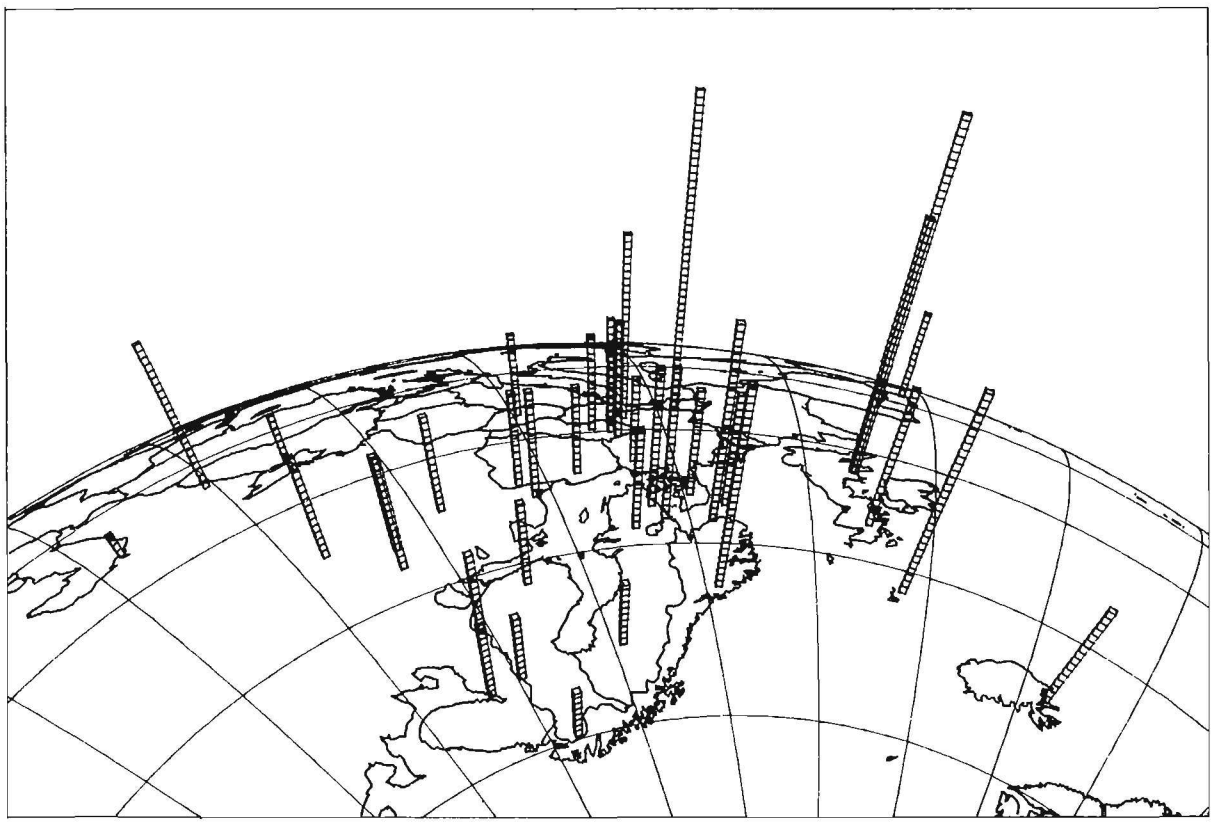
Convention on Long-range
Transboundary Air Pollution

Pilot Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems

2 ANNUAL SYNOPTIC REPORT 1991



Environment Data Centre
National Board of Waters and the Environment
Helsinki 1991

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Cover graphs: Long-term precipitation in IM -areas. Scale unit 50 mm.

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CONTENTS

GUIDANCE TO THE READER

The 2nd Annual Synoptic Report (1991) emphasizes the between-site and in-site variability of the main variables measured within the Integrated Monitoring Programme. The report does not go into detailed analysis of correlation between different variables - this will be covered by the Programme Evaluation Report in 1992.

For the reader the following guidelines may be of use:

Firstly, the variance of s.c. driving variables are presented. These are variables of local climate and runoff.

Secondly, main chemical elements are presented - one in each chapter. In the presentations the monitoring areas are depicted on a map showing their position within the element depositional field. The areas are grouped according to ecozones. For each area an element bar graph is depicted (fig. 1). The bar layers from top to bottom represent compartments/subcompartments of the monitored ecosystem. The abbreviations of the used compartments are:

AC Ambient air (neq/m³)
DC Precipitation (μeq/l)
SF Stemflow (μeq/l)
TF Throughfall (μeq/l)
SW1 Soil water of the topsoil; 0-10 cm depth (μeq/l)
SW2 Soil water at 10-20 cm depth (μeq/l)
SW3 Soil water below 20 cm depth (μeq/l)
GW Groundwater (μeq/l)
RW1 Lake surface water (μeq/l)
RW2 Lake water at 3 m depth
RW3 Lake water at 5 m depth
RW4 Lake water at mean depth of lake (μeq/l)
RW5 Lake water at near-bottom depth (μeq/l)
RWR Runoff water (μeq/l)
NC Needle/leaf contents (meq/kg)
LF Litter contents (meq/kg)
SC1 Contents of organic soil layer (meq/kg)
SC2 Contents of mineral soil; 0-10 cm depth (meq/kg)
SC3 Contents of mineral soil; 10-20 cm depth (meq/kg)
SC4 Contents of mineral soil; deeper than 20 cm (meq/kg)

The top-bottom order implicates roughly the gravitional flow from one compartment to another. The exchangeable storages are presented at the bottom of the graphs.

The values of the bars are concentration levels (units are given above). Levels are shown for the annual mean and the minimum and maximum monthly average. Numbers at the end of each bar explain the temporal variation (number of time samples) and the spatial variation (number of observation points/ permanent plots). The values refer to the hydrological period November 1989 - October 1990 unless otherwise stated.

If bars are missing no measurements exist (no data have been reported) for this medium; if areas are lacking no measurements exist (no data have been reported) at all.

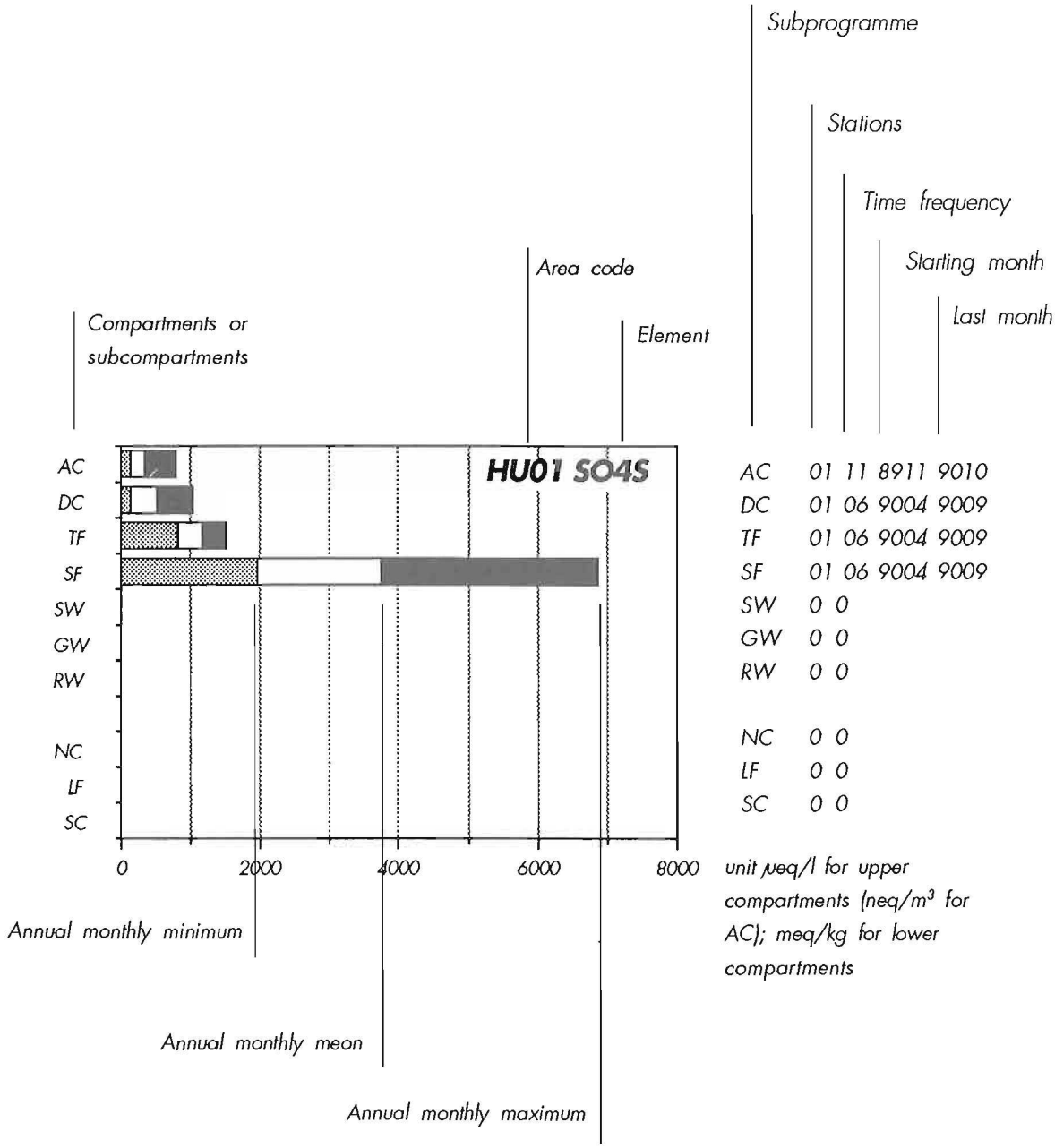
Some time-series showing the between-year variation are presented if such data have been available for repetitive measurements in excess of three years.

Finally the element budgets (expressed in mg/m^2 based on the formula DD+WD-RUNOFF) are shown on a map diagram for those areas where calculations can be made. In the budget calculations the input has been corrected for dry deposition using the chloride-correction method (Wright, R.F. & Johannessen, M. 1980. Input-output budgets of major ions at gauged catchments in Norway. Drablos & Tollan (ed.) Ecological impact of acid precipitation. Oslo.) since throughfall measurements are not extensively in use yet. In the case of sulphur and base cations correction for marine sea-salts have also been made (Mapping critical loads. Nordic Council of Ministers 1990. Miljörapport (Environmental report) 1990:14, Nord 1990:98). For hydrogen (pH) proton balances have been calculated if possible.

Thirdly, biological variables have been presented as indicators of the forest stands and the understorey vegetation.

The variables for the forest stand refer to characteristics of the dominating tree species. The units are percentages for canopy coverage, discoloration, defoliation and vitality, metres for tree height and stem diameter. The PSI-lichen index has been presented in the 1st Annual Synoptic Report.

The variables for the understorey vegetation refer to the community structure of the permanent plots. The variables are coverage in percentage and frequency of occurrence for different life-forms and flora groups and fertility index of the species with the largest area coverage.


Subprogramme
Stations
Time frequency
Starting month
Last month
Area code
Element
Compartments or subcompartments
HU01 SO4S
AC
DC
TF
SF
SW
GW
RW
NC
LF
SC
0
2000
4000
6000
8000
AC 01 11 8911 9010
DC 01 06 9004 9009
TF 01 06 9004 9009
SF 01 06 9004 9009
SW 0 0
GW 0 0
RW 0 0
NC 0 0
LF 0 0
SC 0 0
unit µeq/l for upper compartments (neq/m³ for AC); meq/kg for lower compartments
Annual monthly minimum
Annual monthly meon
Annual monthly maximum

CHAPTER 1

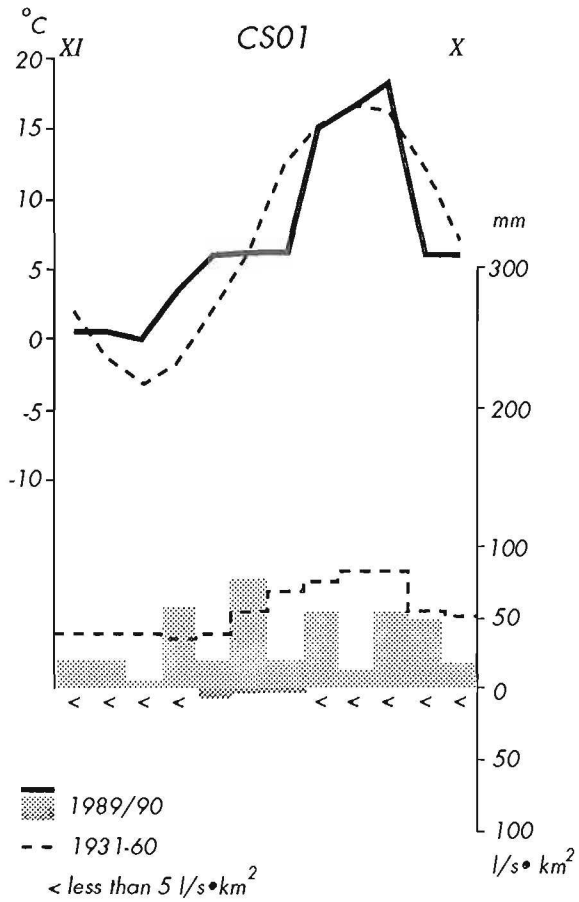
Driving variables

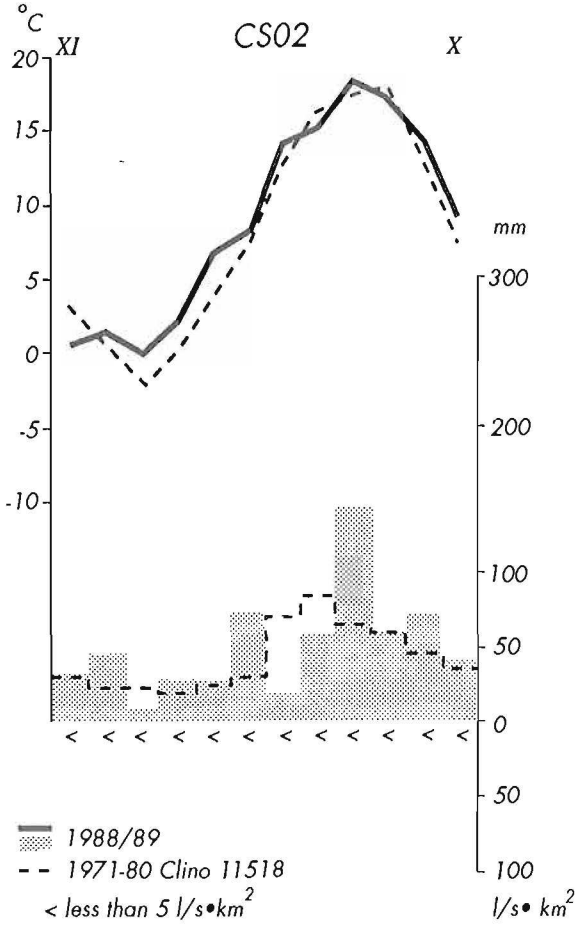
Monthly temperature curves (°C), precipitation (mm) and streamflow (l/s•km²) bars are shown for the periods associated with measurements/observations in the areas dealt with in the report. For comparison curves and bars for long-term climate at the closest meteorologic stations are shown (dashed). Observe that these stations may be quite far away and at different altitudes from the monitoring areas so they are not always directly comparable with the local climate. The long-term climatic information, however, indicates the typical climatic regime for the ecoregions in question and are therefore of interest for perennial biologic activity.

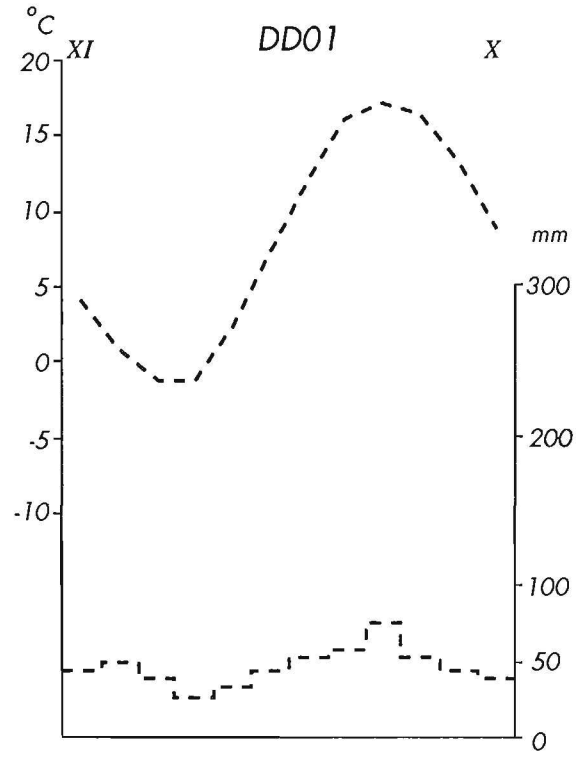
Nemoral Region (CS01,CS02,DD01,PL01,PL02,SU11,GB01,GB02)

Temperature curves for the hydrologic period November-October are sinuisoidal. The coldest months are normally slightly below 0°C becoming colder towards east. During the observation period the minima in the Czech areas were above 0°C. The vegetation period normally exceeds 8 months. Precipitation lies between 25 and 100 mm/month with the largest amounts in summer and winter. Streamflow is very low and mostly below 5 mm/month in Mlynaruv (CS02) and Anenske (CS01) and in summer their streams tend almost to dry out. Flow is predominantly caused by surficial groundwater output to streams. Data on recent climate at Stechlin (DD01), Gardliczno (PL02), Lekuk (PL01) and Preila (SU11) are missing.

In the western parts the temperature curves are smoother and the monthly averages range between +5 and +15 °C becoming somewhat colder along the northern Atlantic. The vegetation period is quite long, between 7-8 months. Afon Hafren (GB02) is in the shadow of the Welsh mountains and Allt-a-Mharcaidh (GB01) somewhat away from the western Atlantic coast and therefore not very humid.







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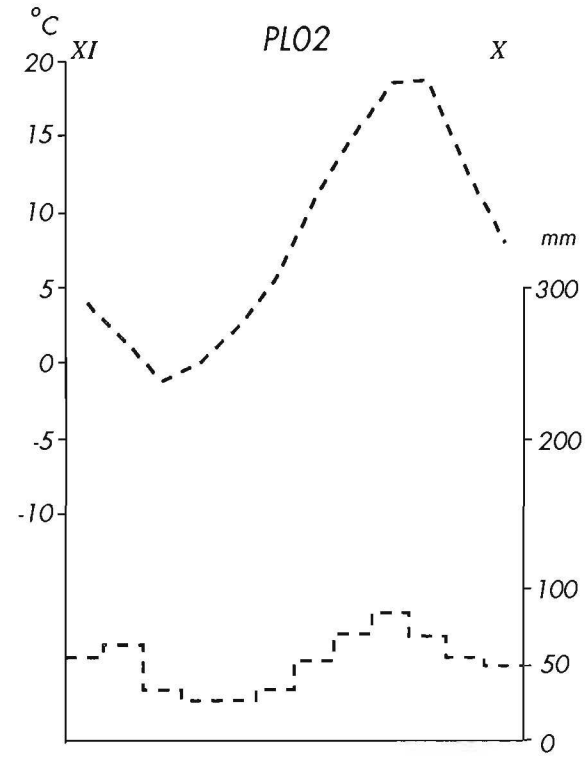
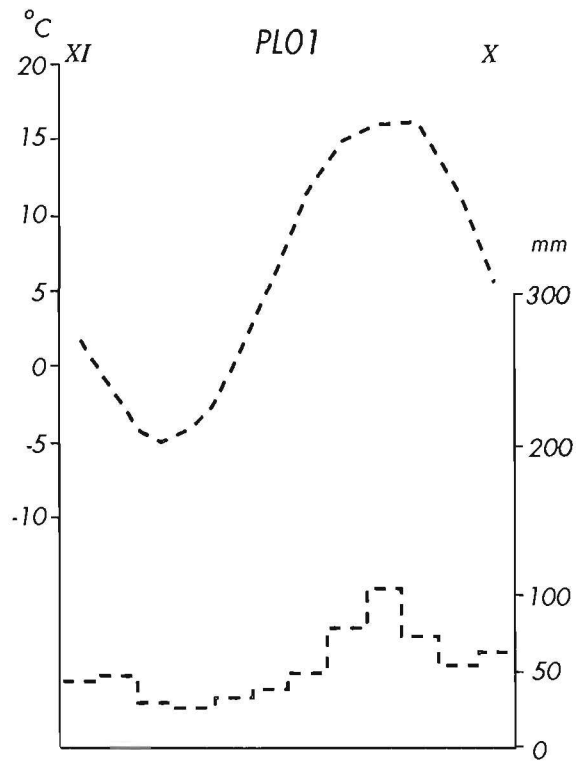


— 1971-80 Clino 12105



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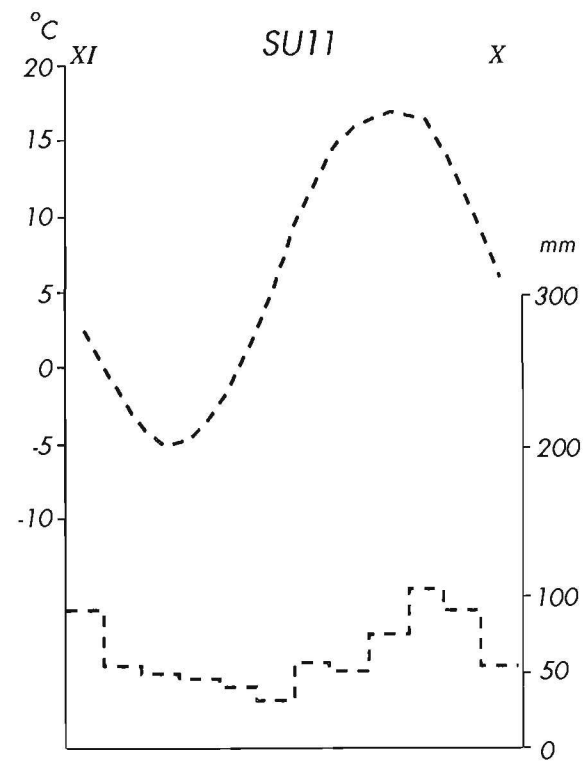
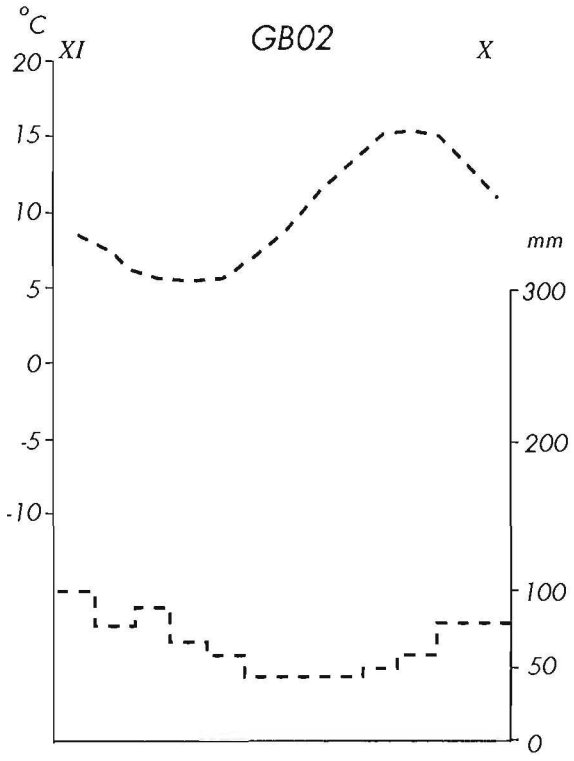
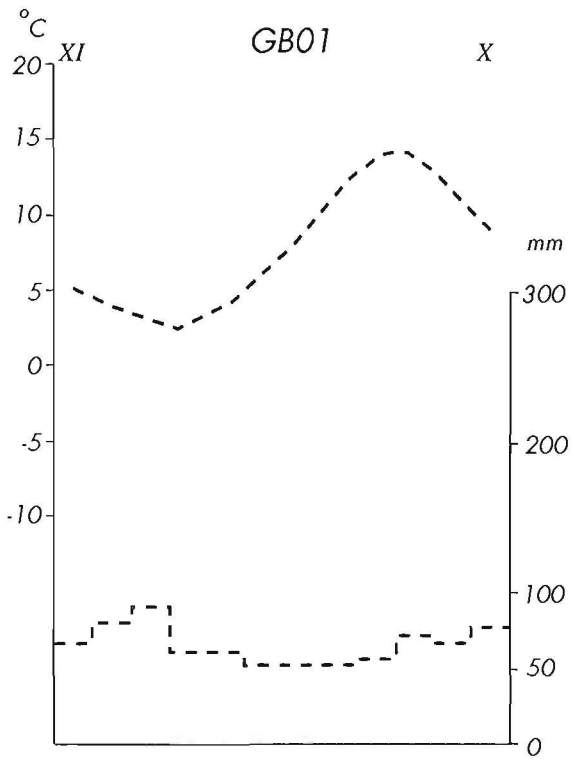


- - 1971-80 Clino 26629/Kalingr.



