The 8th International Conference on Acid Deposition
ACID RAIN 2011
ACID RAIN 15-18, June Beijing China.

Atmospheric deposition chemistry in Italian forested sites

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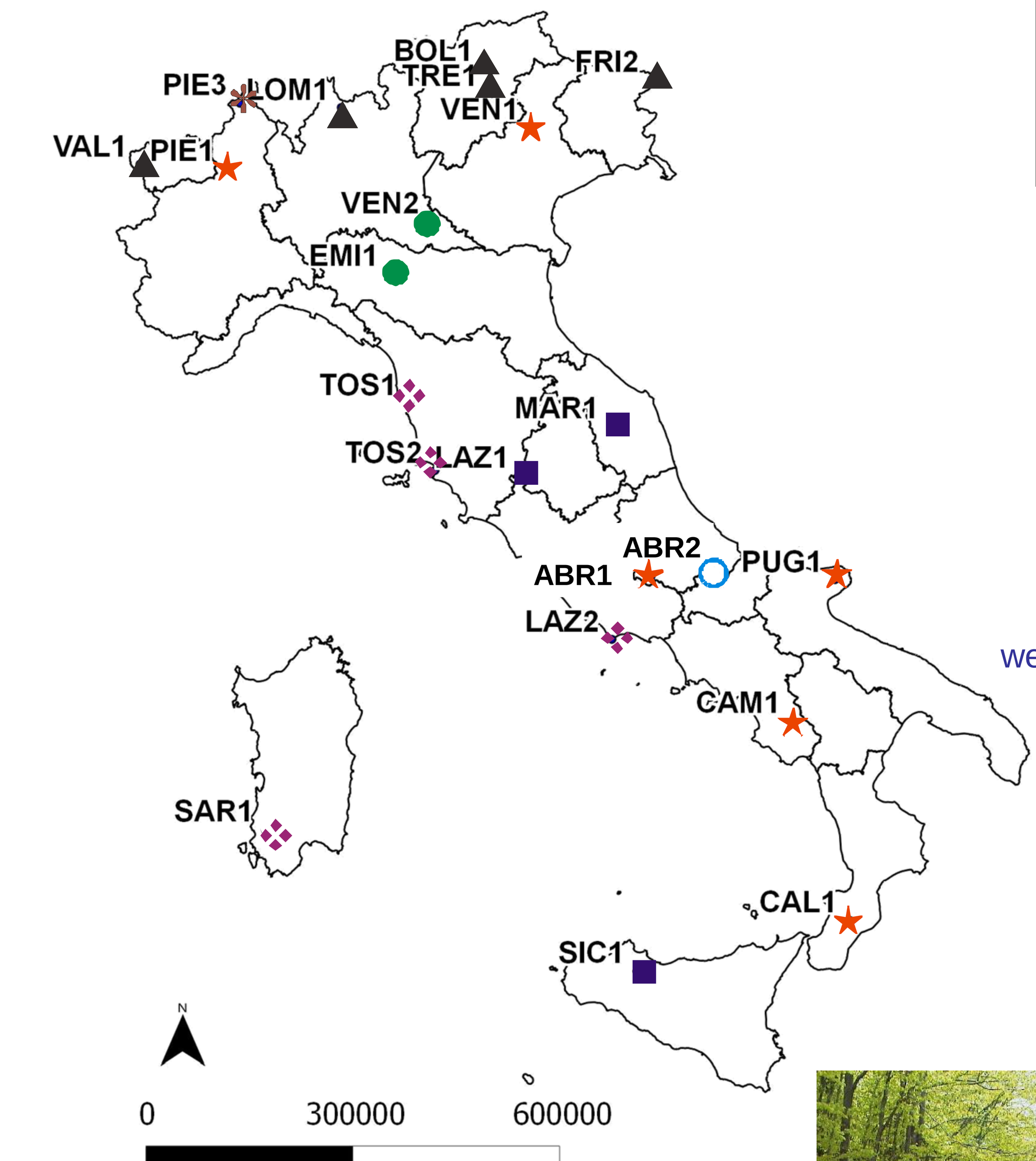
Introduction

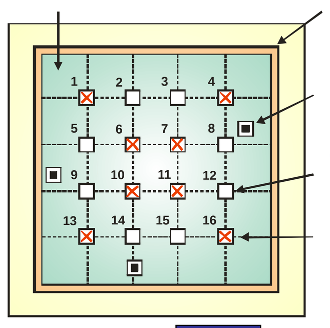
Under the EU-funded Forest Focus and FUTMON Life+ Programme, deposition acidity and ionic content were analysed in 1998-2010 in forested sites in Italy distributed over the whole country.

