol ha^{-1} y^{-1}).

4. DEPOSITION ESTIMATES

Deposition estimates can be made using a canopy exchange model. Such a model is described in the Erisman et al. (2001). The sections below describe the results of the model followed by a description of deposition trends at the different plots.

4.1 Dry, wet and total deposition estimates

Dry deposition fluxes in 2002 calculated with this model, together with the wet deposition data measured by RIVM (RIVM, 1999) and the total deposition is given in Table 4.1. Dry deposition is generally an order of magnitude higher than wet deposition and makes about 70% of the total deposition flux for NH_4, SO_4 and NO_3. The total nitrogen deposition varies between 1600 and 3500 mol ha^{-1} y^{-1}.

Table 4.1 *Deposition estimates per plot in 2002 in mol ha^{-1} y^{-1}*

Location	Dry deposition			Wet deposition			Total deposition			Tot. Nitrogen	Potential Acid
	NH_4	SO_4	NO_3	NH_4	SO_4	NO_3	NH_4	SO_4	NO_3		
Dwingelo	478	353	342	499	159	270	977	512	612	2614	1589
Hardenberg	358	426	257	394	137	479	752	563	736	2002	1488
Speuld	1066	494	442	446	146	234	1512	640	675	3467	2188
Zeist	-116	359	130	359	142	198	243	501	328	1574	571

4.2 Trends in deposition

Throughfall and open field precipitation has been measured at the four sites in 1995-1996, 1998, 1999, 2000 and 2002. From these data the temporal variation can be determined. In a following project monitoring at the sites will be continued. Further evaluation of the 2002 data wil be reported with the results of the period 2003-2005. Figures 4.2a to 4.2d show the temporal variation in deposition estimates for the four sites as derived from throughfall measurements and bulk deposition data after application of the canopy exchange model. Dwingelo, Hardenberg and Speuld do not show a gradually increase or decrease in fluxes. Only the values of 2002 are generally lower then in previous years. Only at Zeist the fluxes do gradually decrease over the years.