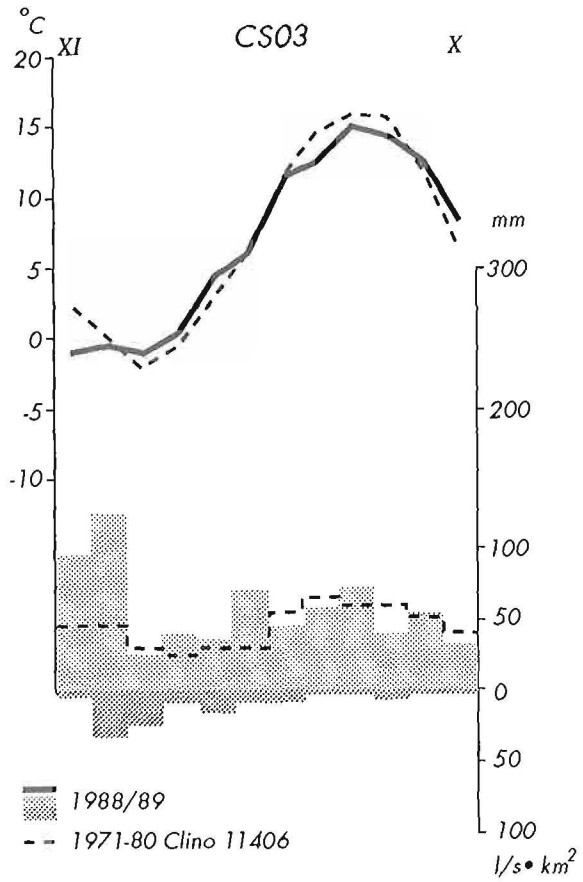
---- *Land W./Clino 1971-80*



-- *1971-80 Aberdeen Dyce*

Montaneous Central (CS03,CS04,DE01,CH01)

The European mountains usually experience summerrains with higher summer temperatures and lower winter temperatures than at lower altitudes. The vegetation period is some 6 months. Temperature rise in the mountain areas of Liz Sumava (CS04), Forellenbach (DE01) and Erlentobel (CH01) were reduced in April after which very steep (in excess of 5 degrees) in May. In Erzgebirge at Jezeri (CS03) the thermal rise was smoother. Daily resolution thermographs from Forellenbach and Erlentobel indicate high temperature amplitudes from day to day, even in excess of 10°C. Frost and non-frost day alternation is high particularly during the winter period. High winter rainfalls were experienced in the Bavarian Alps and very high rainfalls in the Swiss Alps. The daily resolution pluviographs of Forellenbach and Erlentobel show the frequent number of heavy rainshowers in the high mountain areas. The reflection by streamflow is not high in Liz Sumava but pronounced in the steep linear-shaped lateral valley drainage of Erlentobel (and probably also in Forellenbach).


°C
XI
CS03
X
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15
10
5
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-10
mm
300
200
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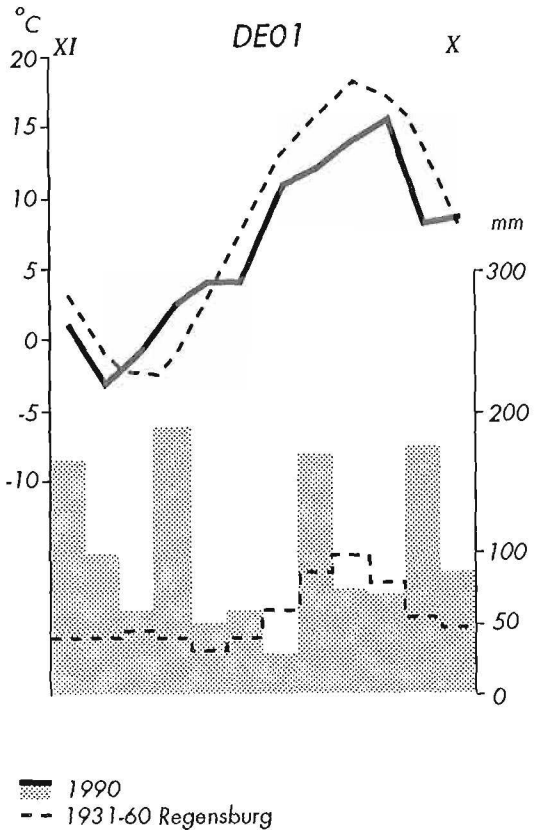
50
0
50
100
l/s• km²
1988/89
1971-80 Clino 11406


°C
XI
DE01
X
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mm
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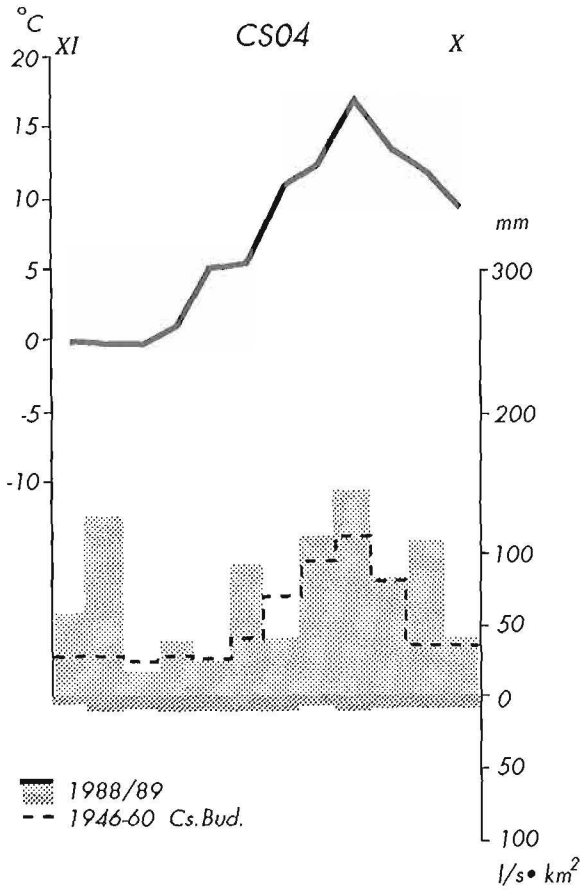
1990
1931-60 Regensburg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CS04
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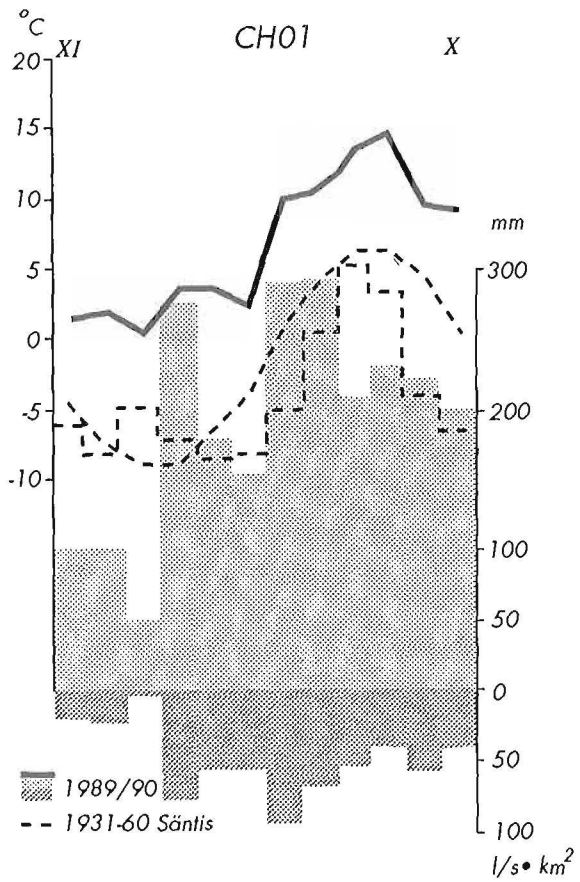
l/s• km²
1988/89
1946-60 Cs.Bud.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XI
CH01
X
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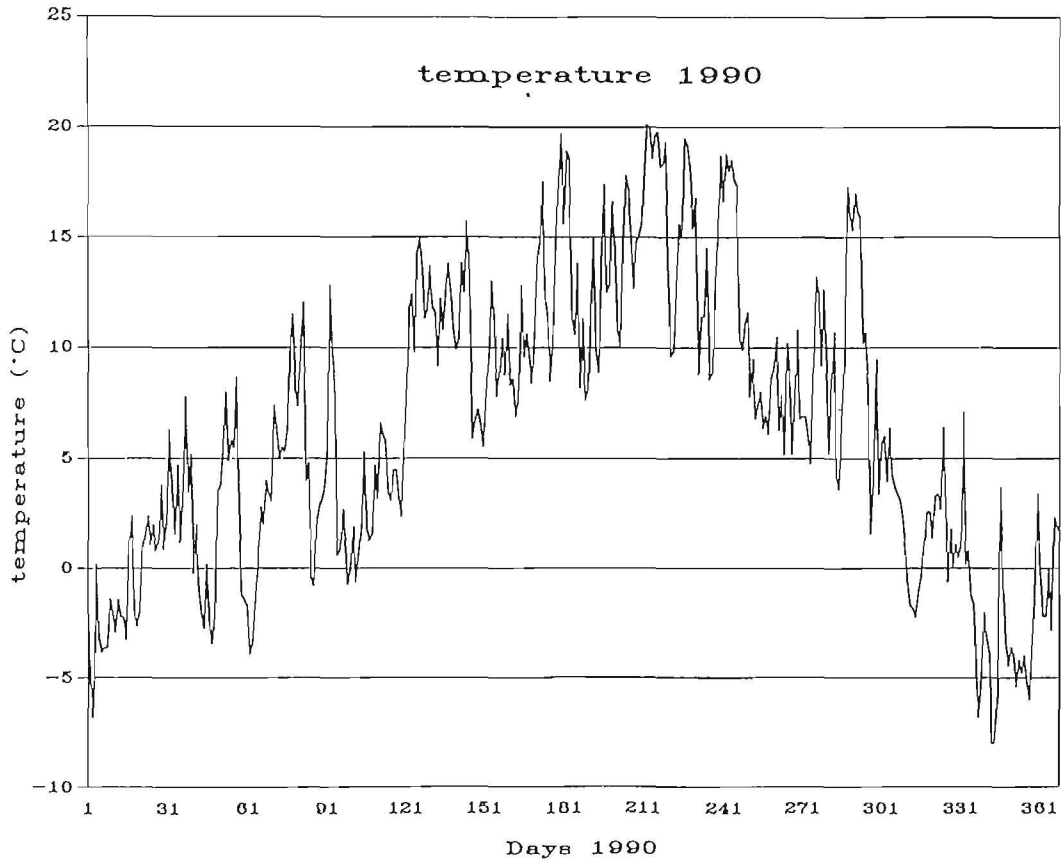
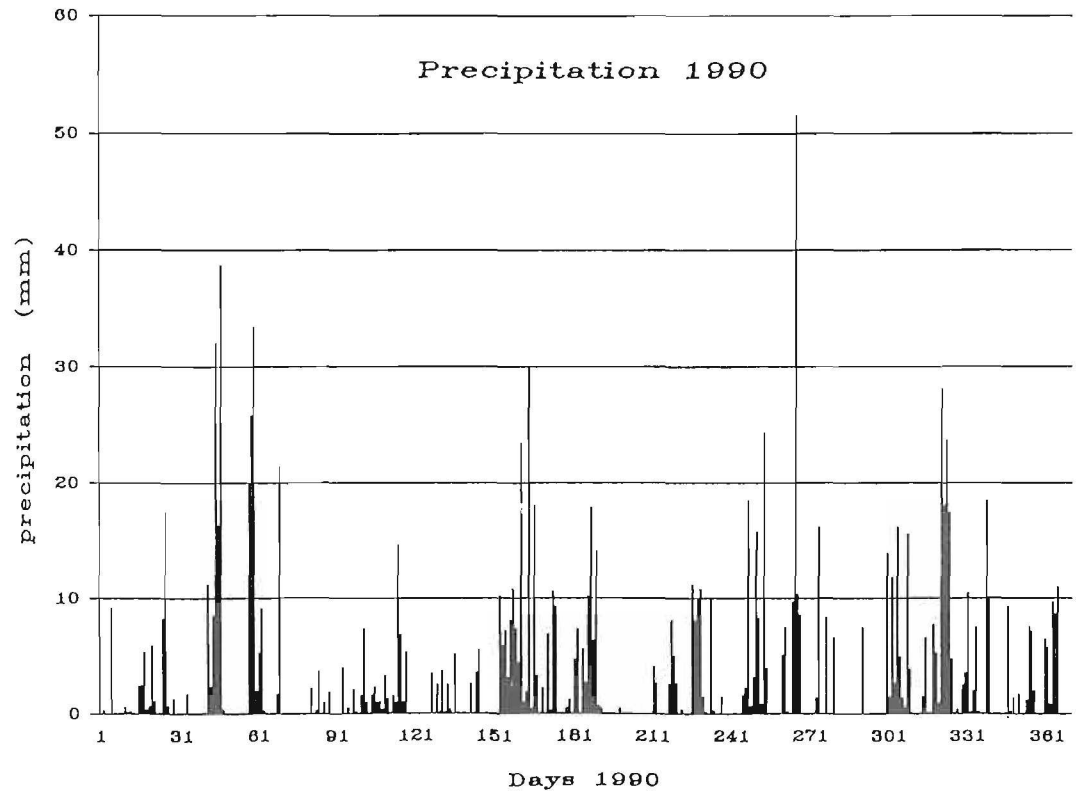
15
10
5
0
-5
-10
mm
300
200
100
50
0
50
100
l/s• km²
1989/90
1931-60 Säntis

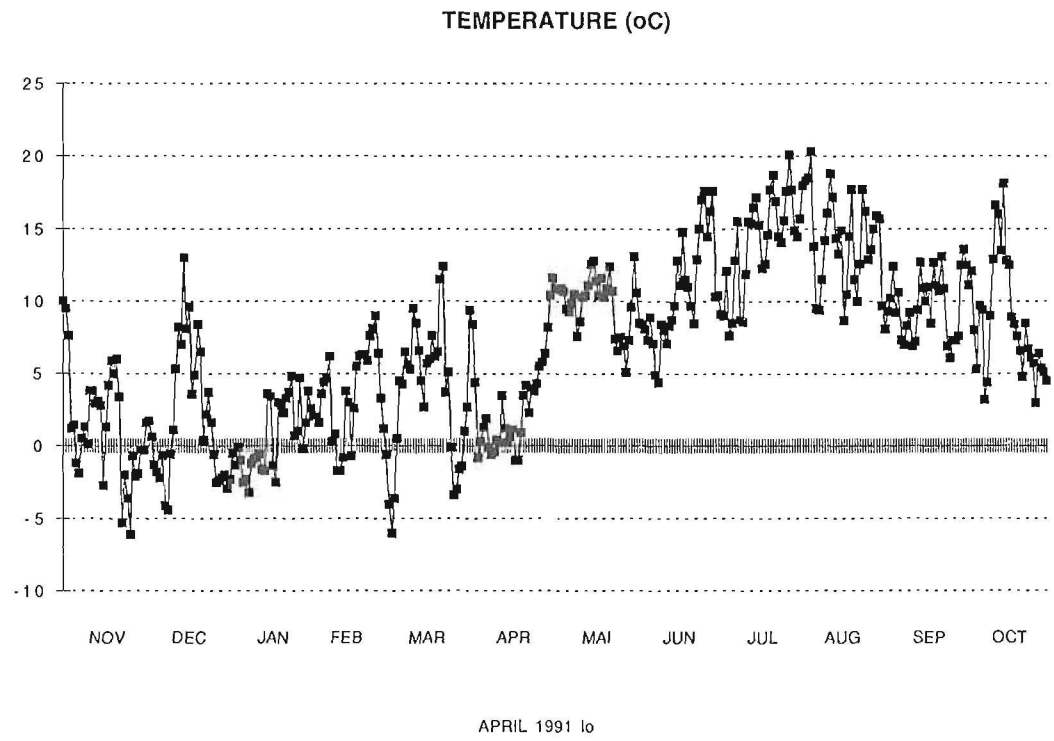
DE01 Forellenbach, temperature



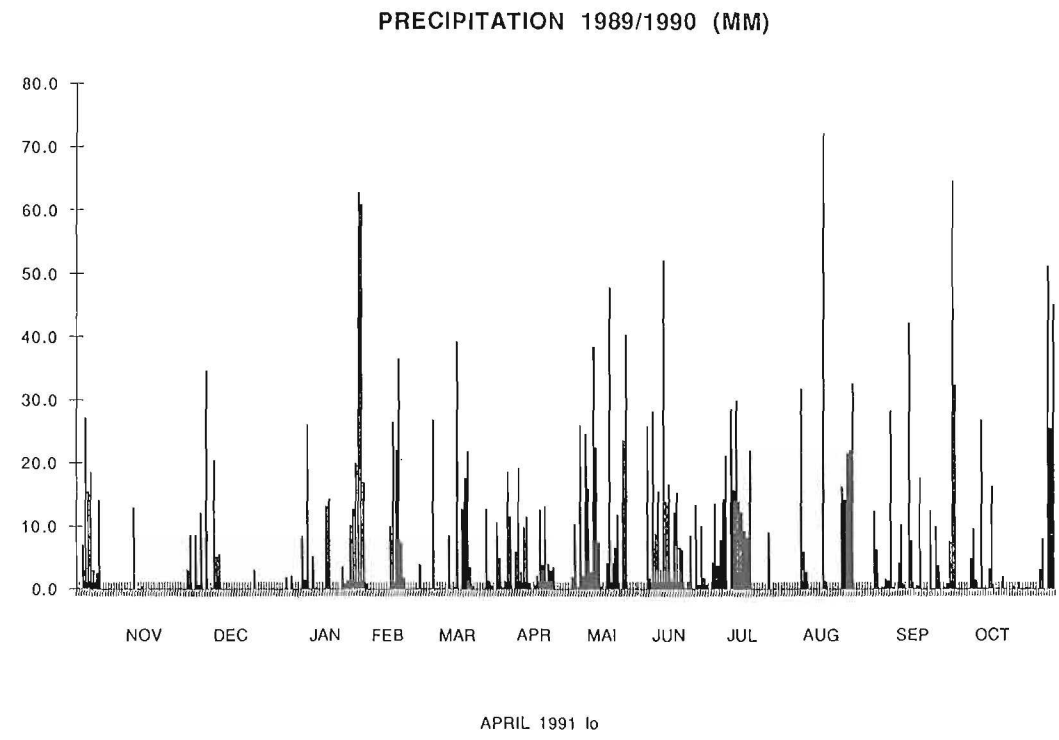
DE01 Forellenbach, precipitation



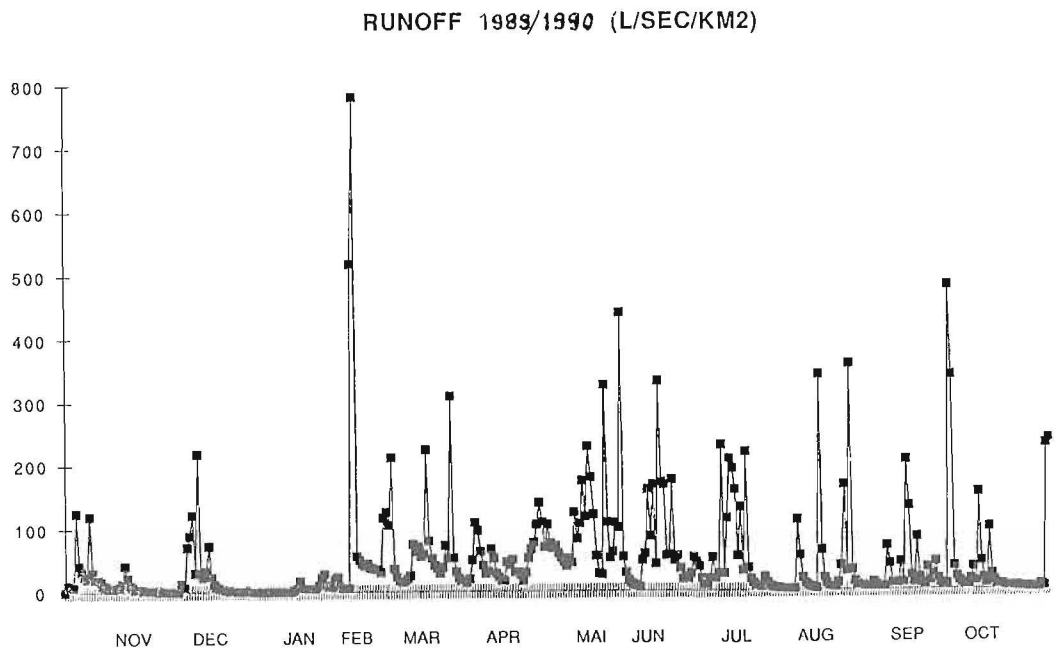
CH01 Erlentobel, temperature



CH01 Erlentobel, precipitation



CH01 Erlentobel, runoff



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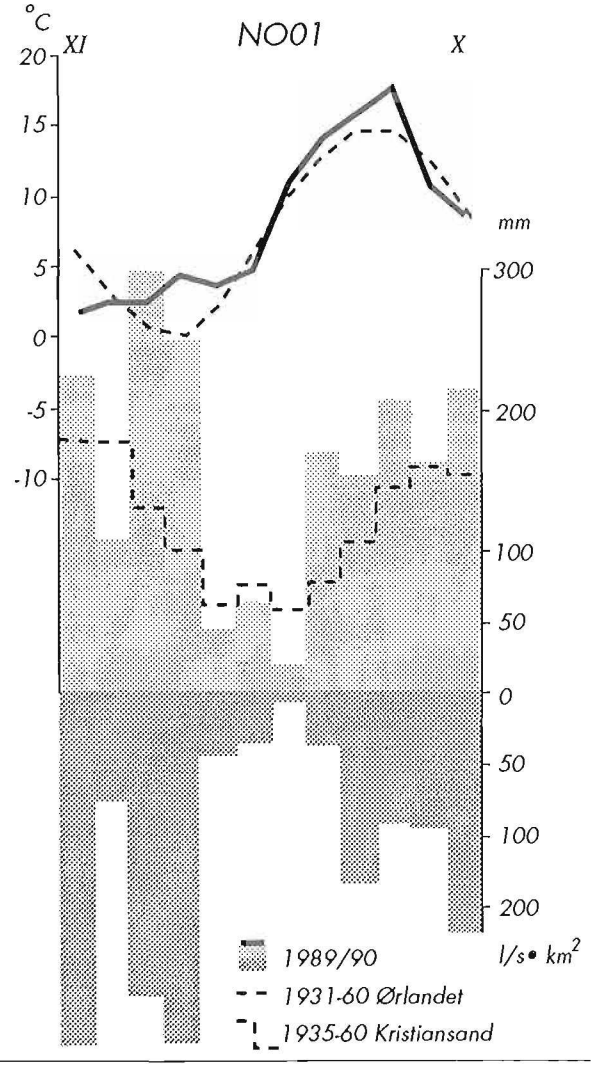
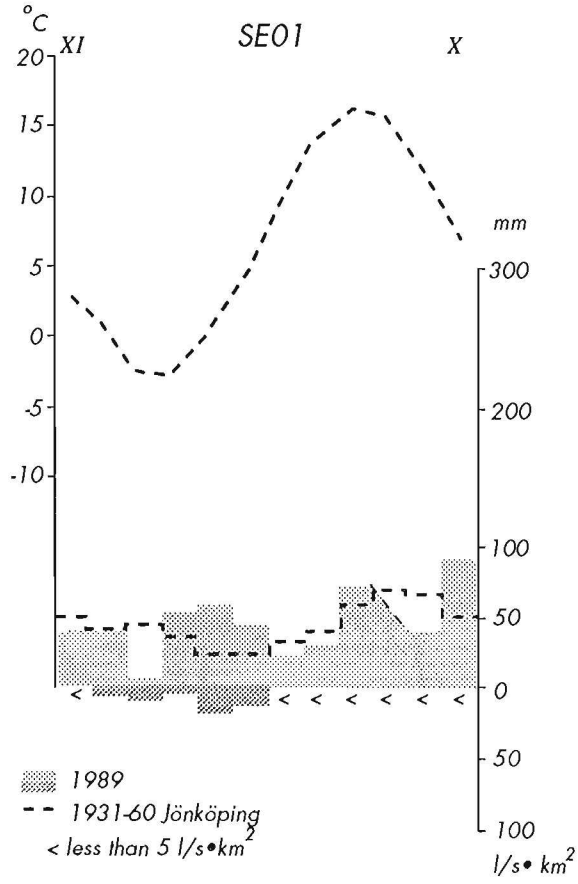
Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