Temporal trends of ion concentration and precipitation amount were evaluated in 10 sites. Finally, critical loads for nutrient nitrogen were used to calculate exceedance and identify the areas most sensitive to N enrichment.

Study area and samplers

- ▲ *Picea abies* – Norway spruce
- ★ *Fagus sylvatica* - Beech
- ■ *Quercus cerris* – Turkey oak
- ✤ *Quercus ilex* - Holm oak
- ● *Q. robur* and *Q. petraea* – European and sessile oak
- ✱ *Larix decidua* - Larch
- ○ *Abies alba* and *Q. Cerris* Silver fir and oak





Bulk throughfall

For throughfall sampling, 16 rain collectors were distributed at regular intervals in the plot.

Open field depositions were sampled weekly using three continuously exposed collectors in each area.

For both open field and throughfall, samples are pooled together and an aliquot sent to the laboratory for the chemical analysis (Tartari et al. 2002).

In a smaller number of sites (PIE1, PIE3, BOL1, TRE1, FRI2, ABR2 and LAZ1), runoff water was sampled weekly even if precipitation did not occur during the week. The watercourses are fairly small streams, but not so small to be dry for more than 3-4 months during the year.

Bulk open field

Bulk open field & throughfall deposition

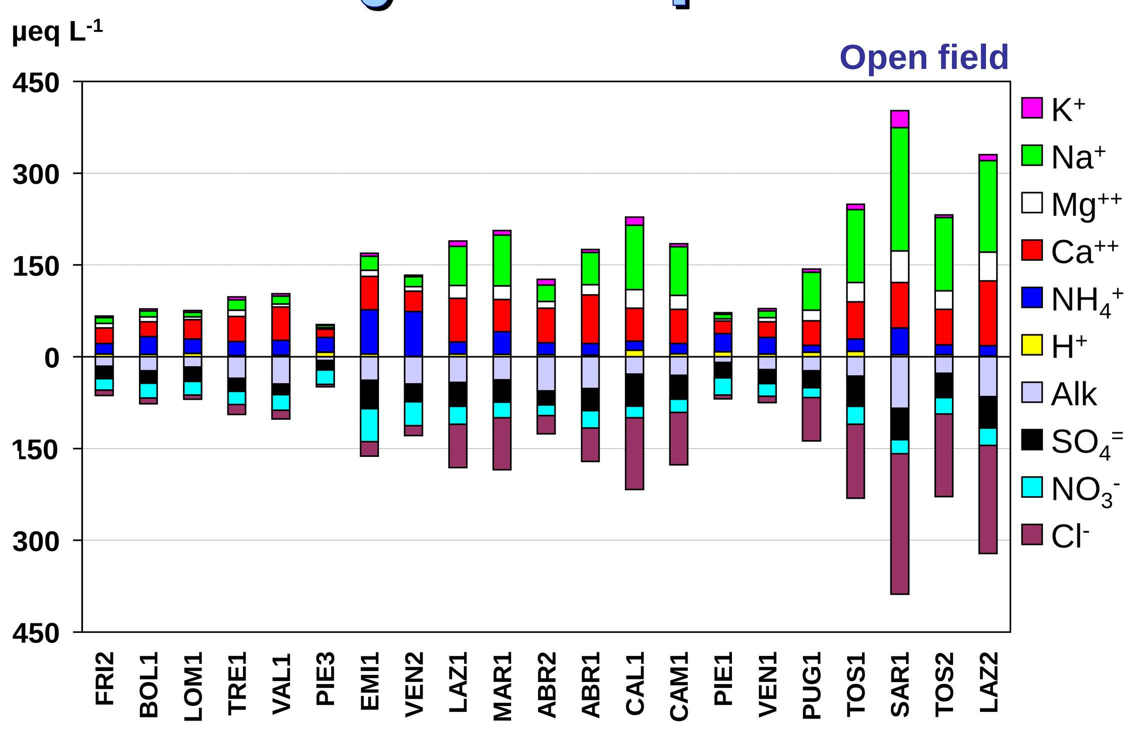
The mean values of the period 2009-2010 for bulk open field and throughfall concentration are shown in these two plots, with the main cations in the upper part of each plot, and the main anions in the lower part.