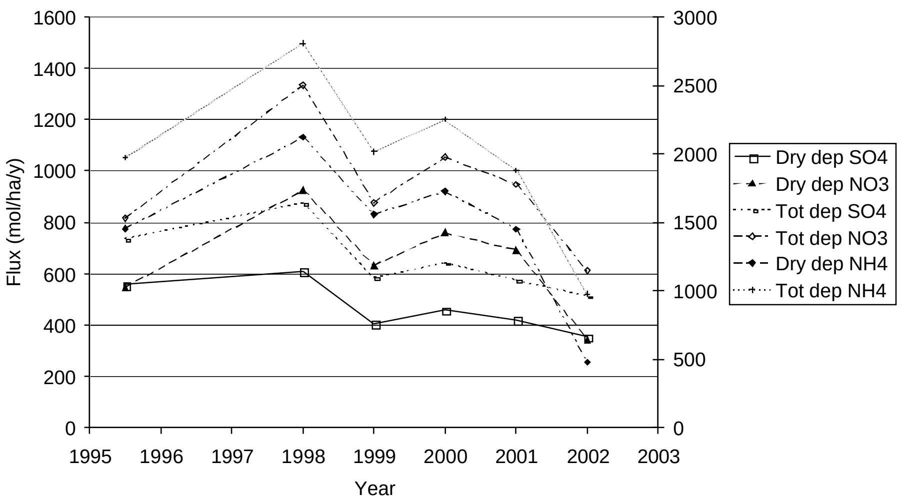

Figure 4.2a *Temporal variation in deposition measured at Dwingelo*

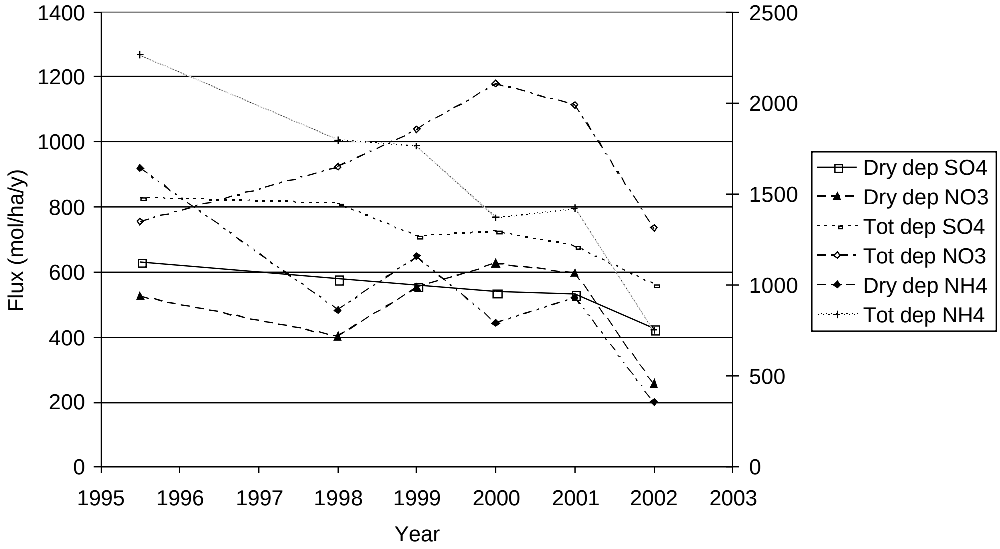

Figure 4.2b *Temporal variation in deposition measured at Hardenberg*

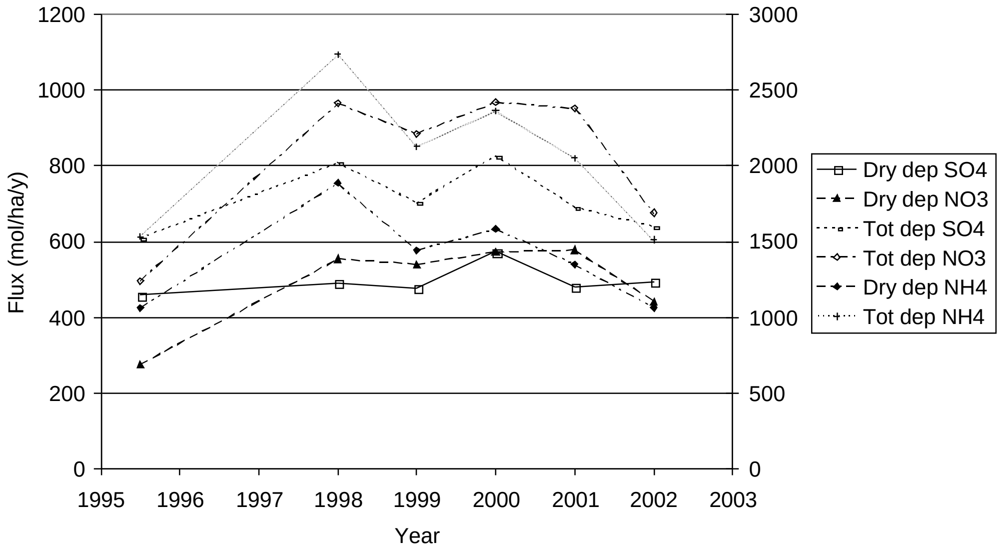

Figure 4.2c *Temporal variation in deposition measured at Speuld*

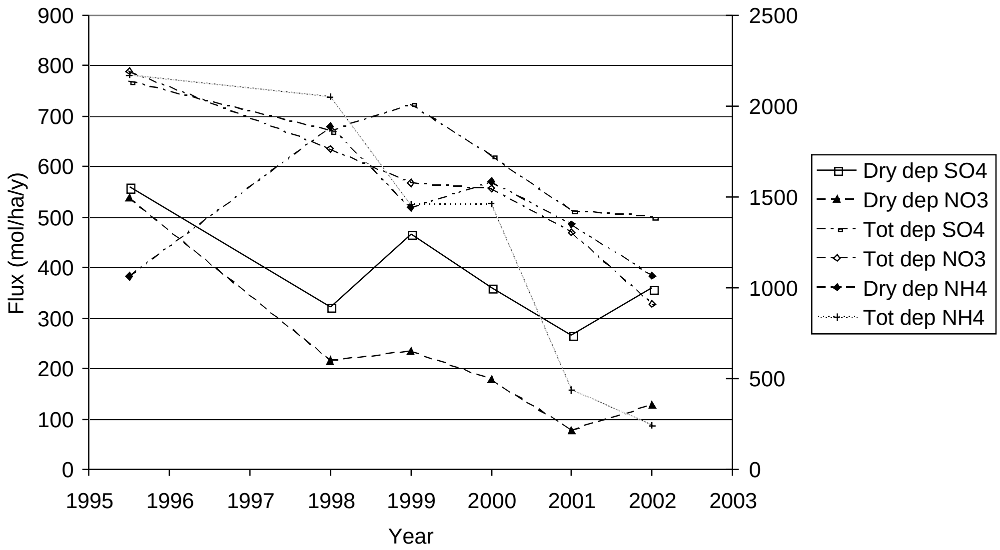

Figure 4.2d *Temporal variation in deposition measured at Zeist*

5. CONCLUSIONS

During one year between January and December 2002 throughfall measurements were done at 4 ICP Level-II plots in the Netherlands. The measurements were made with 10 gutters per plot, sample bottles were stored in light protected bottles at low temperatures, all to assure high quality results. Most of the fluxes could be used to estimate atmospheric deposition after the application of several quality checks. For the estimate of atmospheric deposition a canopy exchange model was applied and dry and wet deposition fluxes were calculated. In general in 2002 somewhat lower deposition fluxes were found in comparison with previous years. At Zeist this decrease of fluxes is more consistent over the last 6 years.

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