The thermal regime is normally somewhat more colder than along the Atlantic coast and in Central Europe, but still with monthly means above 0°C. Between-day amplitudes are seldom very high as examplified by Birkenes (NO01). The vegetative period is ca 6 months. The precipitation diagrams are bimodal with rain periods in winter/spring and autumn. Streamflows follow the rainfall pattern rather well, with predominant high values during snowmelt and smaller peaks during late autumn rainstorms as shown by daily graphs of precipitation and runoff at Birkenes. During high summer in May - August streams almost dry out with flows below 5mm/ month. In Birkenes, an area with shallow soil, the runoff is very nicely mirrored against rainfall.




°C
SE01
XI
X
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mm
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50
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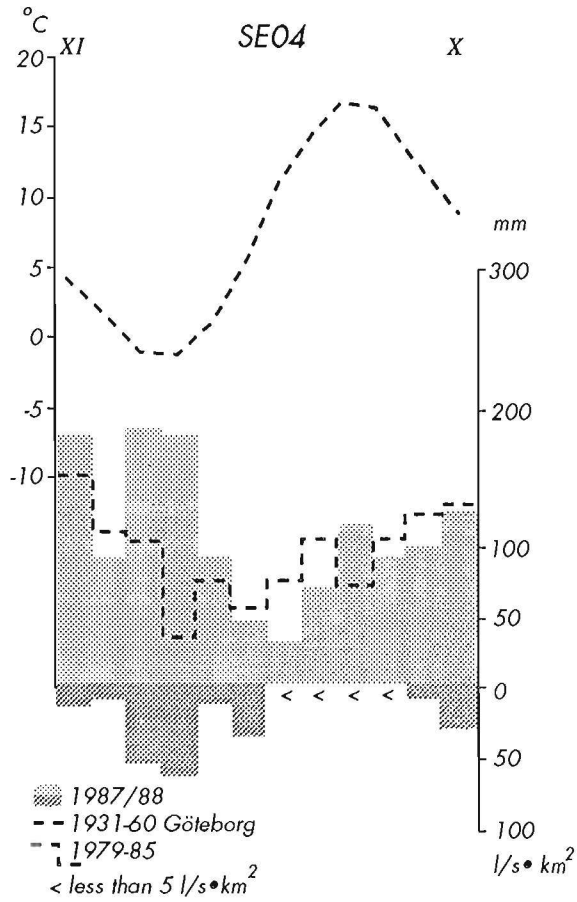
50
100
l/s• km²
1989
1931-60 Jönköping
< less than 5 l/s•km²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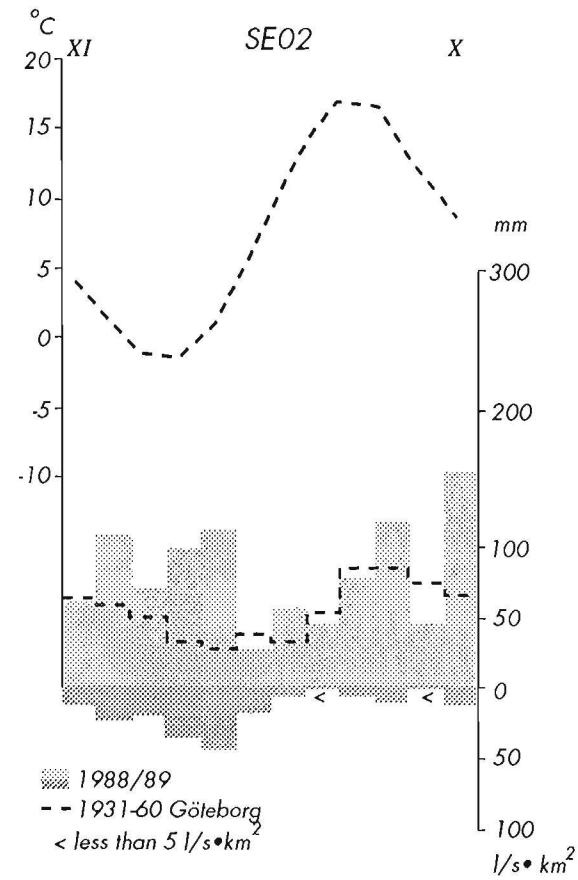
SE04
XI
X
20
15
10
5
0
-5
-10
mm
300
200
100
50
0
50
100
l/s• km²
1987/88
1931-60 Göteborg
1979-85
< less than 5 l/s•km²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SE02
XI
X
20
15
10
5
0
-5
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mm
300
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50
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50
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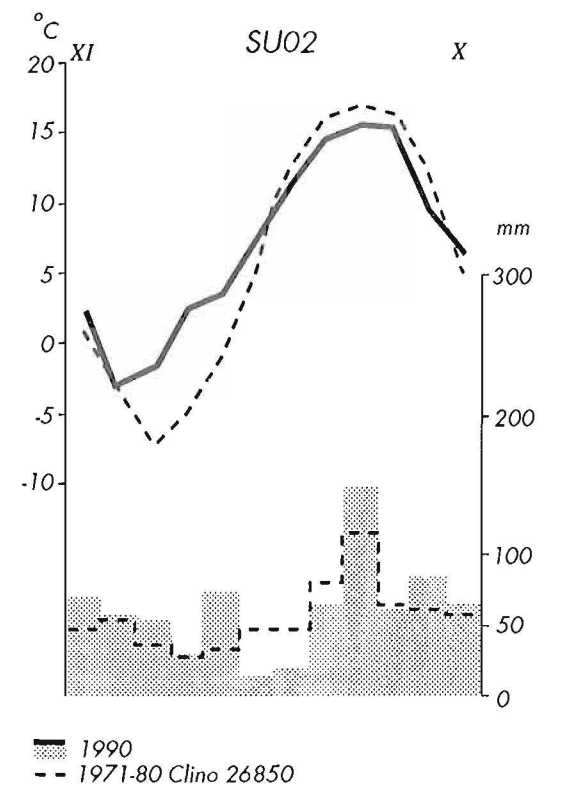
l/s• km²
1988/89
1931-60 Göteborg
< less than 5 l/s•km²


°C
SU02
XI
X
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15
10
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mm
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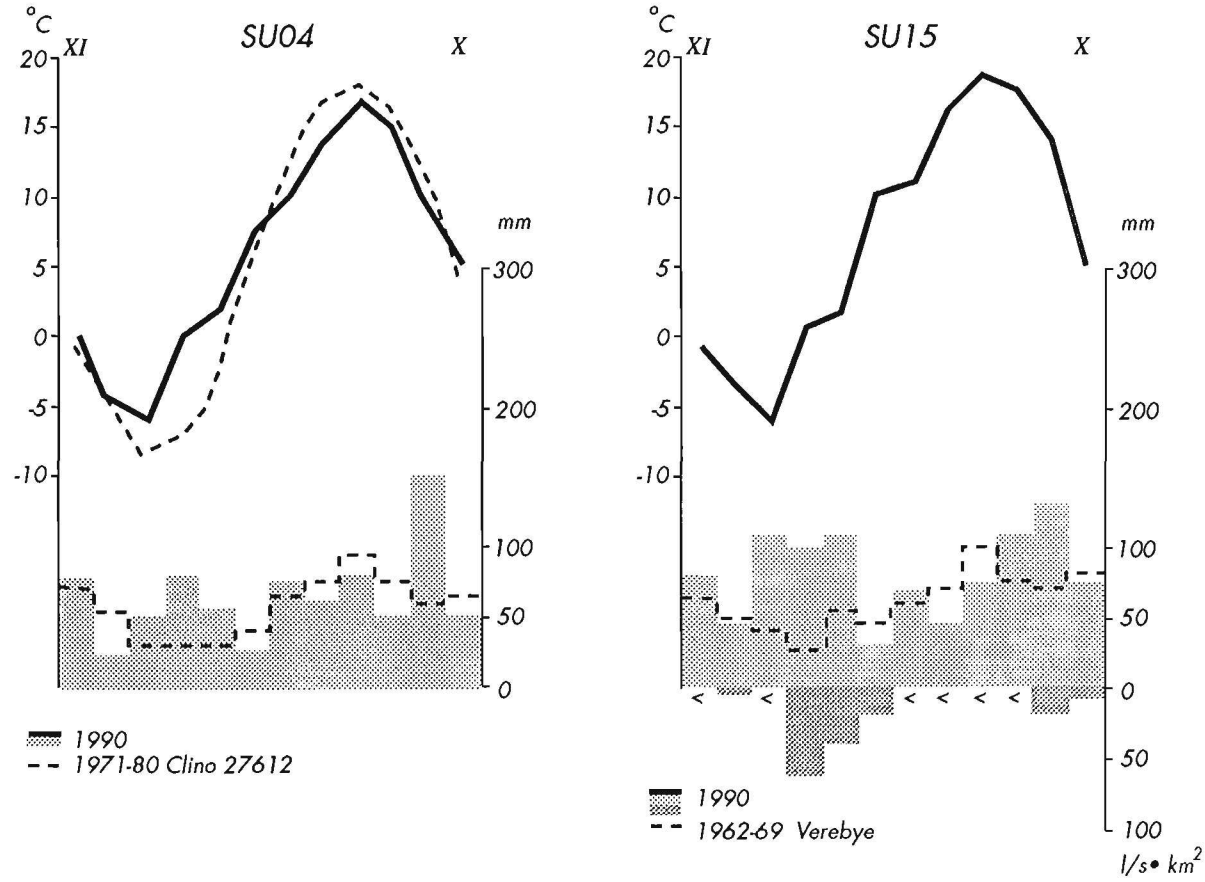
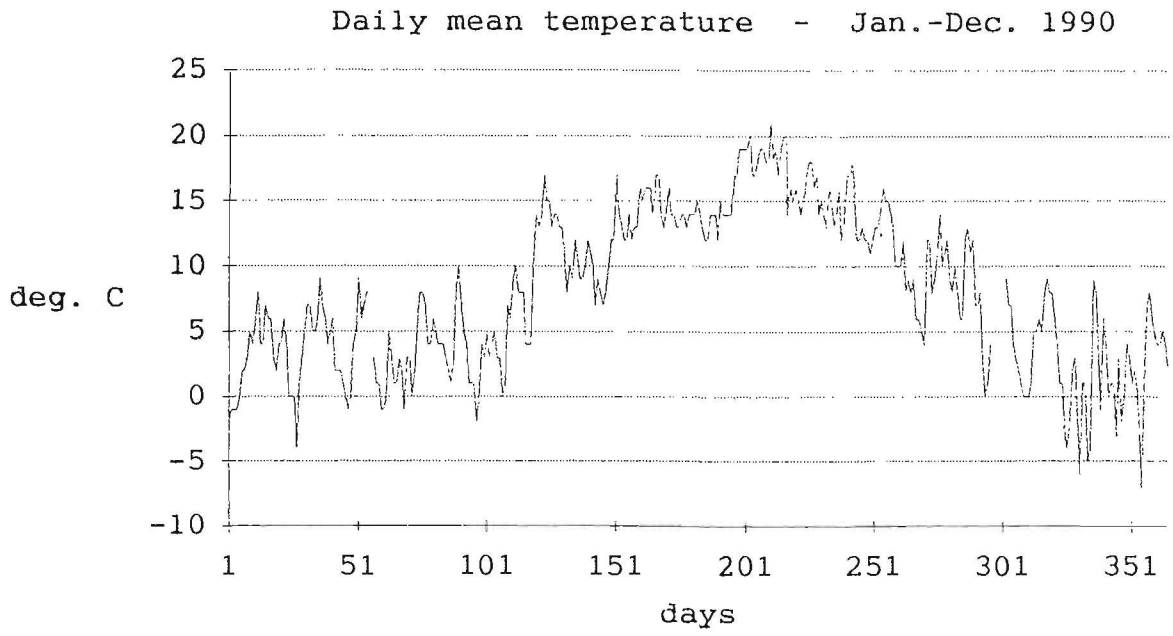
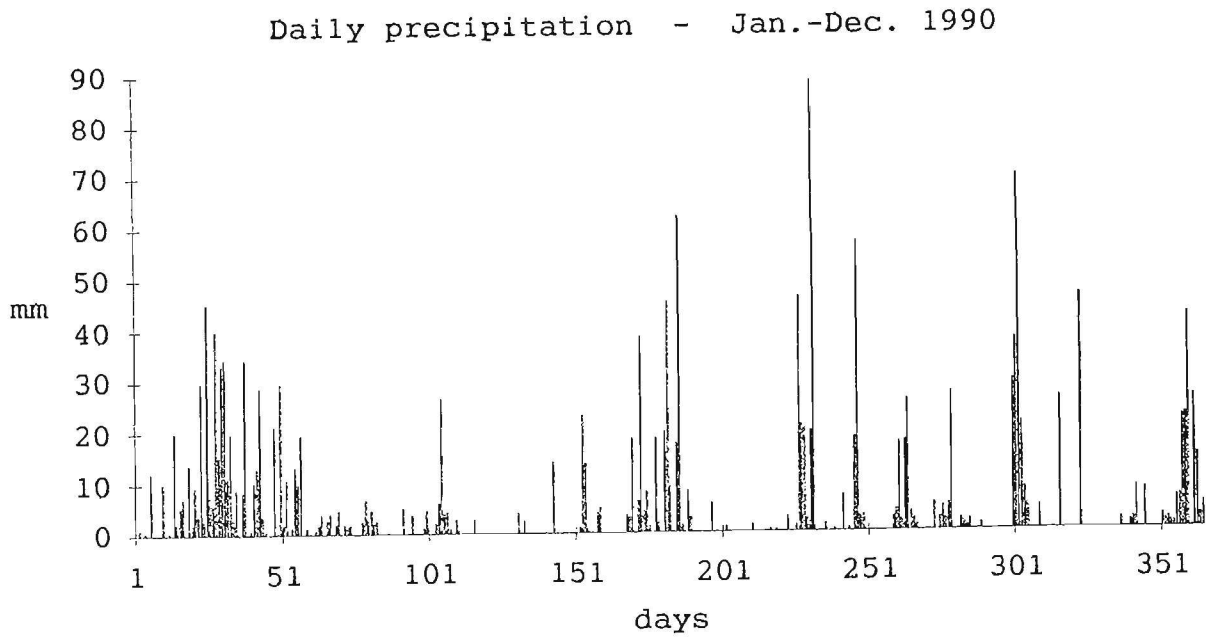
200
100
50
0
1990
1971-80 Clino 26850



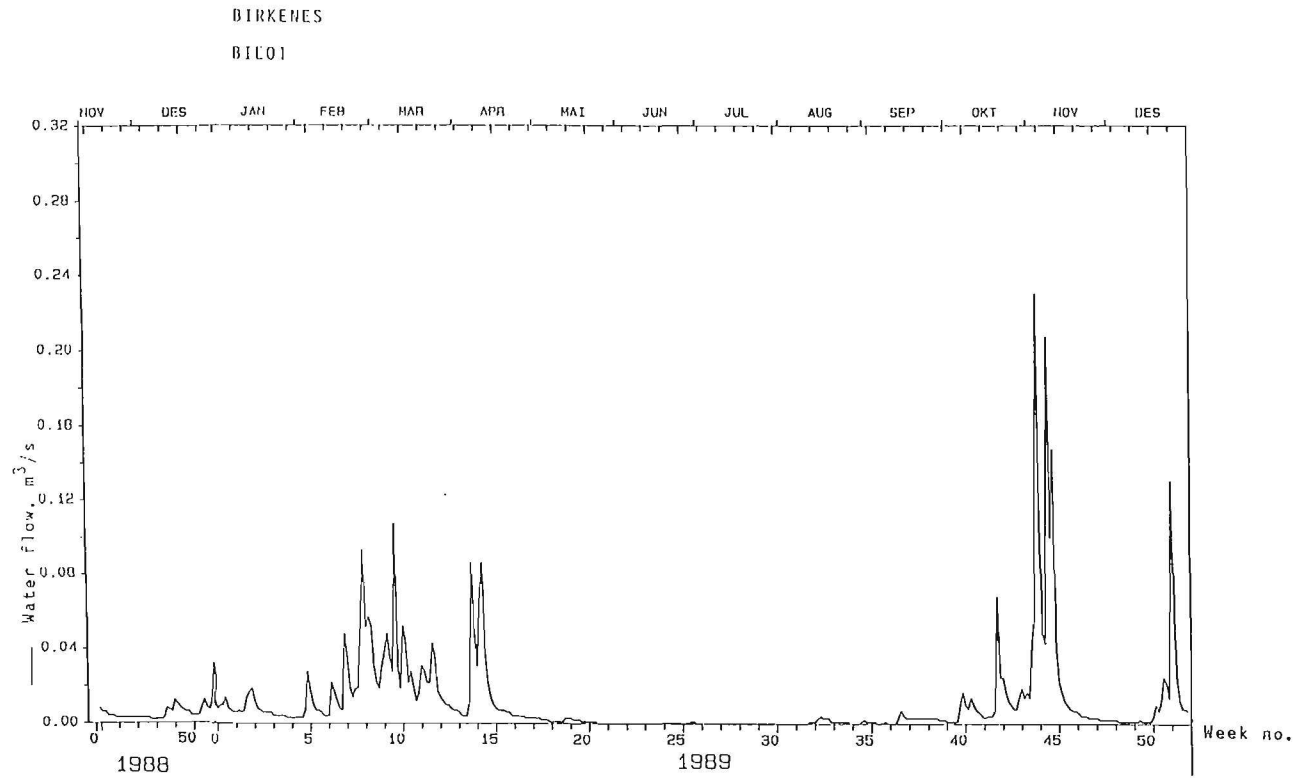
NO01 Birkenes, temperature



NO01 Birkenes, precipitation



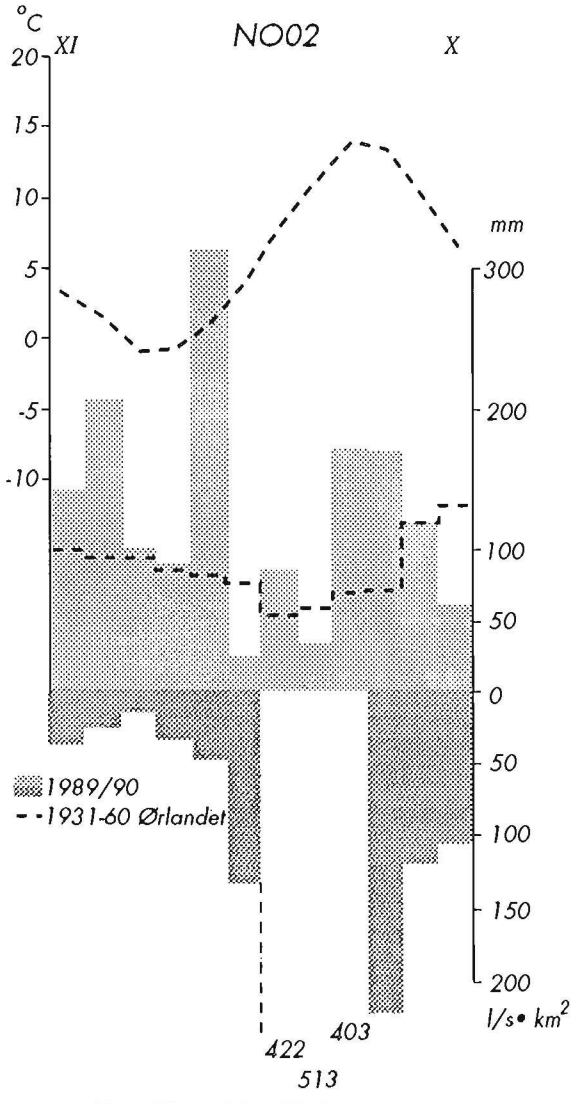
NO01 Birkenes, runoff

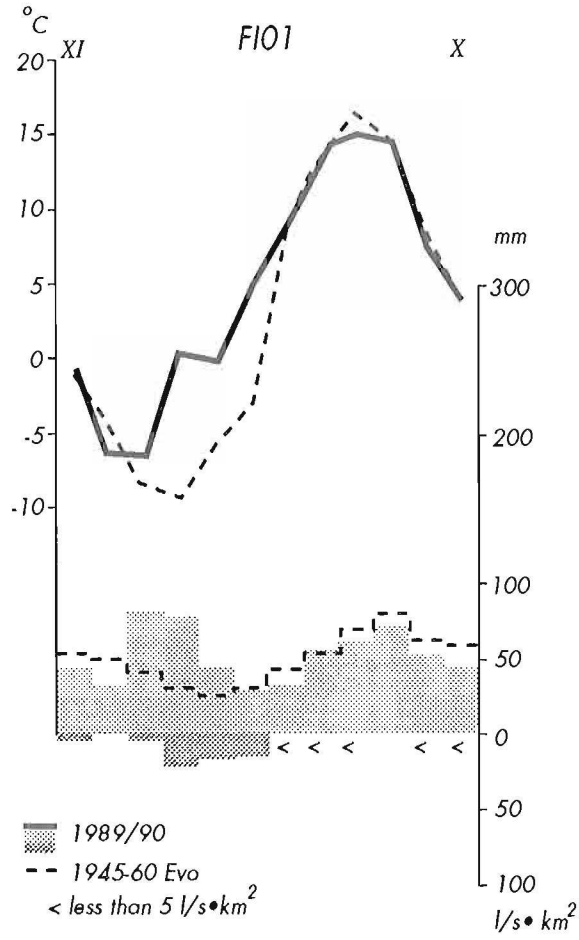


Boreal Region
(NO02,FI01,FI03,SE03,FI04,FI05,SU16)