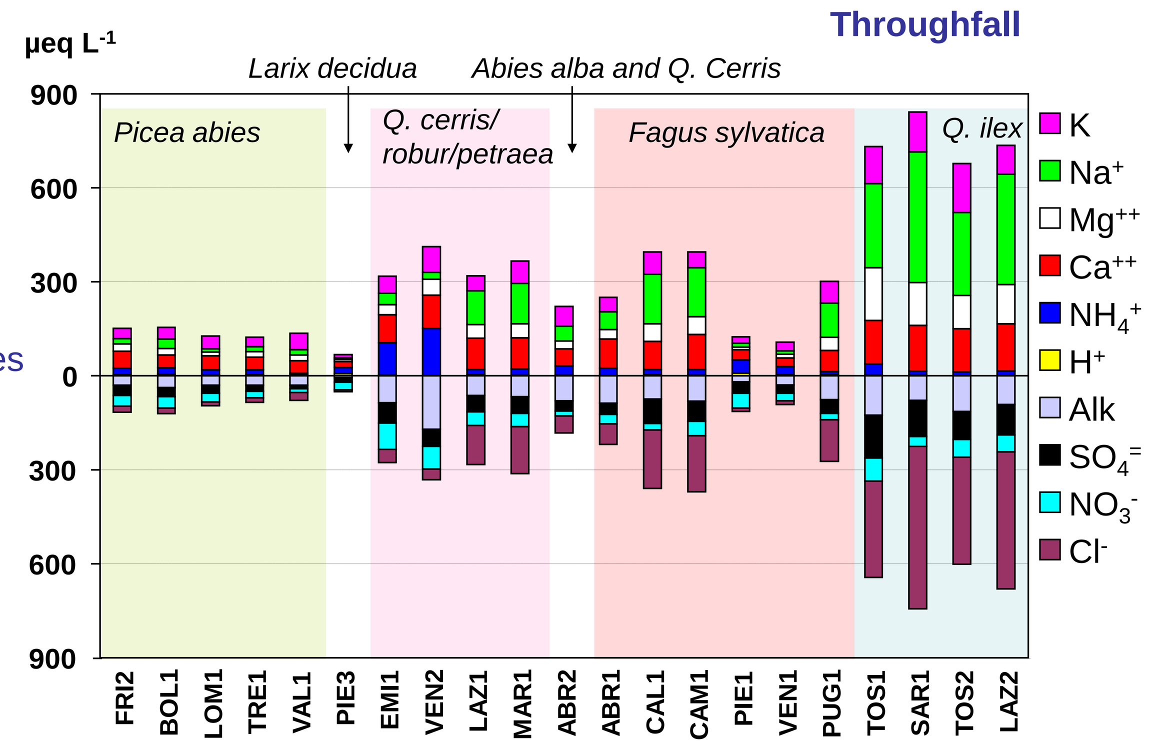
✓ In spite of the remote location of many sites, atmospheric deposition carries high amounts of anthropogenic ions.

✓ Great variability in the bulk ion concentration is due to the marine contribution, as shown by the wide range of chloride and sodium levels.

✓ For base cations (calcium and magnesium) there is a strong latitudinal gradient. Most of these ions derive from the long range transport of Saharan dust, which is more important at the southernmost sites. Base cations buffers the acidity of deposition, so that the mean annual acidity is very low at all the sites.

✓ Throughfall concentration in all the sites is higher than the respective bulk value (please note the different scale). The difference between bulk and throughfall mainly regards alkalinity and the major ions. Exceptions are NH_4^+ and NO_3^-, which in several stations show lower values in throughfall samples, indicating a possible foliar uptake.





Temporal trends (SKT)

Level of significance:

*** p<0.001 ** p<0.01 * p<0.05

Negative trends are in red, positive trends in blue

Open field

	PIE1	TRE1	BOL1	FRI2	EMI1	TOS1	LAZ1	CAL1	CAM1
Cond.	*	***	*	*		***			
Ca^{++}	***	***	*			***			
Mg^{++}		***	***		**	***			
Na^+						***			
K^+	**	***		**	***	***	**		**
NH_4^+		*	**			***			
NO_3^-		**	*						
$SO4^=$	***	***	***	***	***	***	***		
Cl^-		*			*	***			