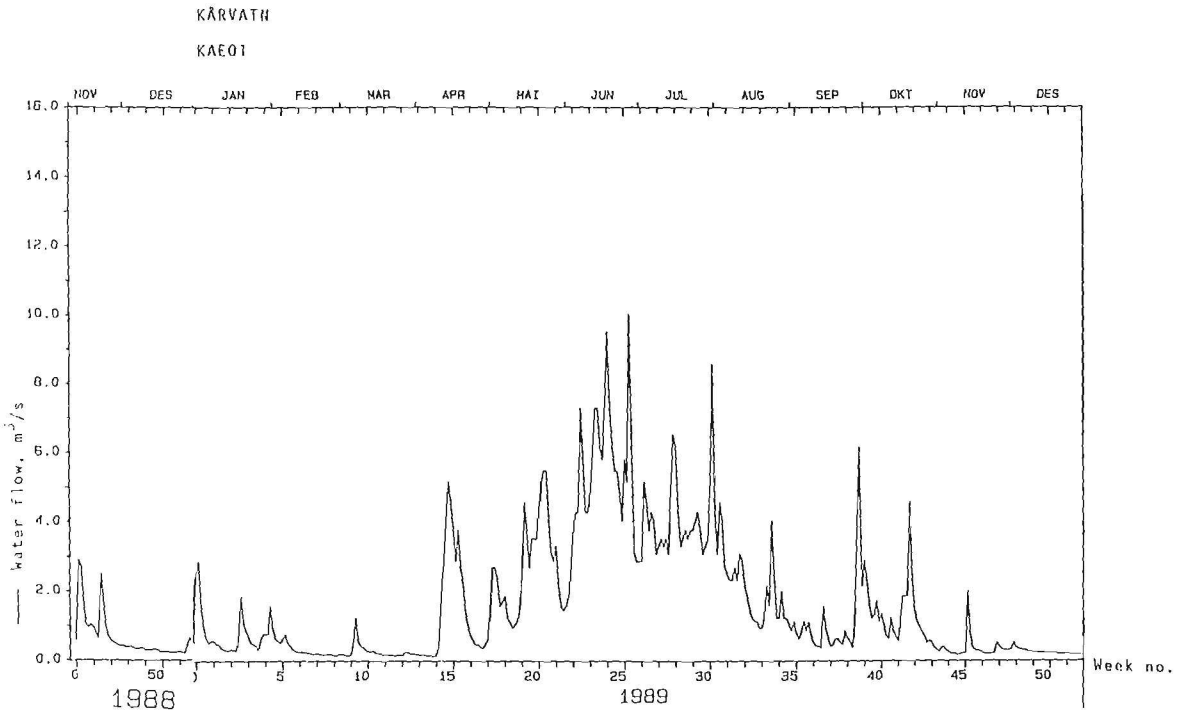
The temperature curves become much more steeper in this region, normally clearly below 0°C for half the hydrological year. Winter minima are felt in January or February often with monthly temperatures below -15°C. The beginning of 1990 was however much milder and wetter as normal. The curves of Valkeakotinen (FI01), Hietajärvi (FI03), Pesosjärvi (FI04) and Vuoskojärvi (FI05) also display cold spells in March whereas summer and autumn temperatures were very close to long-term average ones. The vegetation period is normally 6 months in the southernmost areas but shortens to 4 close to the subarctic forest line.

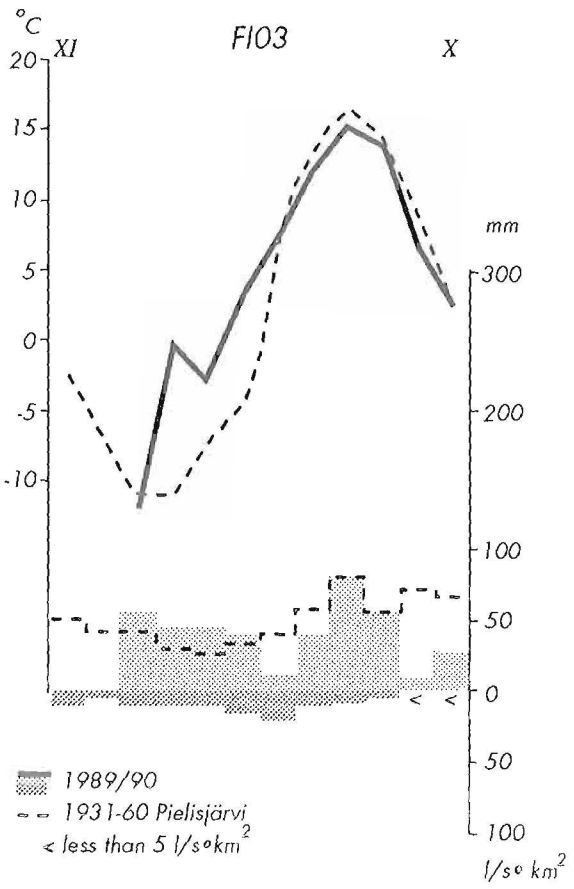
Kårvatn (NO02) on the Norwegian coast is very humid with rainfalls exceeding 100mm/month with the exception of the summer period. Flow in Kårvatn is accentuated in snowfree periods. Notable is the extremely high flow in the summer months caused by springwells bringing down water from the late melting snow and ice of the Caledonian mountains. This steady pumping flow is also discernable in the daily flowgraph. The autumn in both Finnish and Swedish areas were slightly drier than normal. Flows are concentrated to snowmelt in spring, usually defined to April-May in the Southern Boreal and to May-June in the Middle and Northern Boreal. Flow is restricted to surficial groundwater output during most of the hydrological period. Streams can dry out (or come to stand still) during long periods in the summer and autumn. In Hietajärvi the flow is much steadier due to the proportionally high extent of peatbog areas.

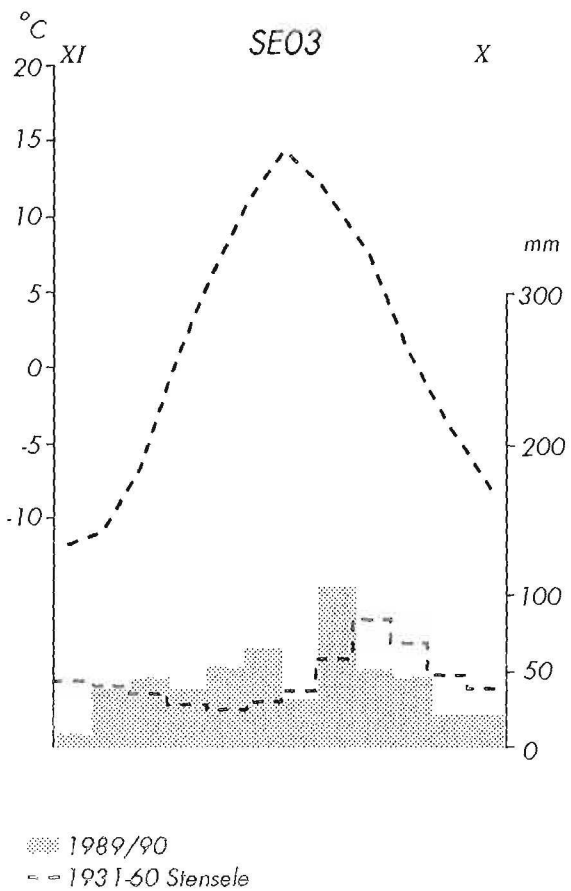


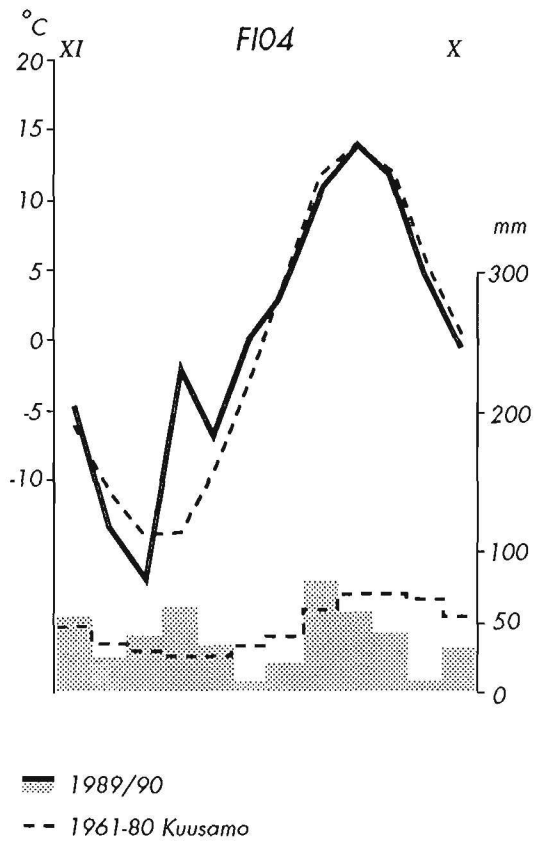


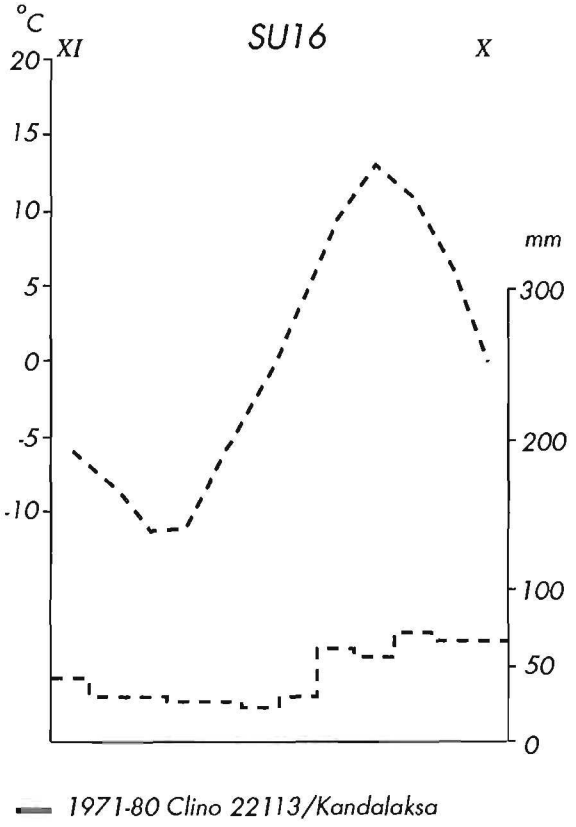
NO02 Kårvatn, runoff

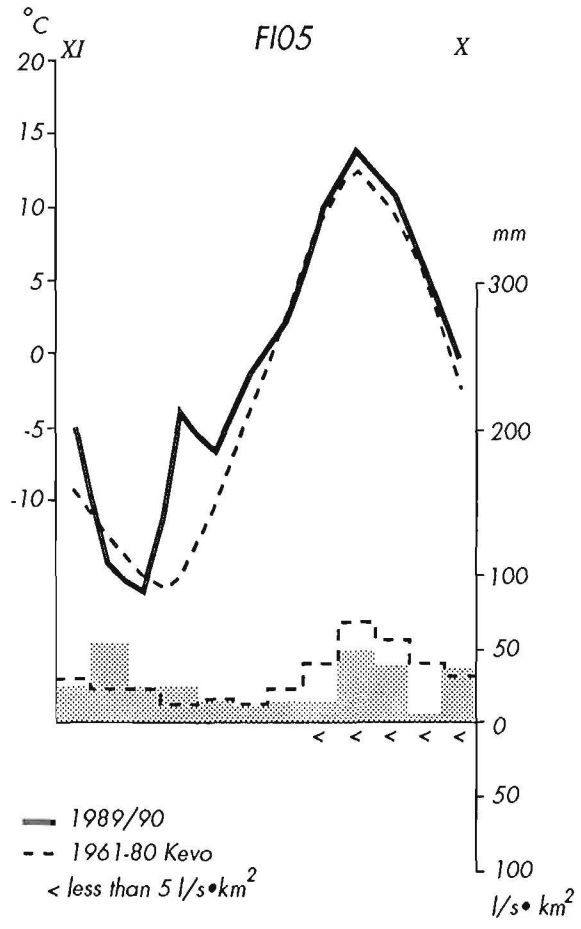






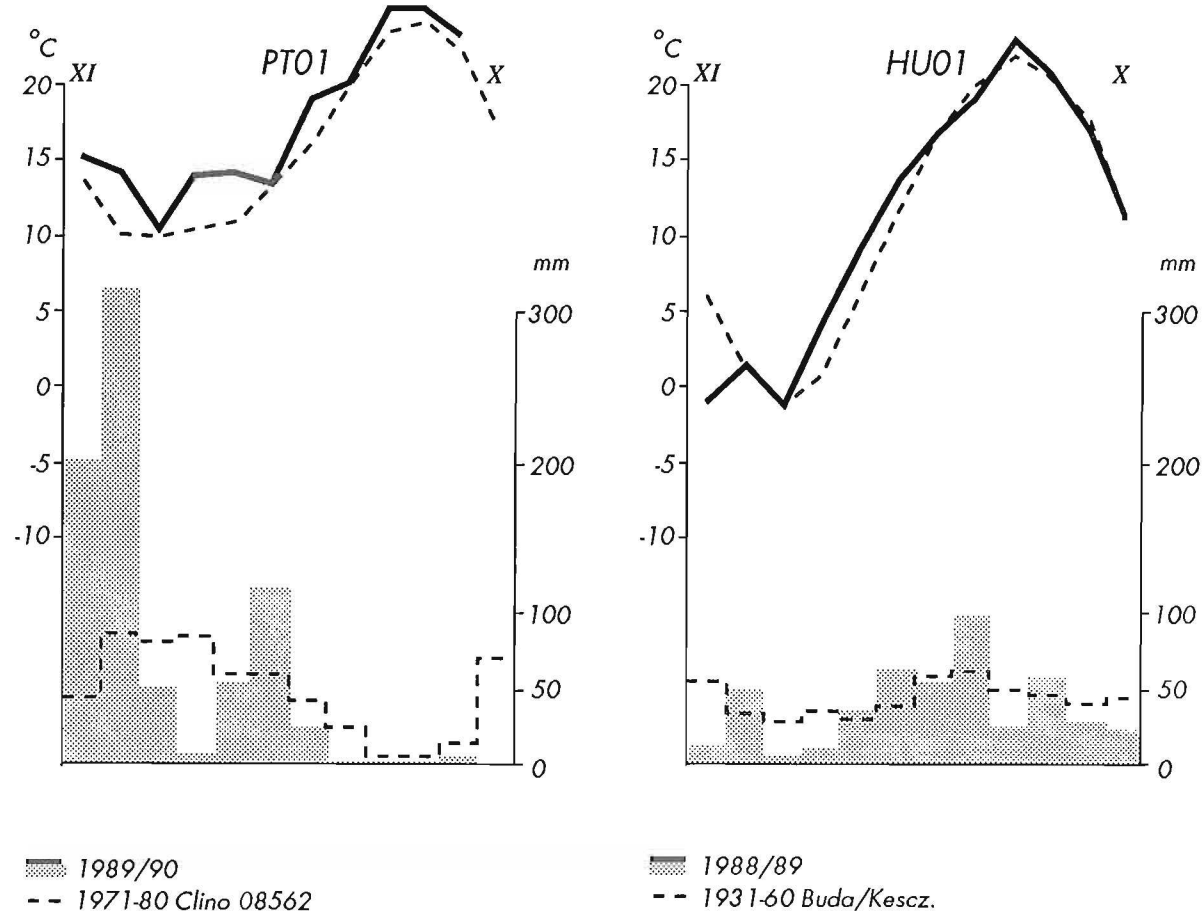




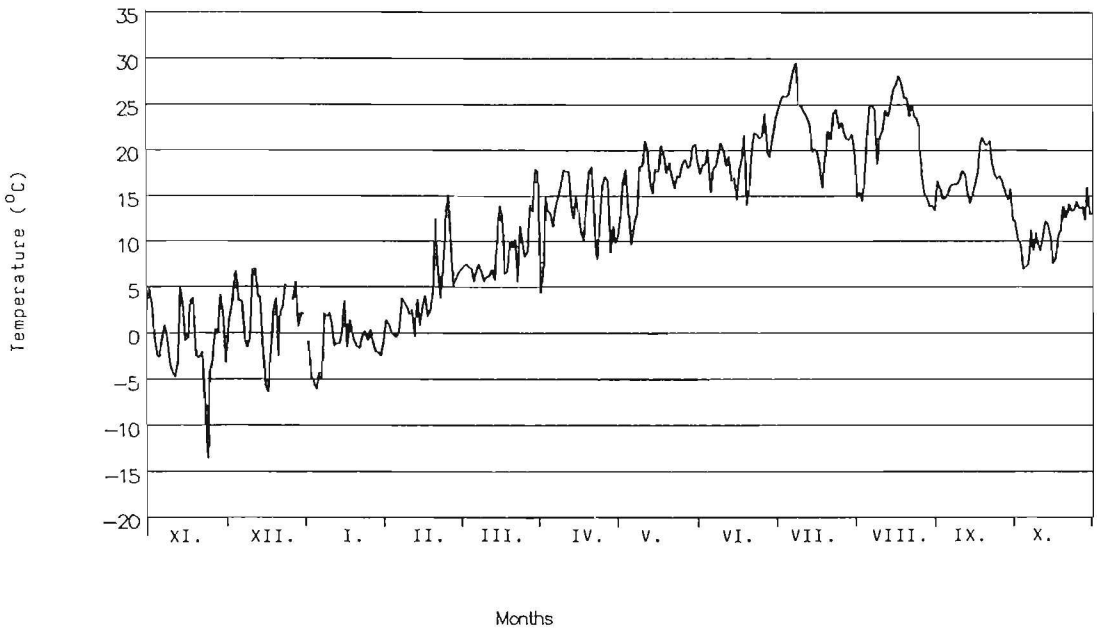


Forest Steppe - Submediterranean Ecotone (PT01,HU01)

Annual mean temperatures in Alentejo (PT01) exceeds +10°C and the vegetation period lasts throughout the year. The area is characterized by winterrains, which were very high in November-December 1989. Contrary, severe drougth lasted for 3 months in June-August 1990. In Komlosi (HU01) both the thermal and rainfall regime resembled that of Central Europe in 1988/89. The daily resolution graphs from Komlosi also show that whereas air temperature fluctuates rather much, soil temperatures (in sand) are quite different. Surface soil temperatures are more constant in winter but show high between-day variation in summer. With depth the thermographs smoothen and frost does not play a role at depths below 50 cm from surface. Temperature regimes significant for different biological activity (leaf development, herbal growth and nutrient uptake by roots) thus vary quite much. Rainfall at Komlosi are scattered between days with distinct shower occasions. Runoff is here subterranean with seepage to groundwater. Despite the occasional showers during the summertime the groundwater level steadily lowered throughout the observation period insinuating that most of the rainwater was consumed by plants or evaporated.



HU01 Komlosi, temperature 1988 XI-1989 X



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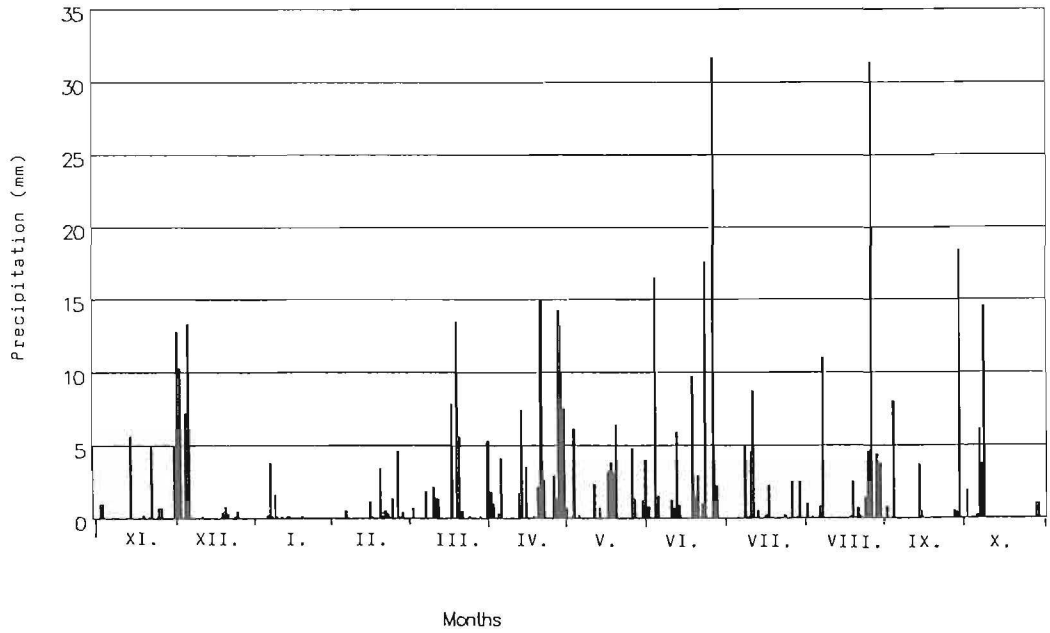
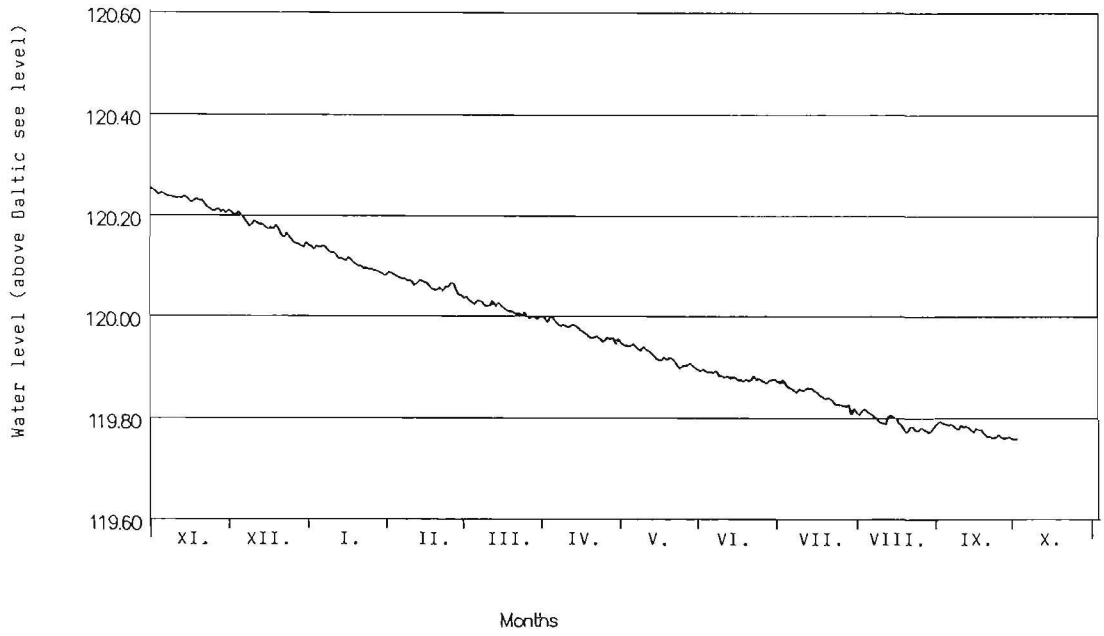
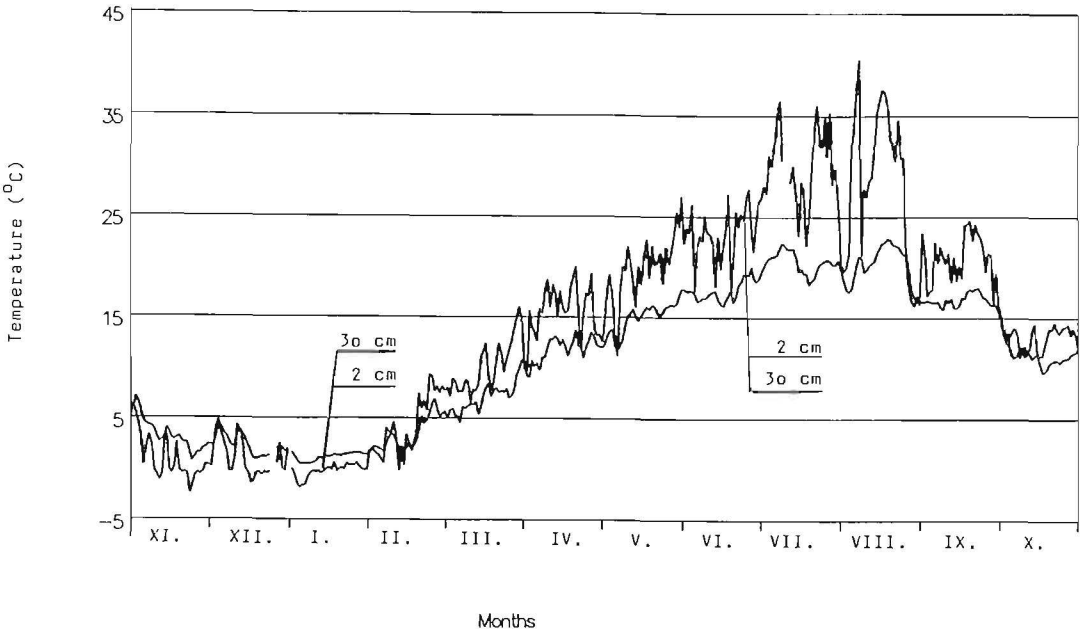


HU01 Komlosi, water level in the central well 1989



HU01 Komlosi, temperature of soil 1988 XI -1989 X



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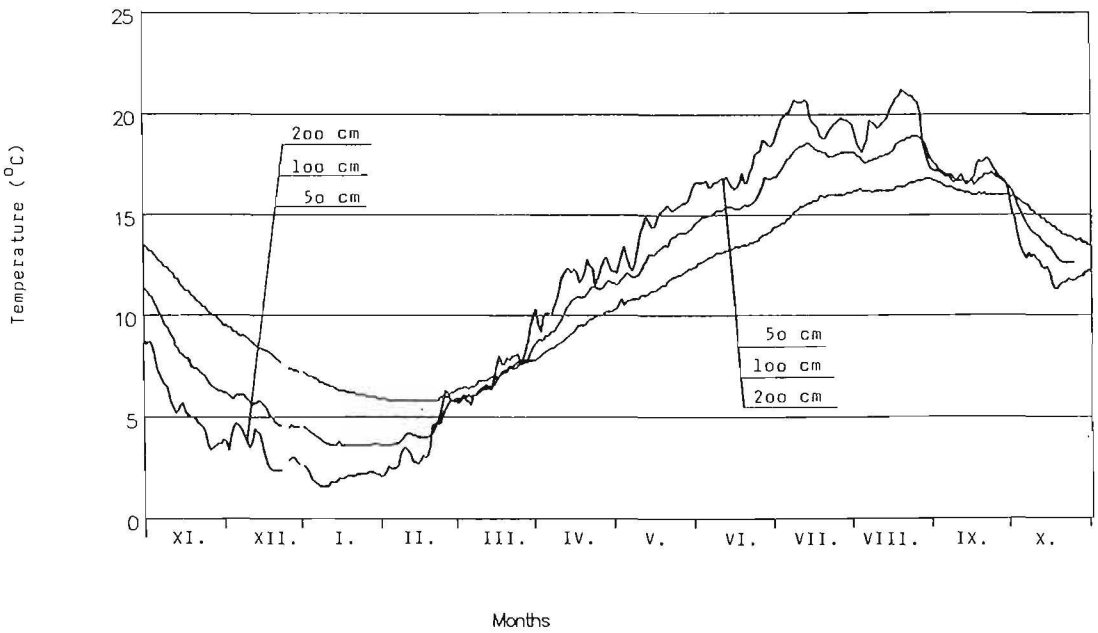
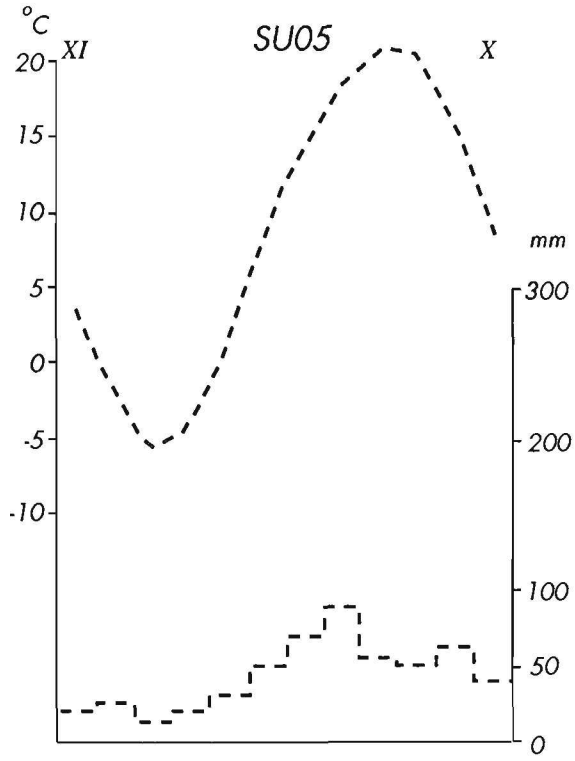


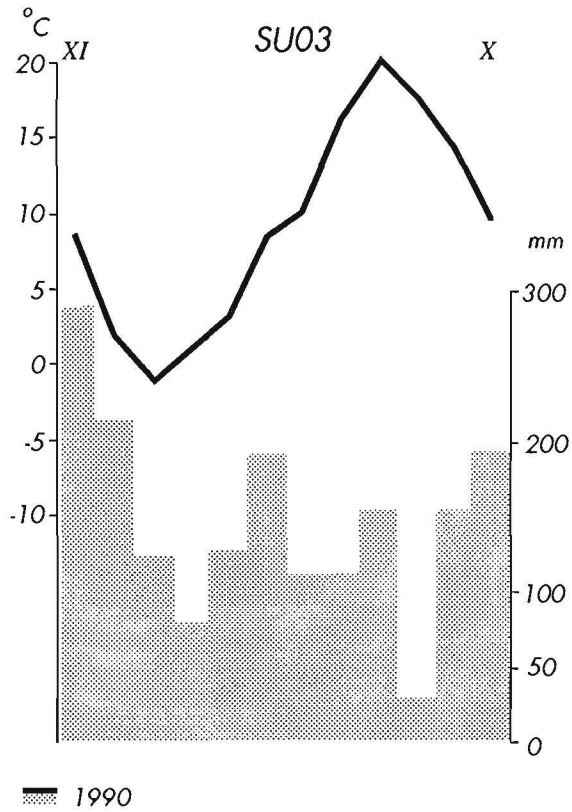
Montaneous East (SU03,SU05)

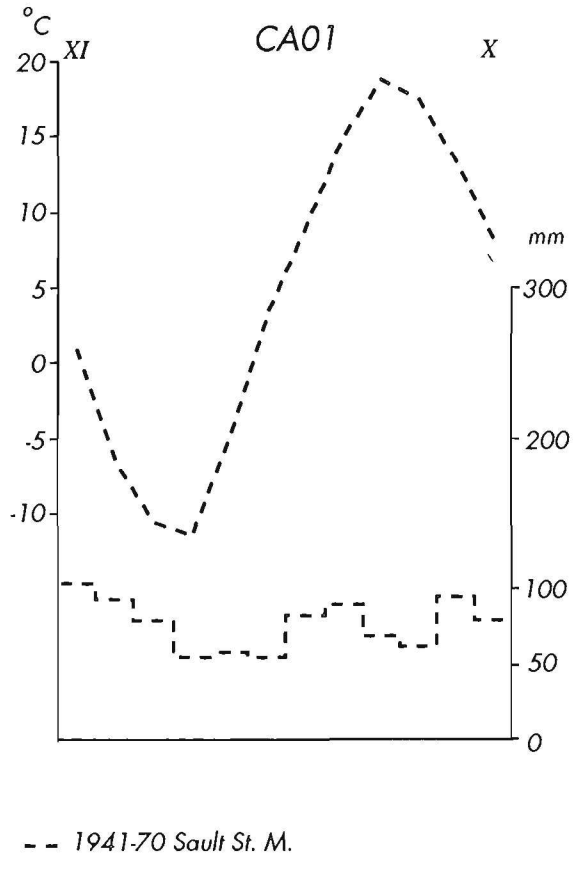
The Caucasian BR (SU03) on the southern slopes of Caucasus experiences a much milder and wetter climate than the Juga Massif (SU05) on the north side. Rainfall in the Caucasian BR is associated with the winter, in Juga with summer.

(Great Lakes - St.Lawrence) Nearctic Nemoral (CA01)

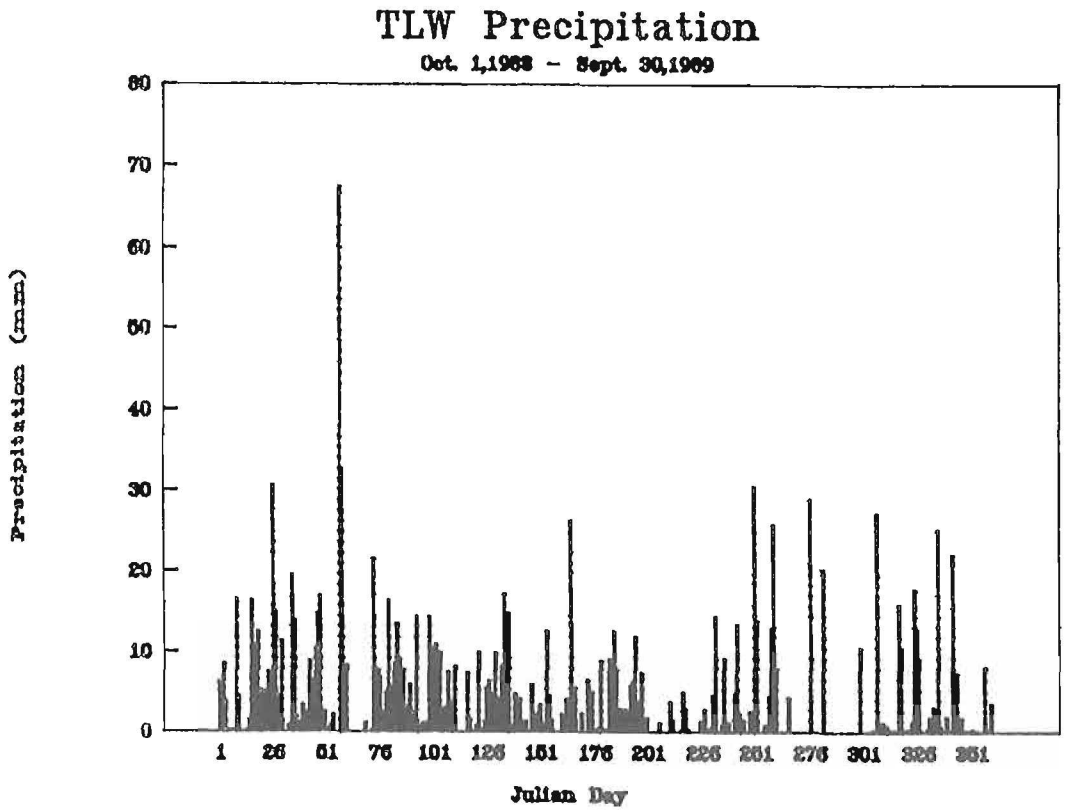
The long-term climatic regime of Turkey Lakes (CA01) resembles thermally the Southern Boreal region but rainfalls are frequently between 50-100 mm/month. The number of rainy days is high as displayed by the pluviograph. Streamflow is bimodal with peaks late in the calendar year (November-December) and during high summer (June-July).



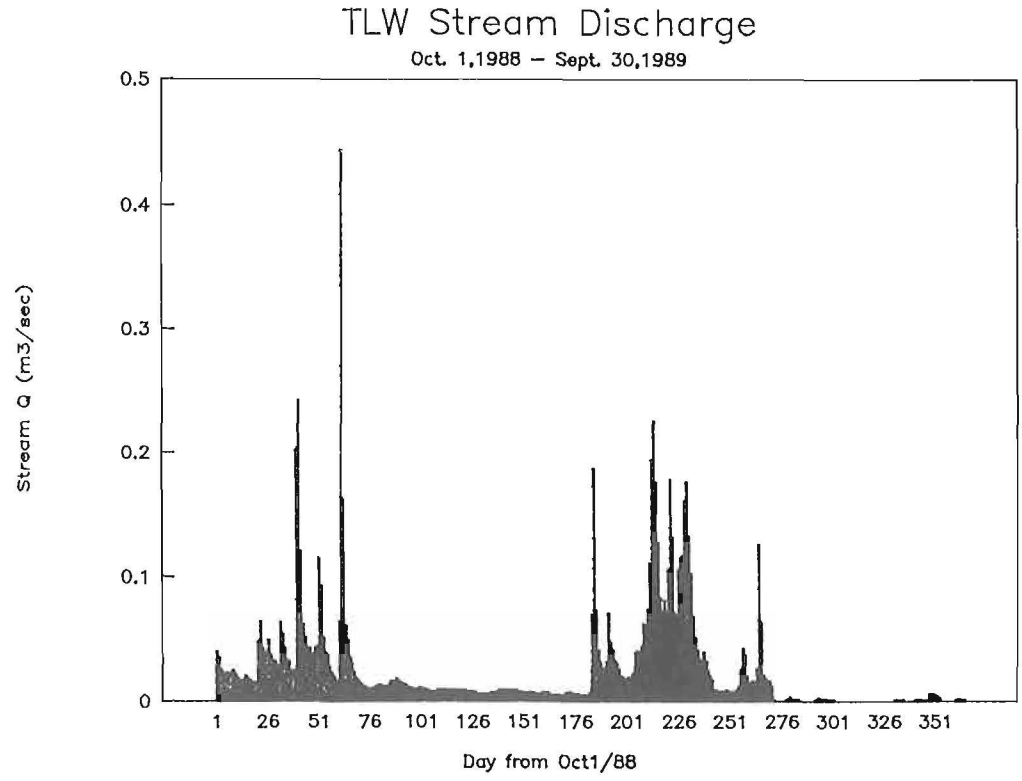




CA01 Turkey Lakes, precipitation



CA01 Turkey Lakes, stream discharge

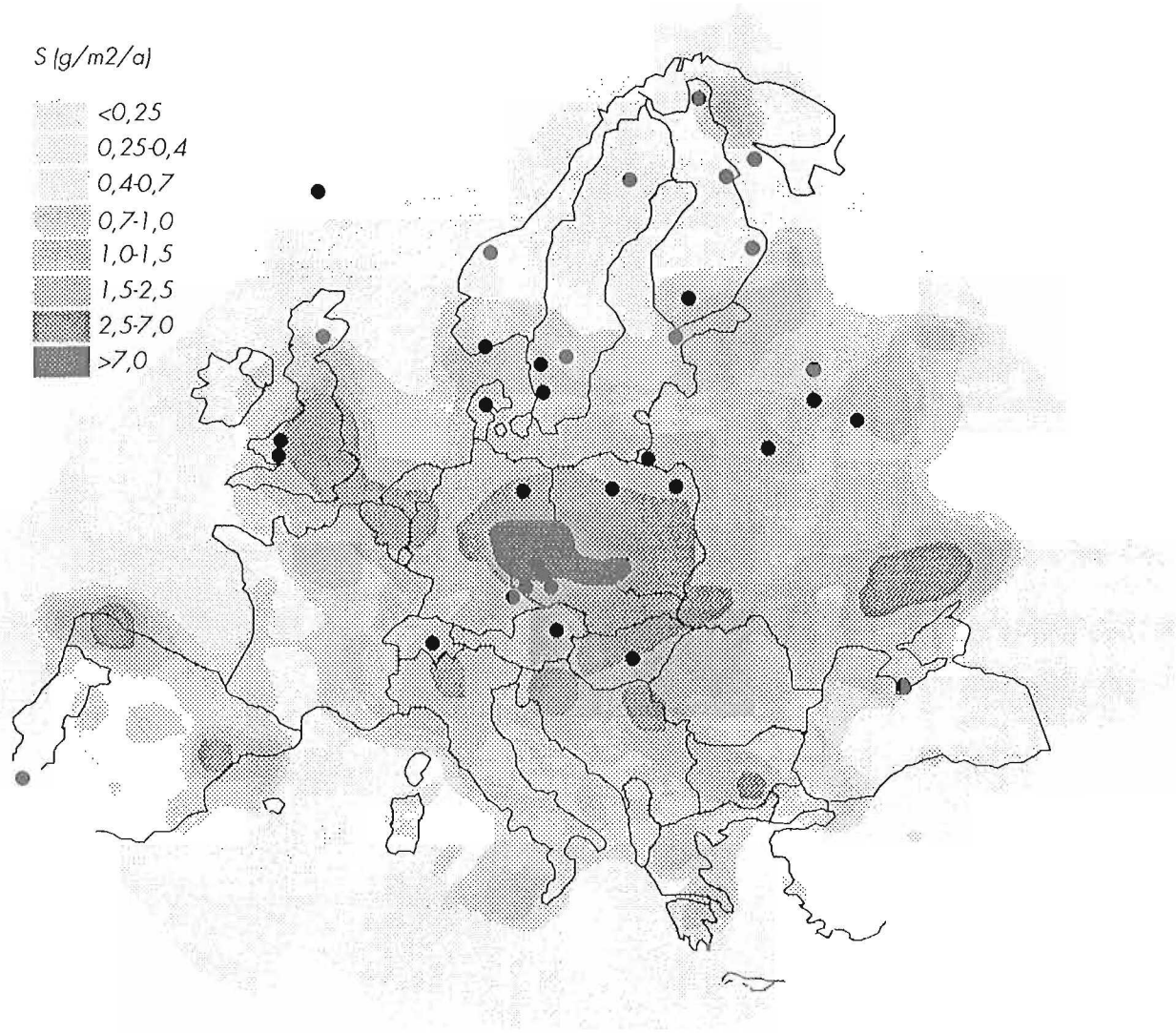


CHAPTER 2

Sulphur

2.1 Fields of deposition

The main source of sulphur is in the anthropogene emissions from burning fossil fuel and from sulphic ore smelters. Close to the sea the natural source is sea-spray which might constitute a considerable part of the deposition along the coasts. Sea-spray sulphur is neutralized and does not take part in the acidification process but passes through the ecosystem. Hence corrections for sea-salts are commonly done in processing budgets for the element. The monitoring network covers rather well different depositional regimes of sulphur. Lack in coverage is specially felt in northern Italy and Spain and north of the Black Sea, where regional high deposition occur.

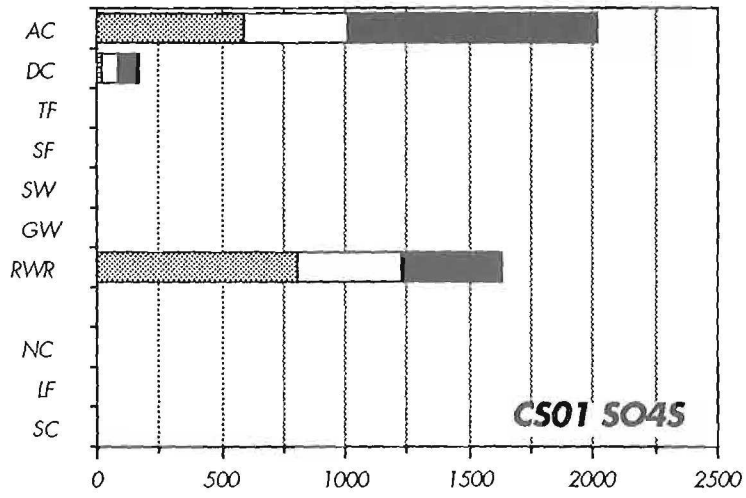


Field of deposition of S (g/m²/a) in 1988 acc to EMEP (CCC 4190).

2.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,SU11,GB01,GB02)

The central nemoral areas are subject to high deposition of sulphur. Levels in precipitation range from 100 to more than 250 µeqv/l/month. Ambient air concentrations are also high as displayed by the Anenske (CS01) area. AC is sum of SO_2S (g) and SO_4S (part.). Atlantic rains bring sea-salts rich in sulphur to the coastal areas. Sulphur levels in the runoff of the Czech areas are much higher than in rainfall, ranging from 500 to more than 1500 µeqv/l/month. Runoff concentrations vary much more than concentrations in wet deposition. The highest levels are normally reached during summer when flow is at smallest and evaporation increases concentrations of streamwater.