Throughfall

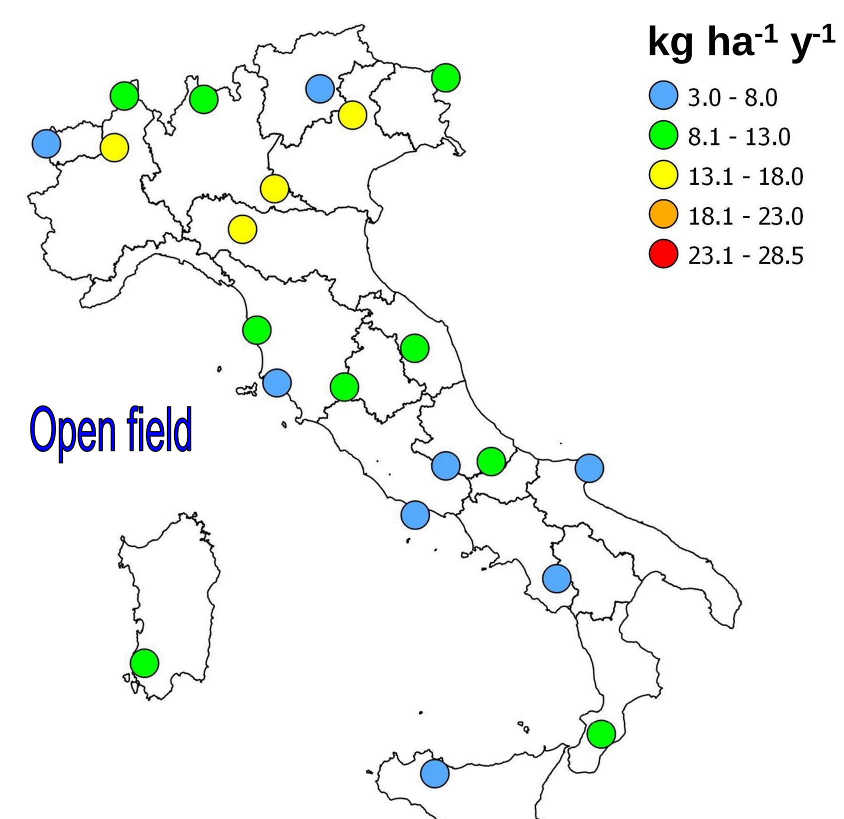
	PIE1	TRE1	BOL1	FRI2	EMI1	TOS1	LAZ1	CAL1	CAM1
Cond.		**				***			
Ca^{++}	***	***	*		*	***	*		
Mg^{++}	*	***	***		*	***			
Na^+			**			***			
K^+						*			
NH_4^+			**			***		***	*
NO_3^-		*	**			**			
$SO4^=$	***	***	***	***	***	***	*		**
Cl^-		**				***			

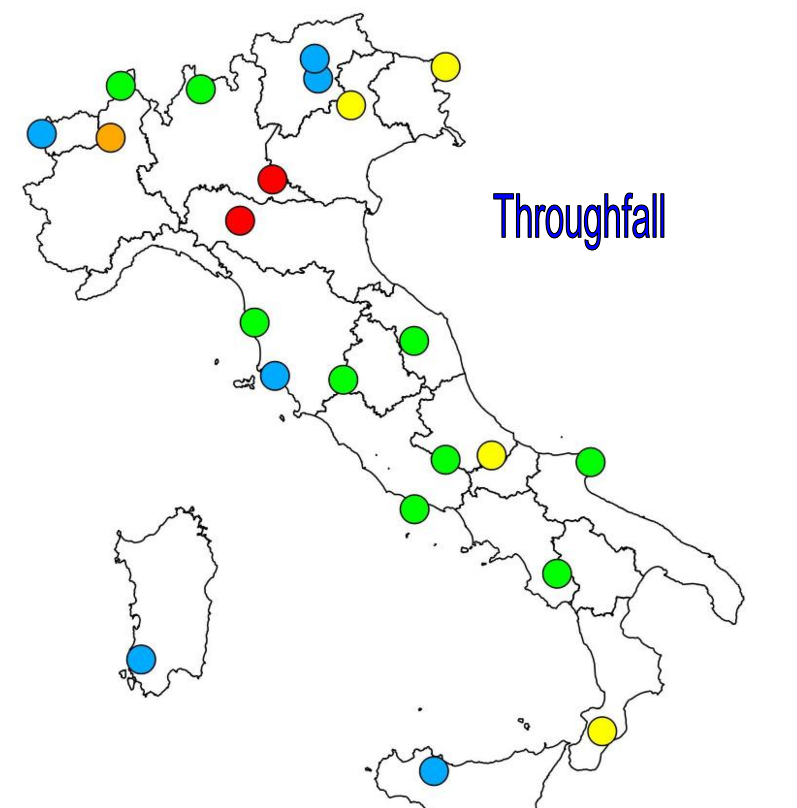
Temporal trends in precipitation chemistry were tested with the **Seasonal Kendall Test** (Hirsch et al. 1982) applied to monthly blocks of data for the period 1998-2010. SKT has been identified as a suitable method for the analysis of water quality data, and is applied in a number of monitoring programmes, including ICP Waters and ICP Integrated Monitoring (Stoddard et al. 1999; Forsius et al. 2001).