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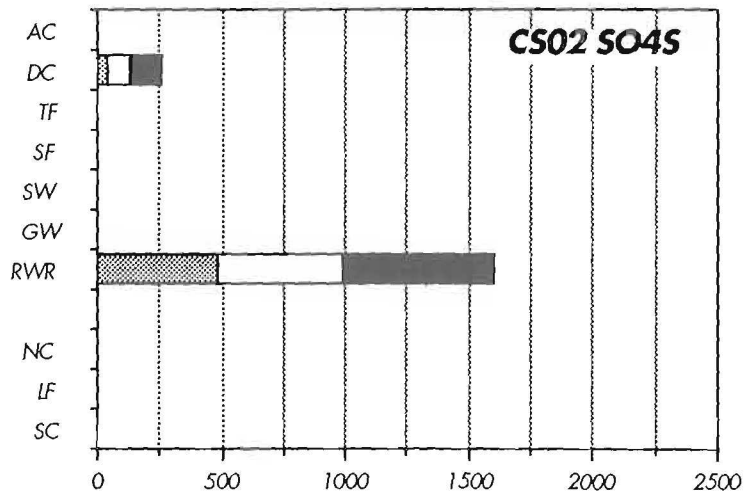

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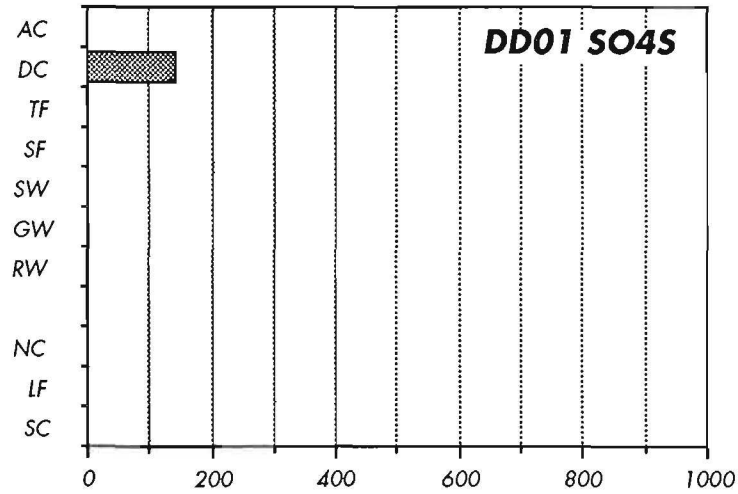

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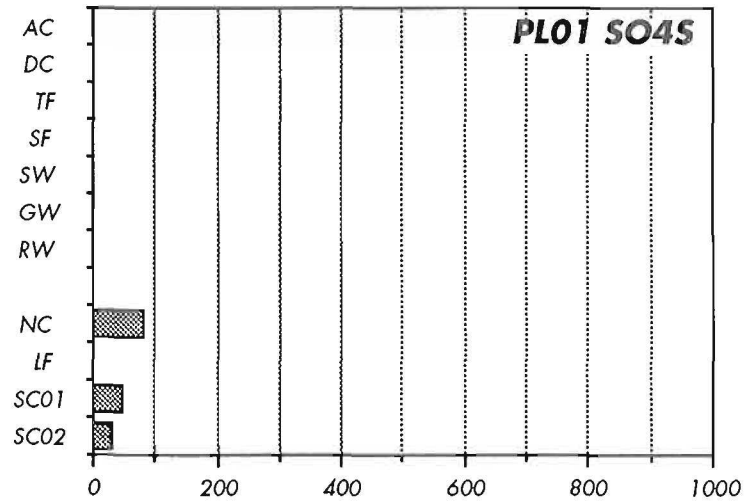

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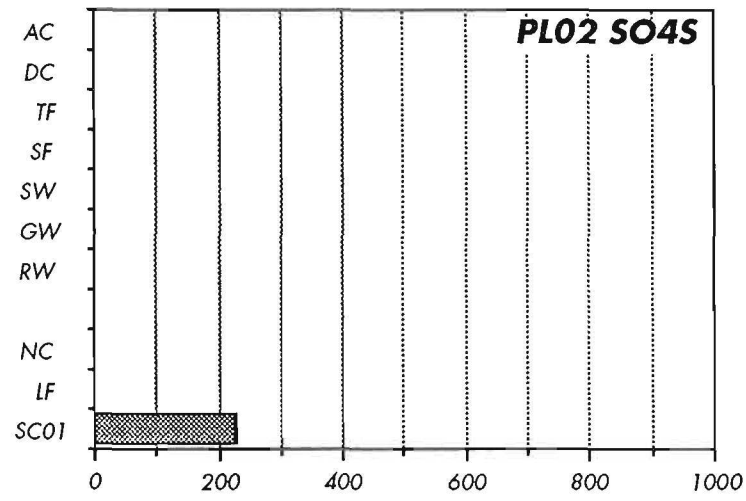

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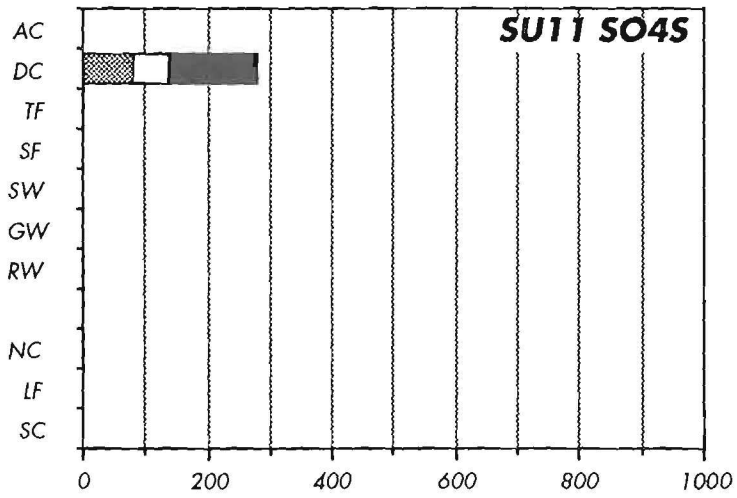

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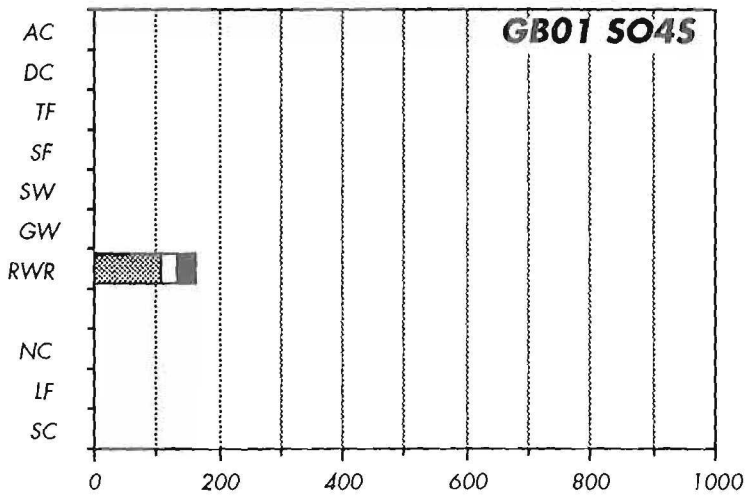

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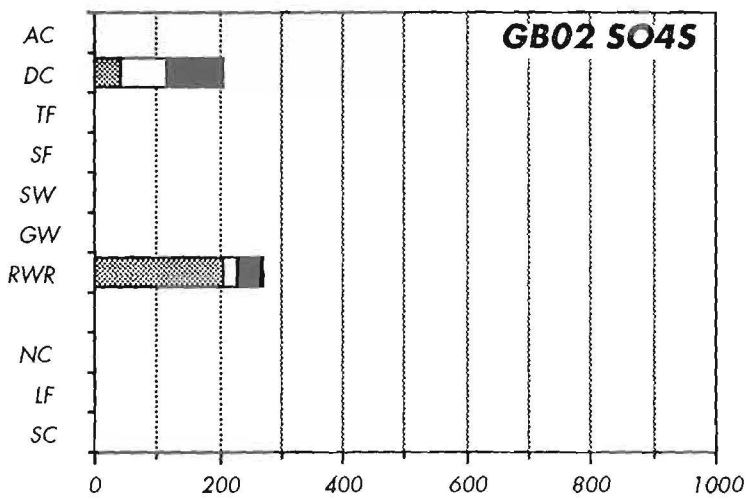

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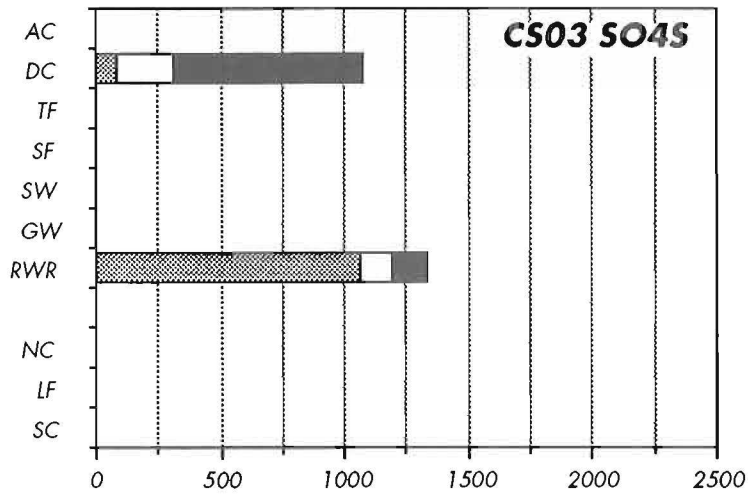
Montaneous Central (CS03,CS04,DE01,CH01)

Sulphur concentrations in rainfall in the mountains are lower than in areas north of them. The highest levels are found in Erzgebirge, at Jezeri (CS03), where the intra-annual variation is at largest. Levels on the Czech side of the Bavarian mountains are higher than on the German side. Data from Forellenbach (DE01) indicate that levels are higher in throughfall, soilwater and groundwater than in precipitation. Sulphur concentrations increase thus by an enrichment factor of 2 on passage through canopy and by 2.5 after passage through soil to groundwater. Mean annual concentrations in runoff water of Liz Sumava (CS04) and Erlentobel (CH01) are quite the same, but the intra-annual variation in the Swiss Alps are very high; once again probably due to alternations of high and low flow.



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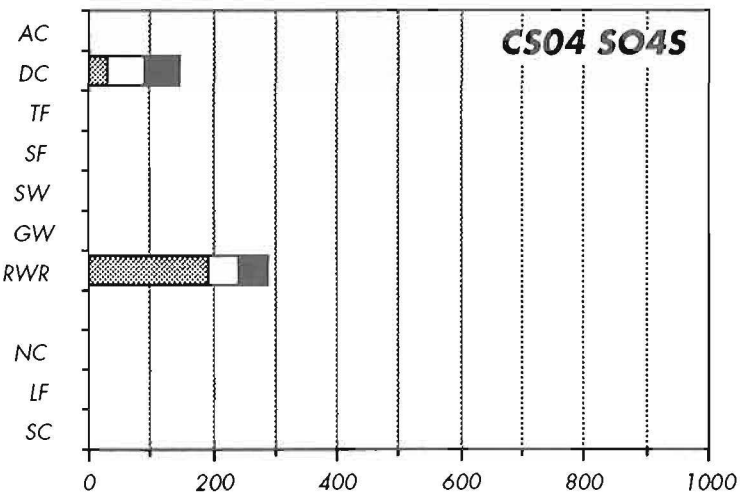

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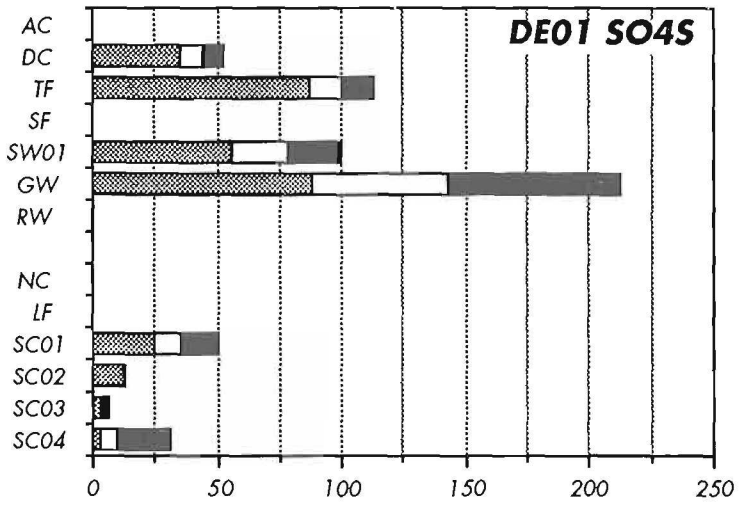

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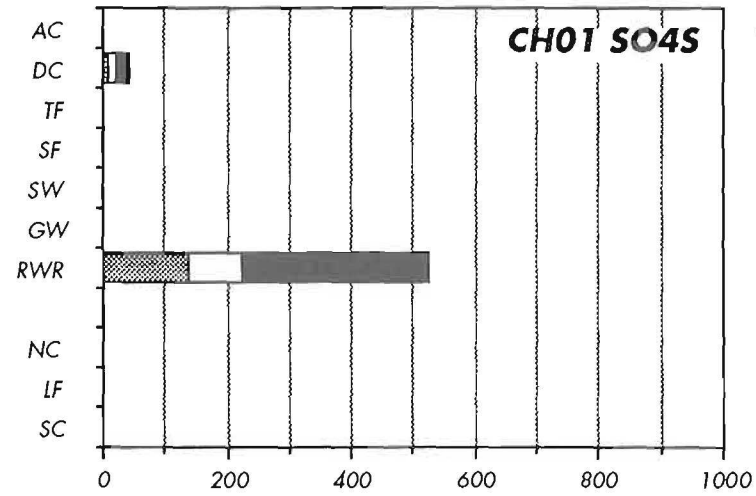

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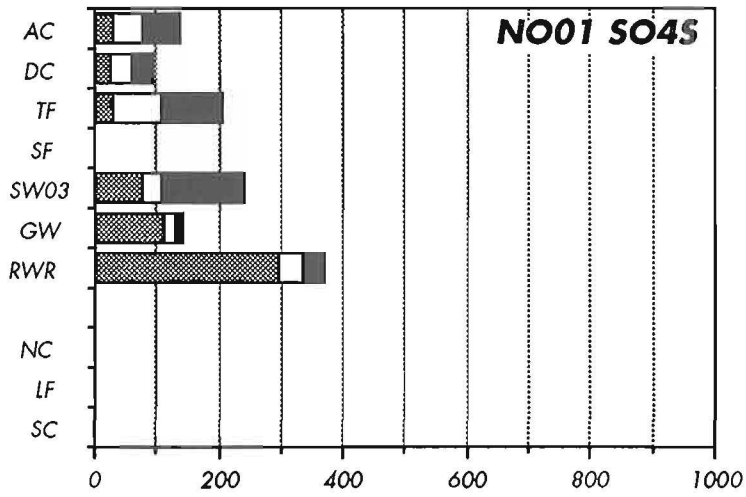
Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

Mean annual monthly levels in rainfall are very alike, ca 60 µeqv/l/month, except for Valday (SU15) where values are twice as high. The monthly variation is largest in Gårdsjön (SE04) implying much transboundary fluxes from Central Europe. Levels rise in throughfall by an enrichment factor of 2 in Birkenes (NO01) but with as much as 3.5 in Gårdsjön and Valday. In Birkenes levels increase on passage through soil to groundwater and runoff water, in which the enrichment factor is already 5 (> 400 µeqv/l/month). In Gårdsjön the levels are high in the topsoil, and in mineral soil they grow with depth but somewhat decrease in groundwater and runoff water. In Berg (SE02) groundwater levels are also lower than mineral soil water levels but increse much in the runoff, occasionally by an enrichment factor of 10 in comparison to rainfall during spring snowmelt. In Valday concentrations of the groundwater is at highest (max > 1200 µeqv/l/month).



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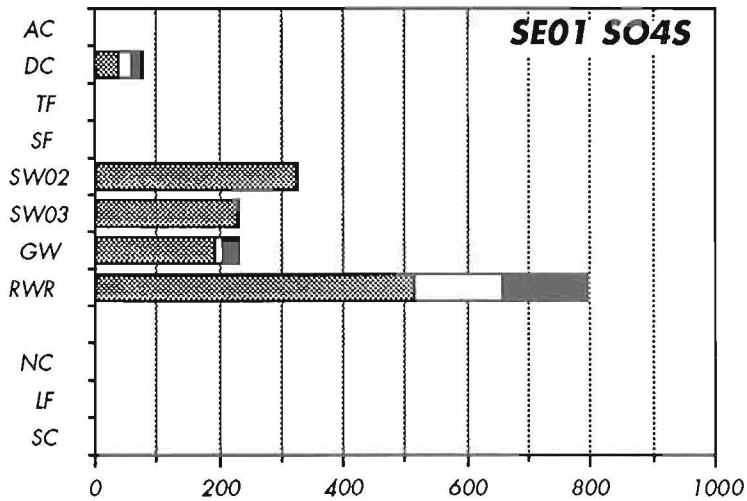

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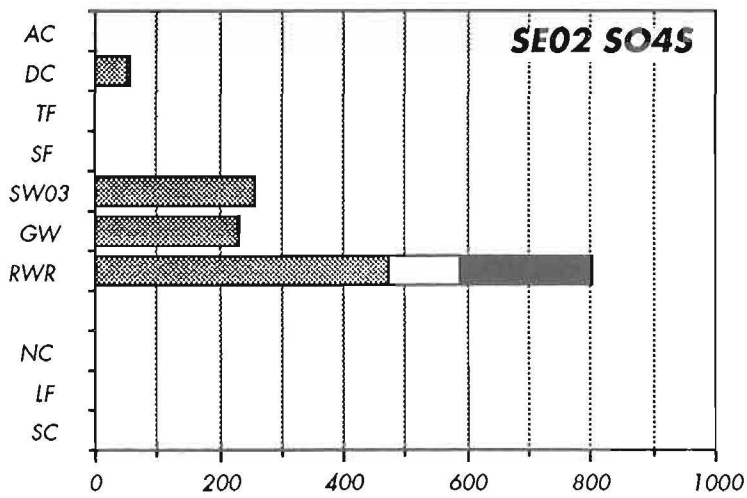

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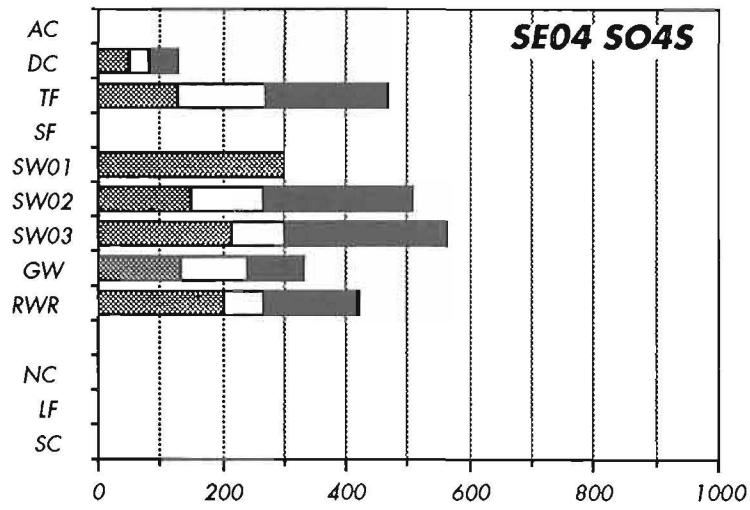

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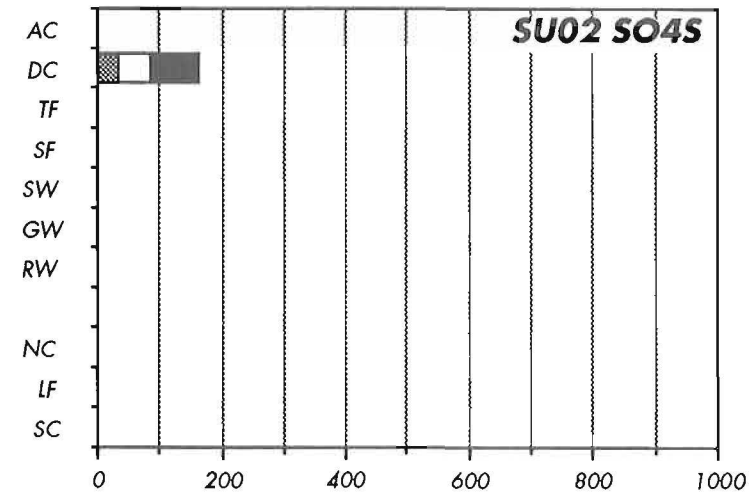

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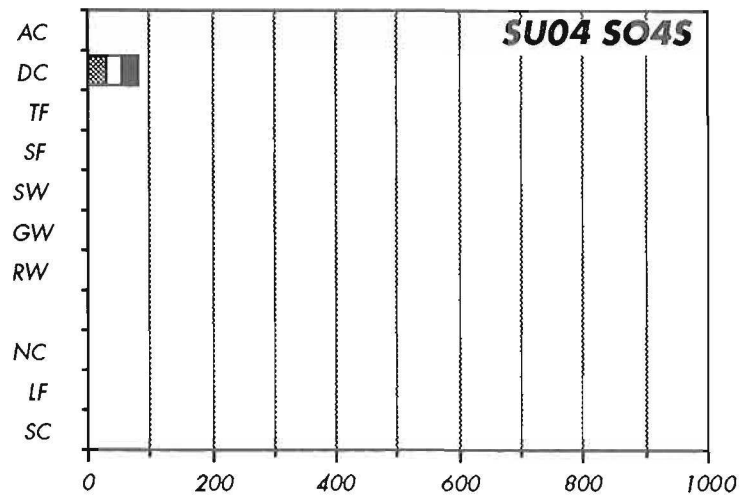

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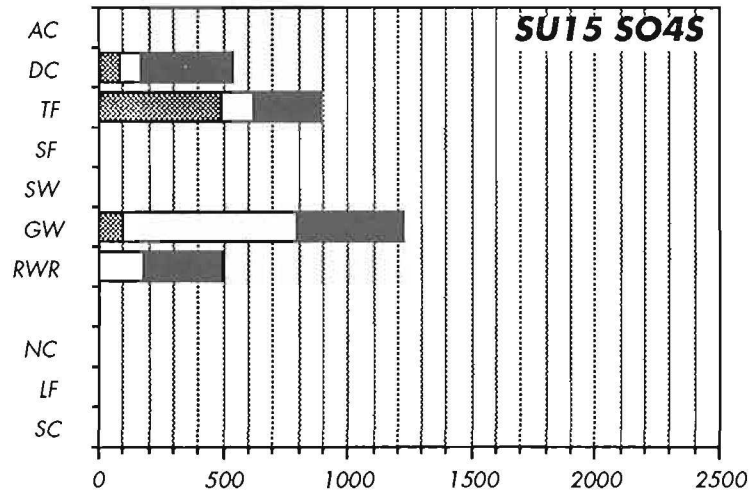

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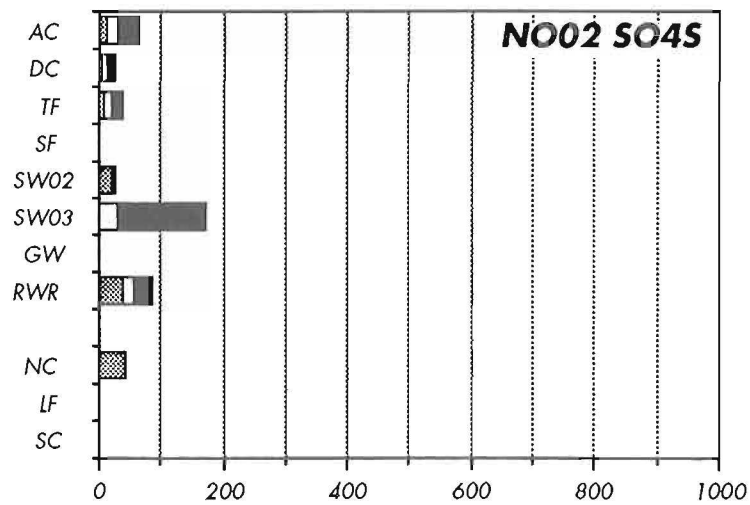
Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

In the southern parts the precipitation levels are low and in the middle and northern parts they are even lower but with higher maxima. Throughfall concentrates by an enrichment factor of 1.5...2. Measurements of stemflow during summer months indicate high enrichment factors; in the southern parts by 10 (> 400µeqv/l/month) in the northernmost, eg. in Vuoskojärvi (FI05) by 100. The higher levels are caused by evaporation of water and inclusion of dry deposited particles concentrating the remaining canopy throughfall and downflow along stems. For epicortical organisms, in particular lichens, the consequent stemflow of summerrains poses a considerable acidic shock which might disturb their uptake of nutrients from humid air and hence become deformed and loose vitality. Contrary to conditions in formerly mentioned ecoregions, the sulphur levels decrease with the passage through soil and only slightly increase with depth in lakes and runoff water. Even in Kårvatn (NO02) throughfall levels exceed precipitation levels which are similar to topsoil water levels. With increasing depth in soil through the passage to groundwater and runoff water the levels are again rising.



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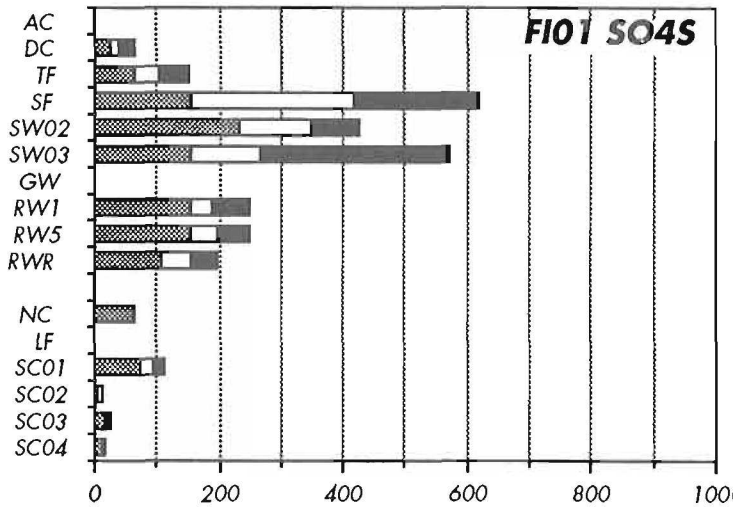

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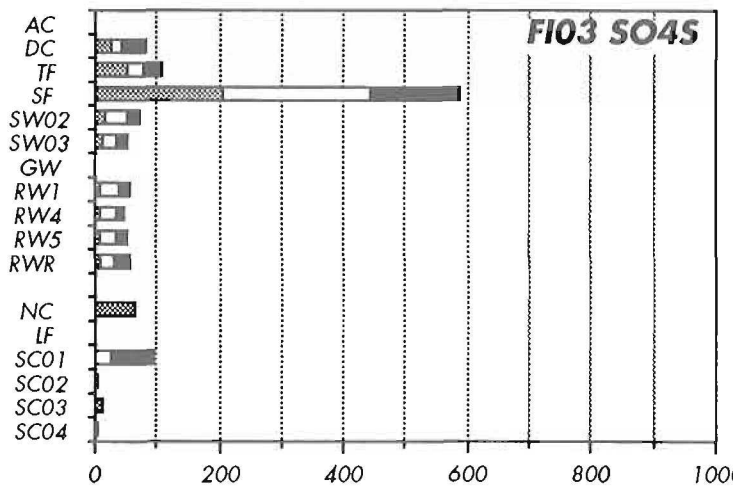

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RW4	02 06 8912 9006
RW5	02 06 8912 9006
RWR	02 08 8911 9006
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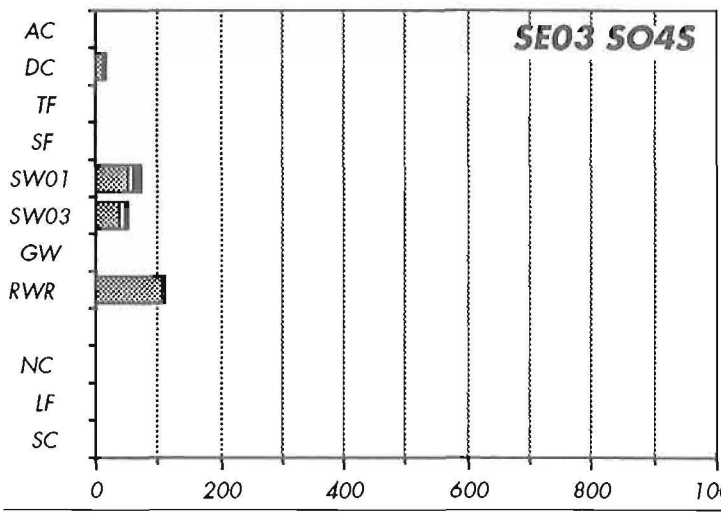

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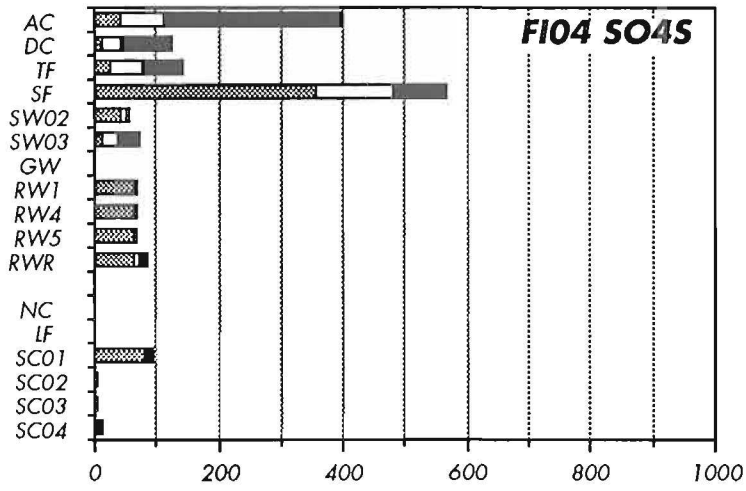

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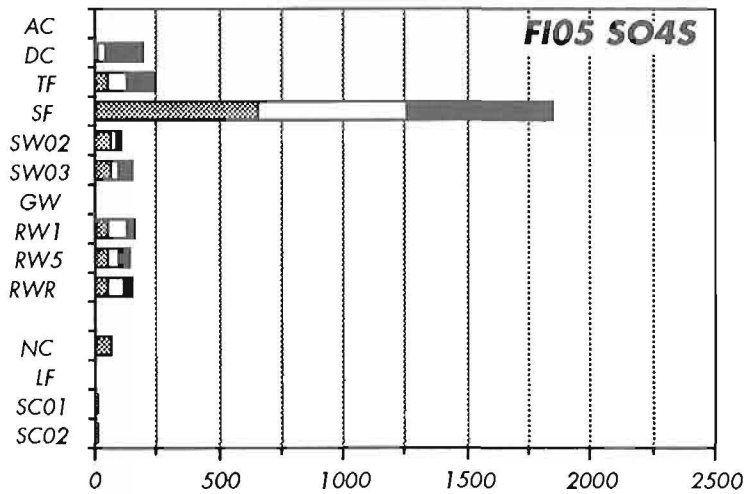

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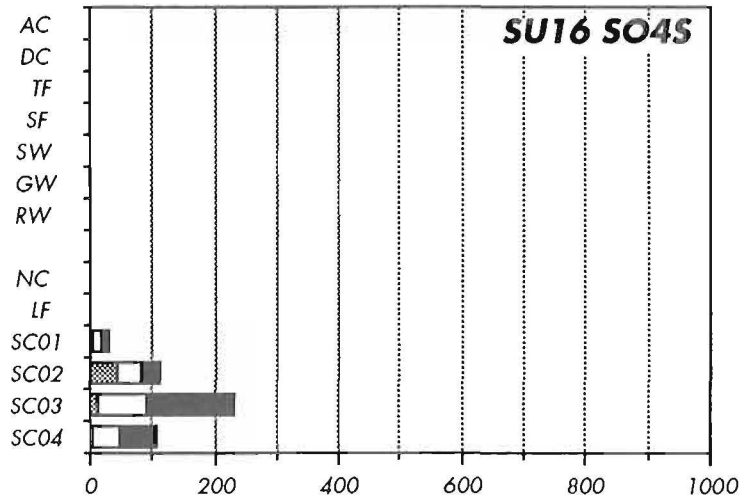

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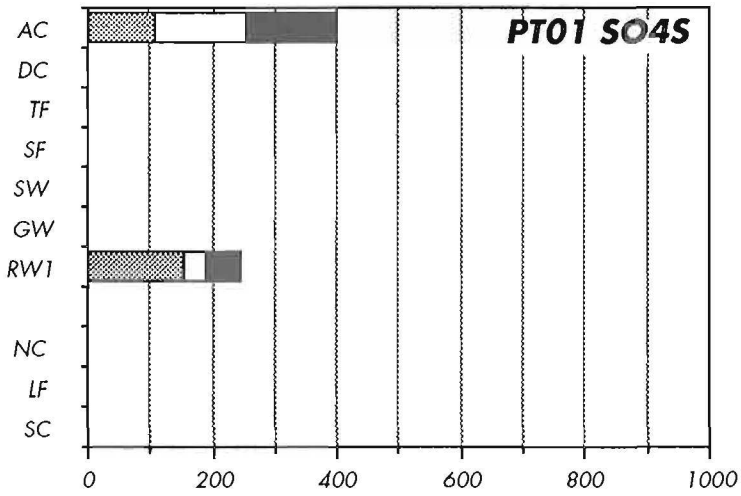
SC03	03 01 8908 8908
SC04	03 01 8908 8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

In Alentejo (PT01) the sulphur levels of the lake surface water are lower than in Central Europe and of the magnitude to be found in southern Finland. In Komlosi (HU01), with high annual evaporation, the enrichment factors of throughfall and stemflow are very considerable (100 to 700). Stemflow of pines shows concentrations between 2000 and 7000 µeqv/l/month which exceeds any living conditions for epiphytic organisms.



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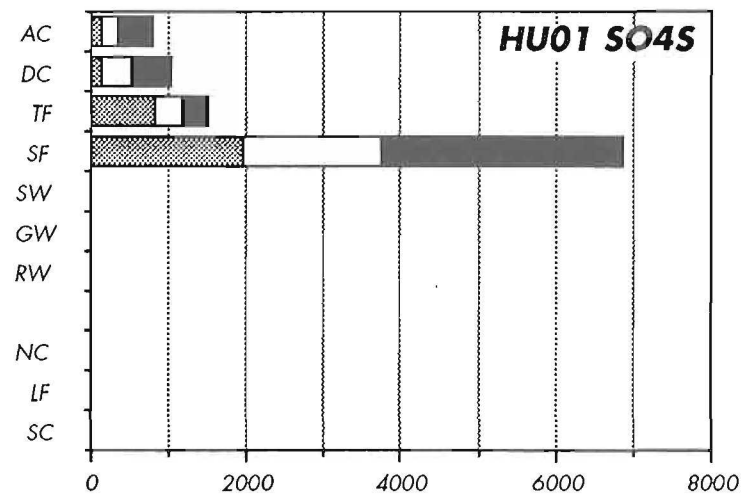

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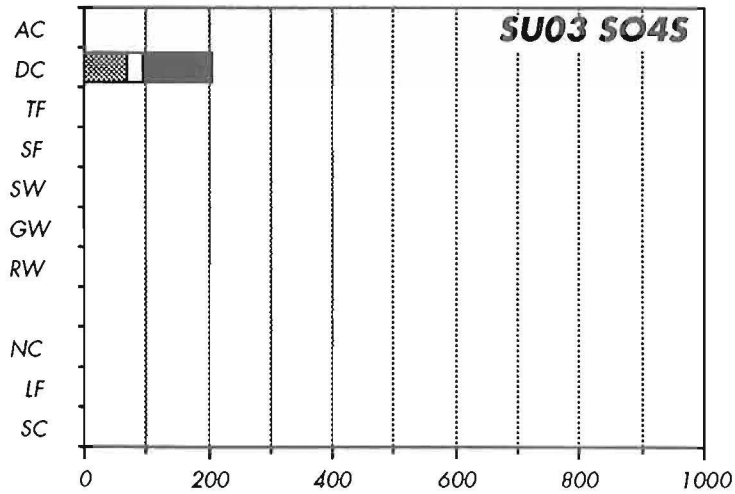
LF	0 0
SC	0 0

Montaneous East (SU03,SU05)

Precipitation values range between 20 ... 200μeqv/l/month. In Juga Massif (SU05) the throughfall enrichment factor is ca 2. Runoff water concentrations are slightly higher than those of precipitation and groundwater concentrations are rather low.

Nearctic Nemoral (CA01)

Sulphur levels of precipitation and runoff resemble highly those in the Southern Boreal region in Europe.



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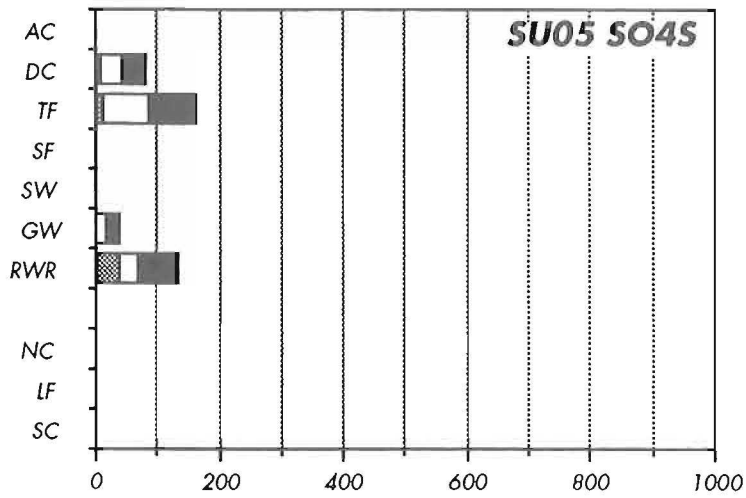

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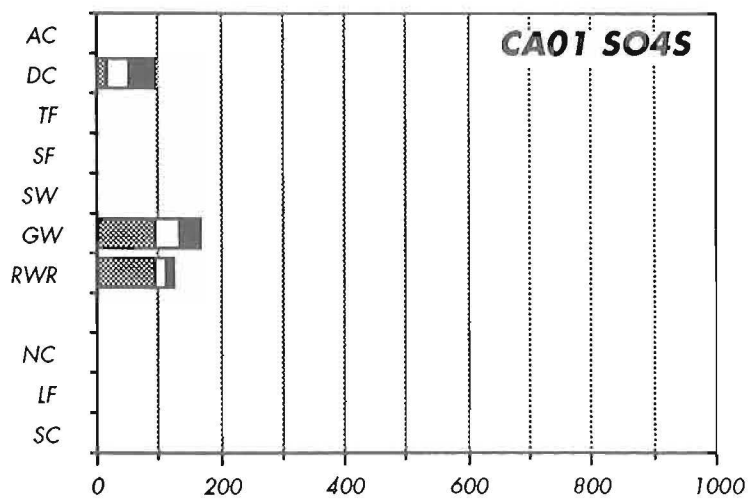

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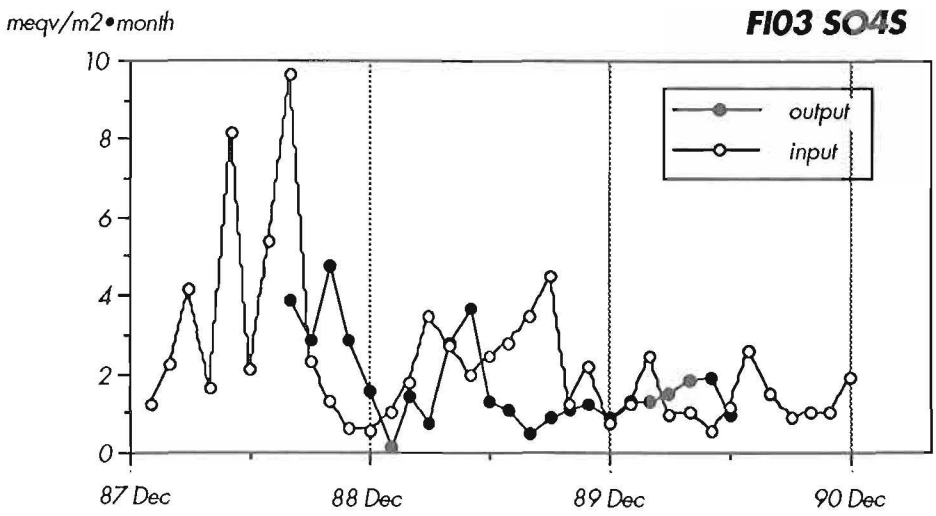
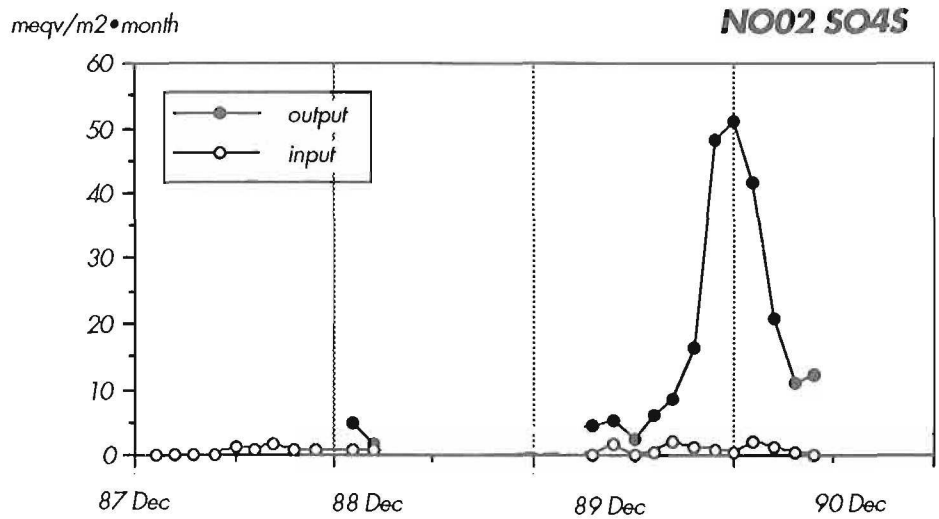
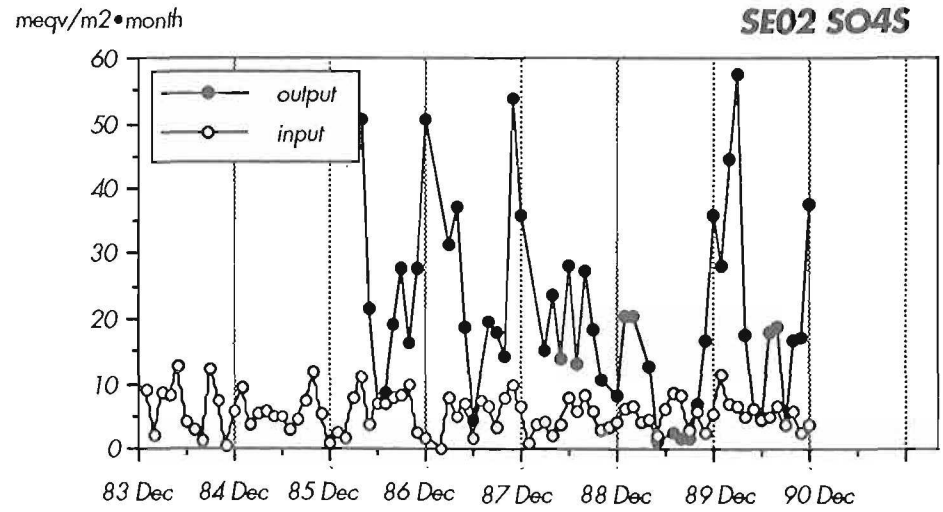
2.3 Long-term temporal variation

In this section, time series of monthly fluxes of sulphate sulphur expressed as meqv/(m^2•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02). N.B. Not corrected for sea-salts.