Results show significant decreasing trend for $SO_4^=$ for most of the plots, both for open field and throughfall deposition. A significant decrease, for both the sample typologies, also emerges for calcium, magnesium and potassium, but in a smaller number of plots.

A negative trend was detected for inorganic nitrogen only at few plots in bulk open field samples, while for throughfall at CAL1 a positive trend for ammonia was found. Significant negative trends were also found for chloride at TOS1, TRE1 and EMI1.

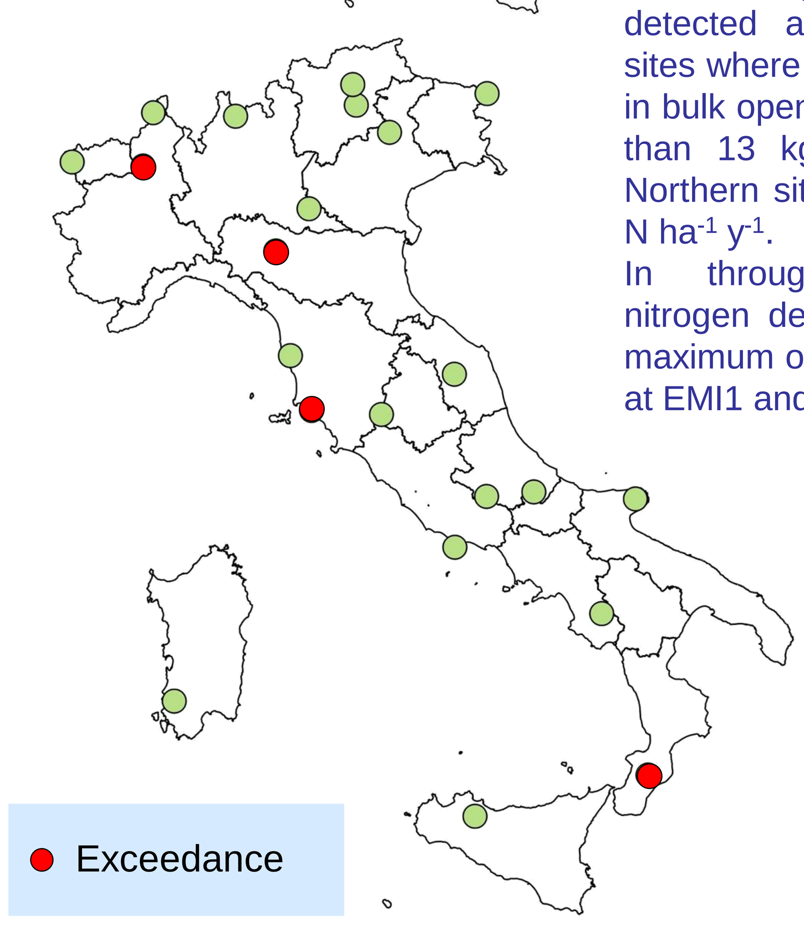
Total nitrogen deposition and critical load

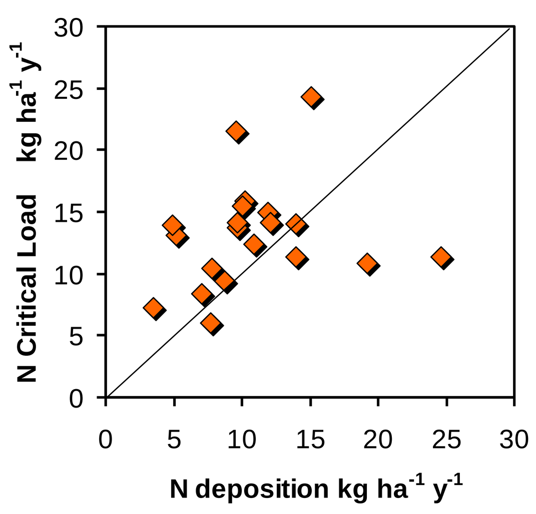




Lower deposition values were detected at the Central-Southern sites where total nitrogen deposition in bulk open field samples are lower than 13 kg N ha^{-1} y^{-1}, while at Northern sites the range is 8-18 kg N ha^{-1} y^{-1}.

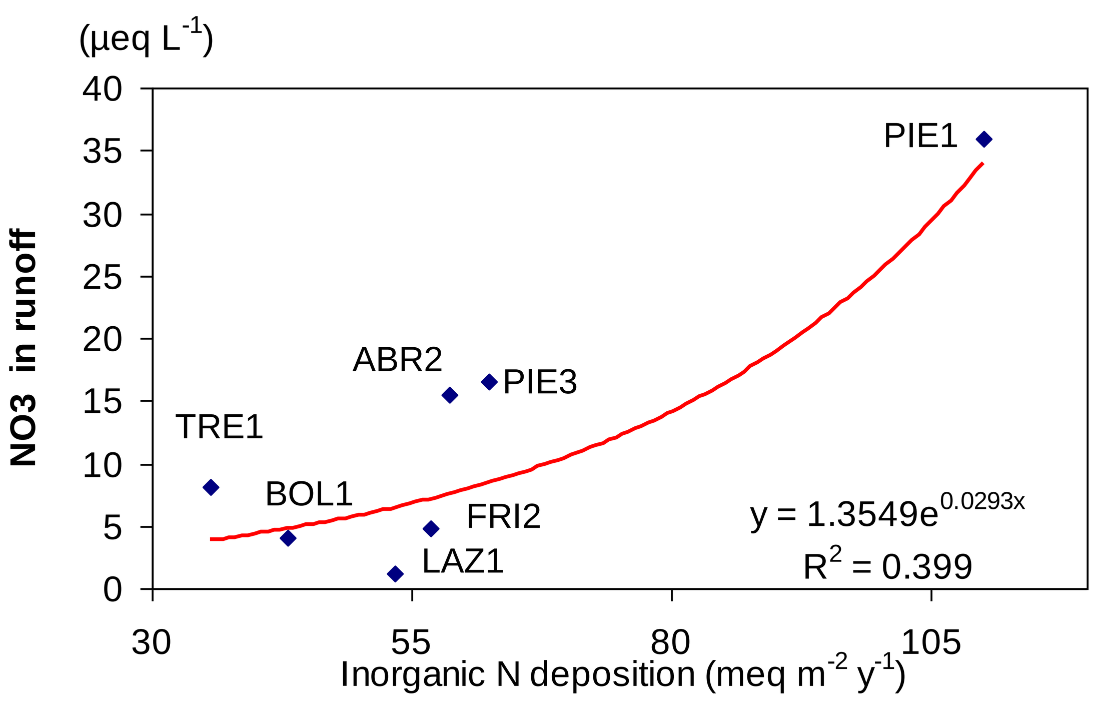
In throughfall samples, total nitrogen deposition increases, with maximum of 25 and 28 kg N ha^{-1} y^{-1} at EMI1 and VEN1, respectively.





At most of the sites, total N deposition is close to the estimated critical loads of nutrient N, while in part of the Po Plain (i.e. stations PIE1 and EMI1) and at TOS1 and CAL1 the critical values have been exceeded during the study period.

Runoff water



In this figure, mean NO_3 concentration (2009-2010) measured in runoff water at 7 sampling sites are plotted against inorganic nitrogen deposition values (sum of NH_4 and NO_3). A relationship between the variables can be observed, with increasing NO_3 leaching when the critical value of 10 kg N ha^{-1} y^{-1} of N deposition (71 meq m^{-2} y^{-1}) is exceeded (Dise and Wright 1995).

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Acknowledgement

This work was partially funded by the European Union under Regulation (EC) 2152/2003 ("Forest Focus") and programme LIFE+ 07/ENV D 000218 "FutMon" (Further Development and Implementation of an EU-level Forest Monitoring System) and by the Italian National Forest Service.

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