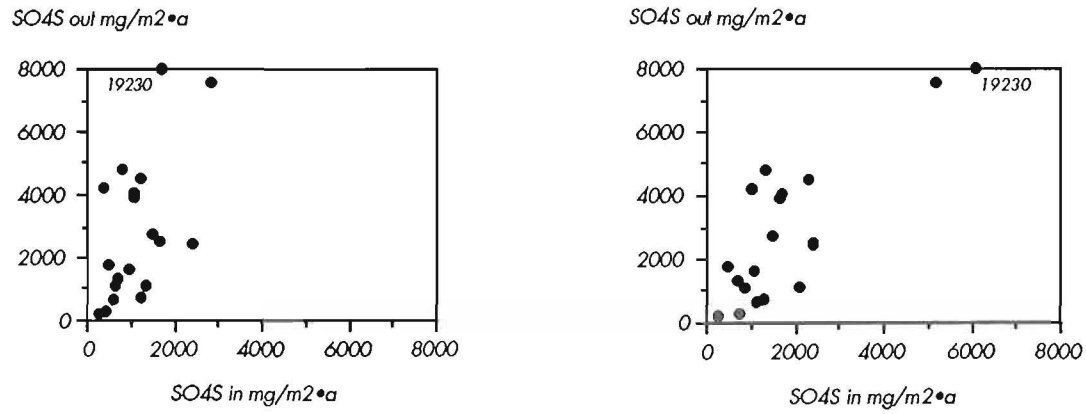




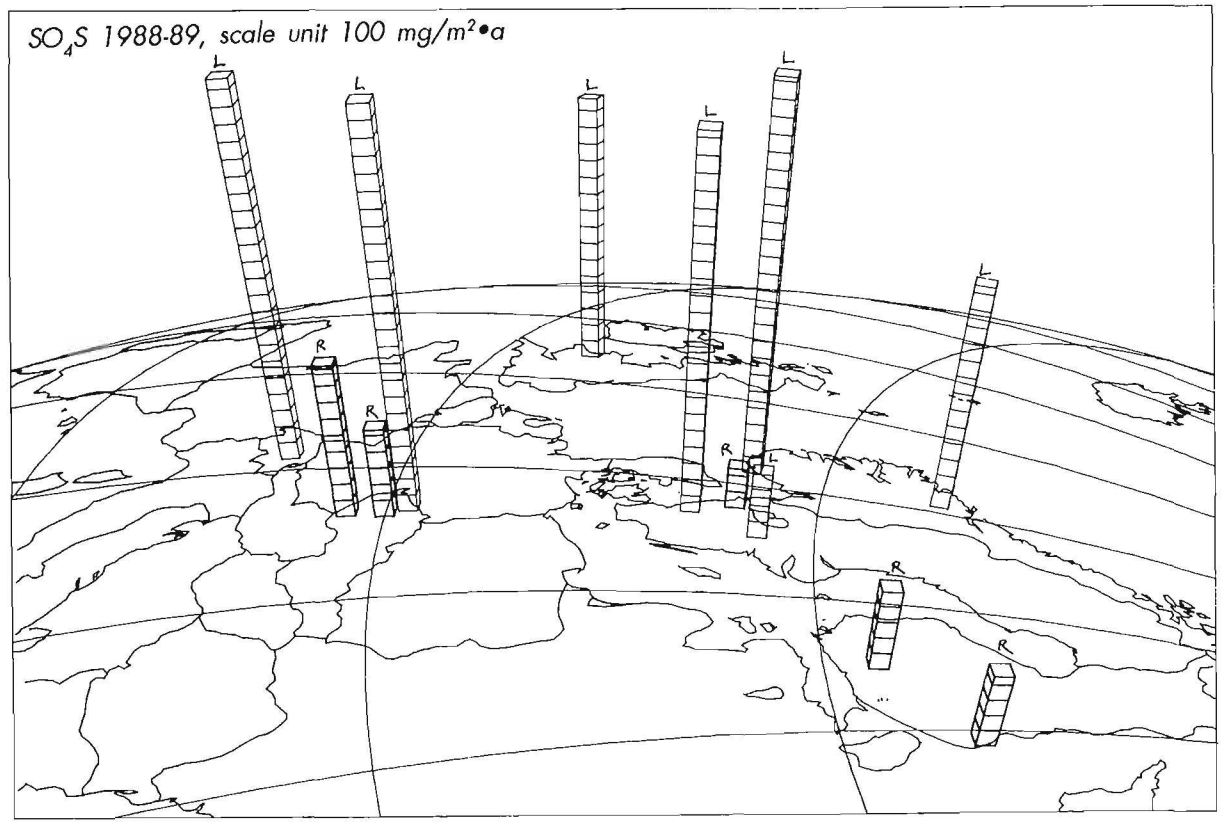


2.4 Mass balances

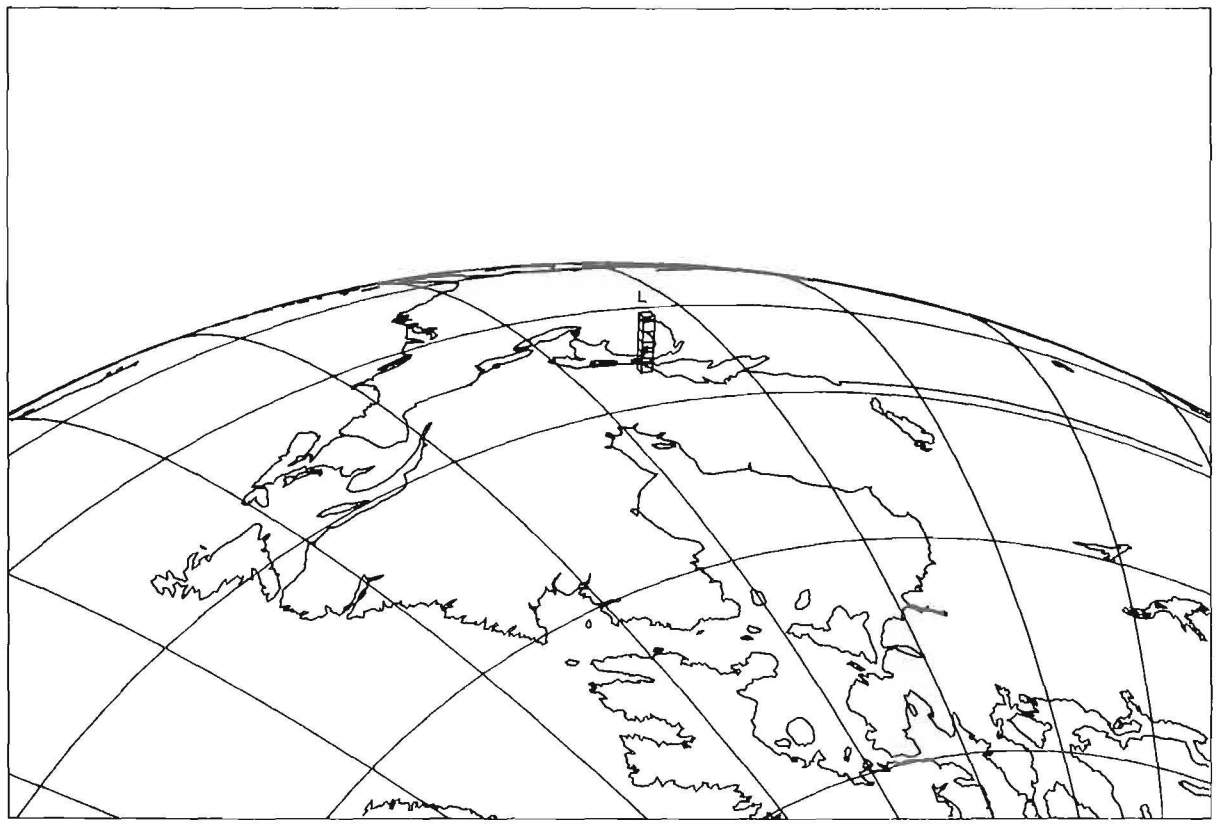
Mass balance calculations for the periods 1988/89 and 1989/90 show that anthropogenic sulphur accumulates in the eastern part of Europe but is predominantly leached in the Hemiboreal and Nemoral Regions. According to earlier investigations (Hauhs et al., 1989) retention has been correlated with younger glacial soils and leaching with genetically older soiltypes outside the range of glacial transformation. The presented picture does not fully agree with this statement. Notable is that in those areas where leaching occur, the concentration levels grow with passage to groundwater and runoff, whereas in accumulating areas in the Boreal Region levels drop in soil due to neutralization by humic topsoil. As seen from table 1 the C/S ratio of the topsoil is very high in the northernmost areas, between 200 ... 400, and extreme in Velikiy (SU16), > 2500.



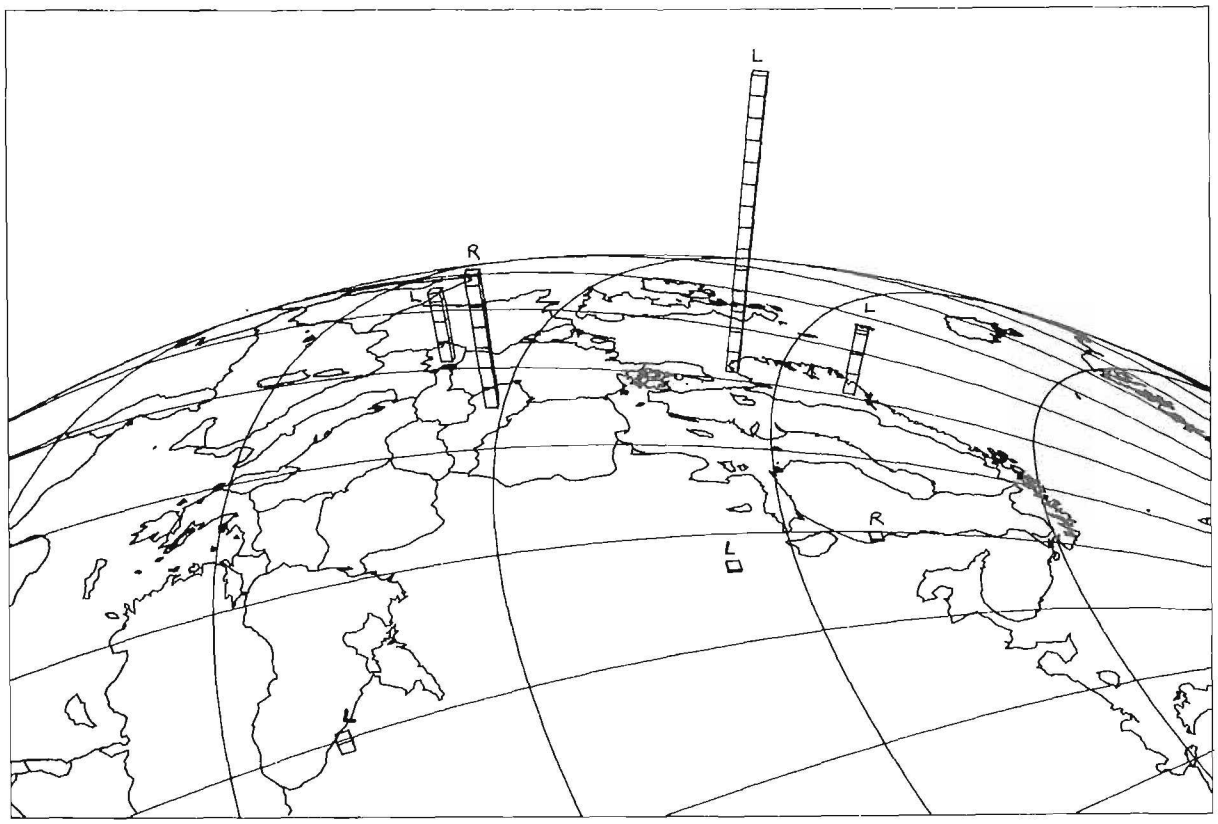
In the figure on the left, the output of sulphate sulphur is plotted versus the bulk/wet input, expressed as mg/(m²•a). There is a substantially higher output than input, which can be attributed to dry deposition, if internal processes involving sulphate and resulting in net leaching are considered negligible. In the figure on the right the dry deposition is estimated by the chloride correction method. Some of the difference is eliminated, but it is still obvious that the dry deposition originating from e.g. SO_2 is not well covered by the chloride correction method. The outflux from the Birkenes area (NO01) in 1989-90 was over two times higher that of any other area for the years of which data for sulphate I/O calculations are available in the IM data base.



Canada SO_4S 1988-89, scale unit 100 mg/m²•a



SO_4S 1989-90, scale unit 1000 mg/m²•a

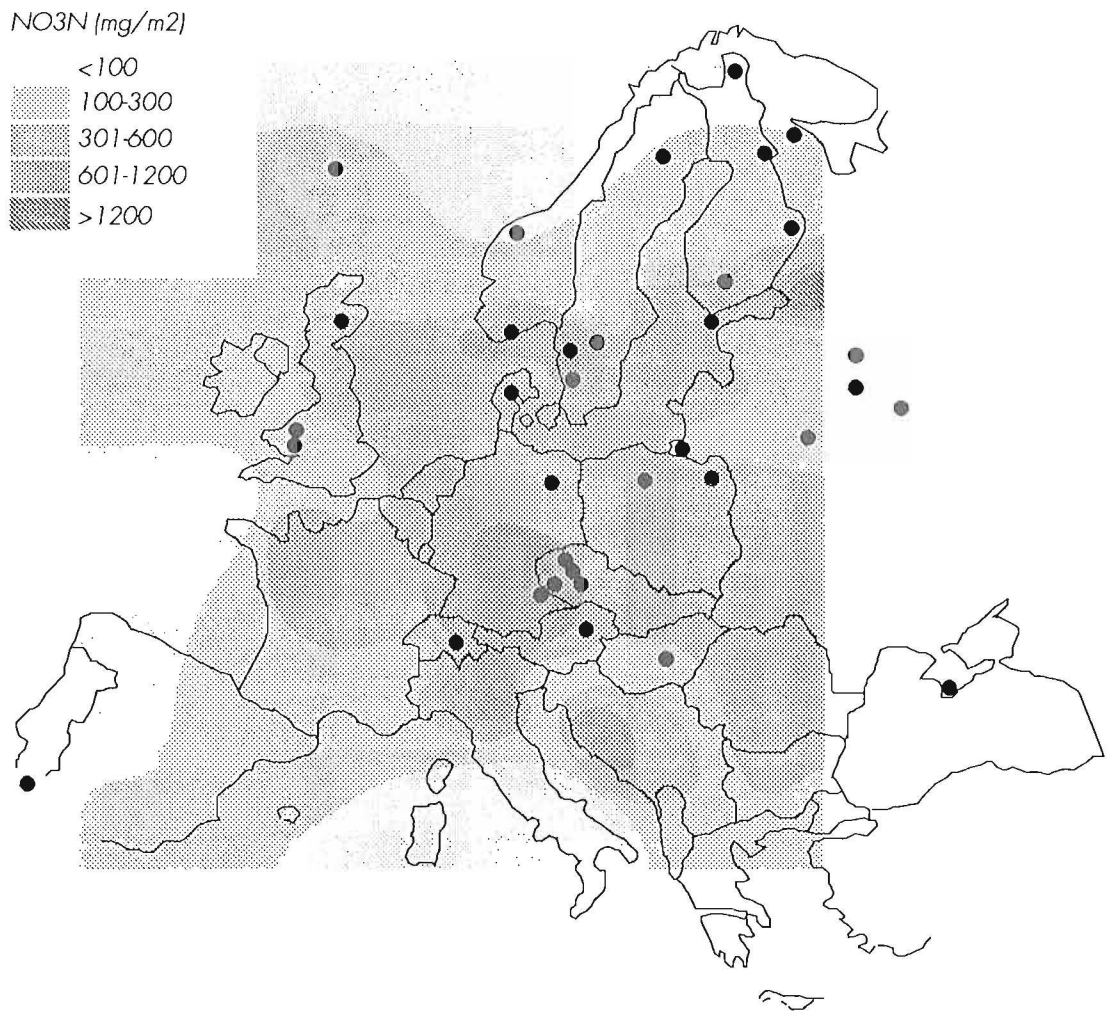


CHAPTER 3
Nitrogen oxides

3.1 Fields of deposition

The main anthropogenic source is the combustion of fossil fuels in traffic and in energy plants. Thunder flashes and NOx by plant respiration are natural sources, but not in the order of emissions from combustion in highly populated areas.

The monitoring network covers quite nicely the different depositional regimes, with perhaps the exception of northern Italy.

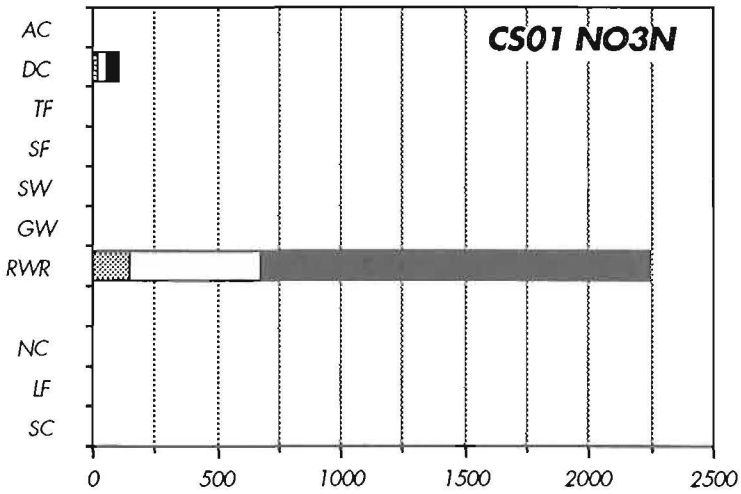


Field of deposition of NO_3N (mg/m²) in 1988 acc to EMEP (CCC 4190).

3.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,SU11,GB01,GB02)

Wet deposition values range between 50 - 75 µeqv/l/month in all areas. Runoff concentrations in Anenske (CS01) are very high, above 600 µeqv/l/month and temporally even 2500 µeqv/l/month. In comparison, at Mlynaruv (CS02) runoff levels are between 10 - 130 µeqv/l/month. In areas of United Kingdom the nitrate runoff levels are very low. High concentration values in needles at Lekuk (PL01) probably reflects high uptake since the topsoil also show high levels. The area has a rich alder growth promoting fixation of nitrogen.



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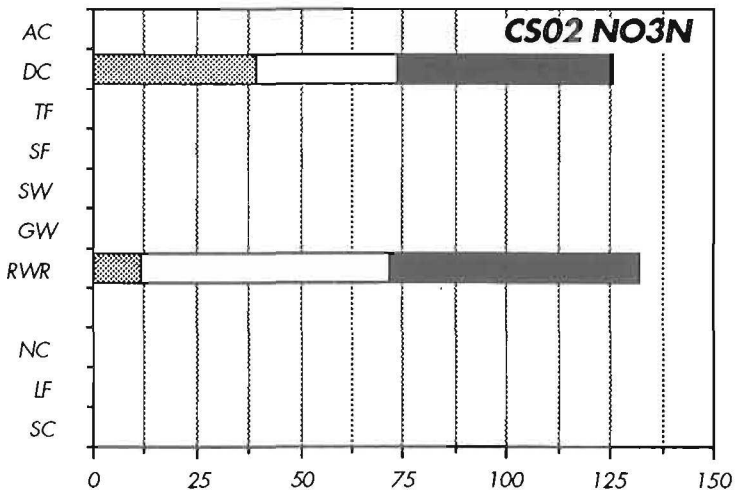

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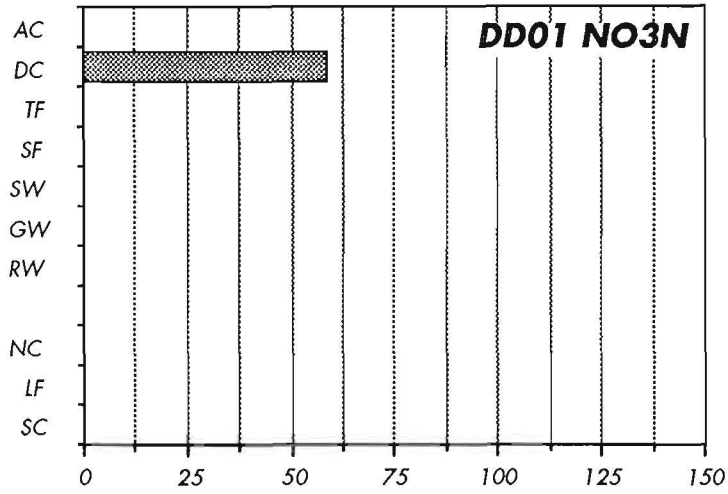

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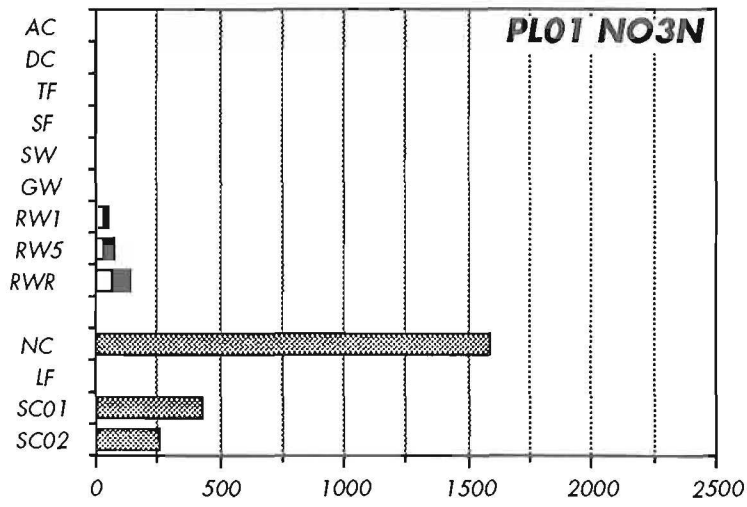

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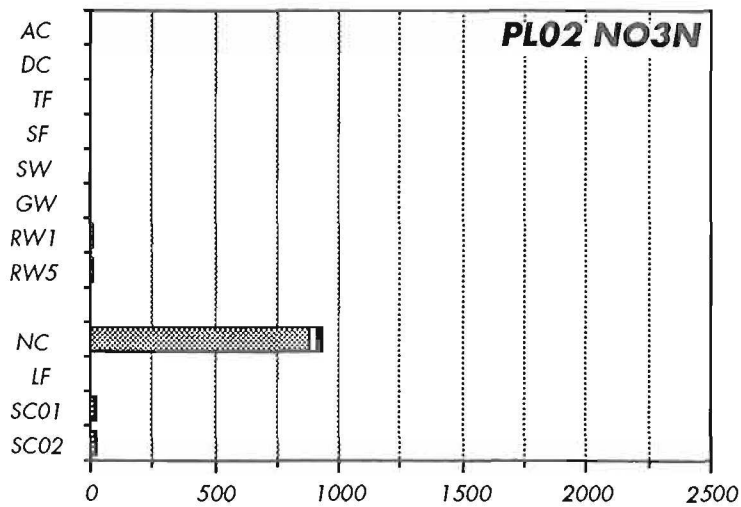

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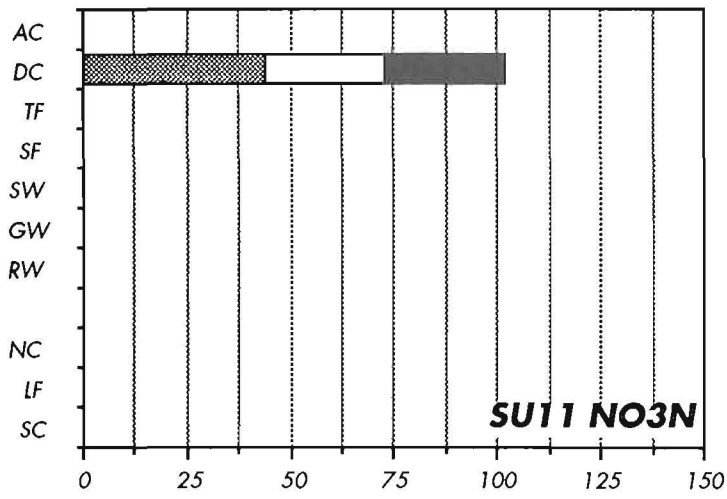

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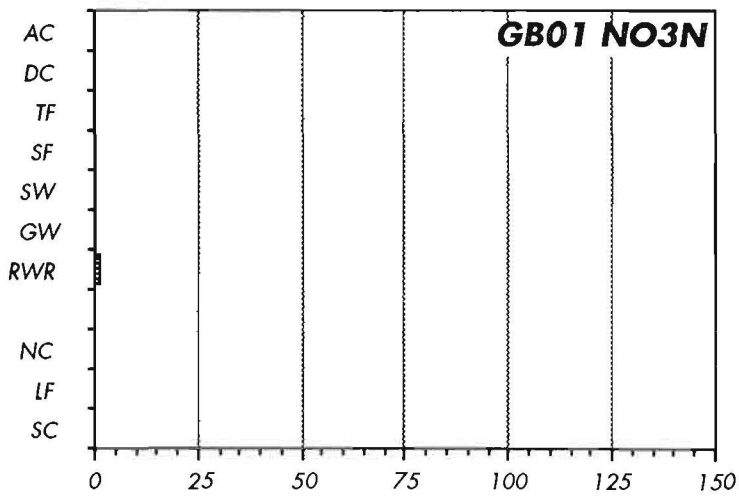

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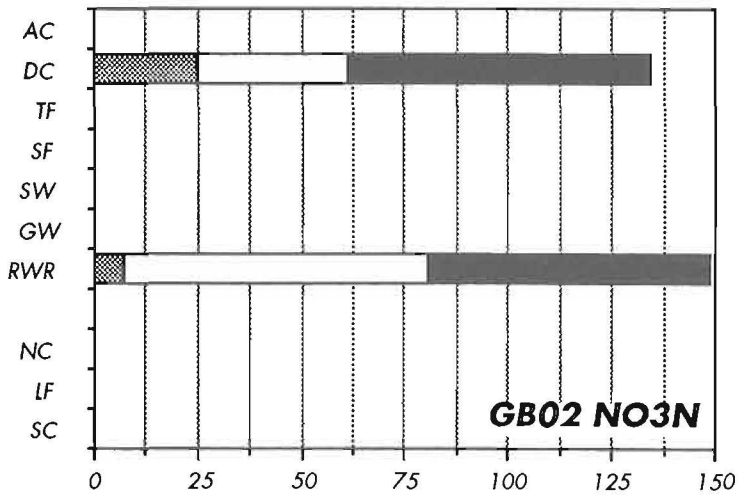

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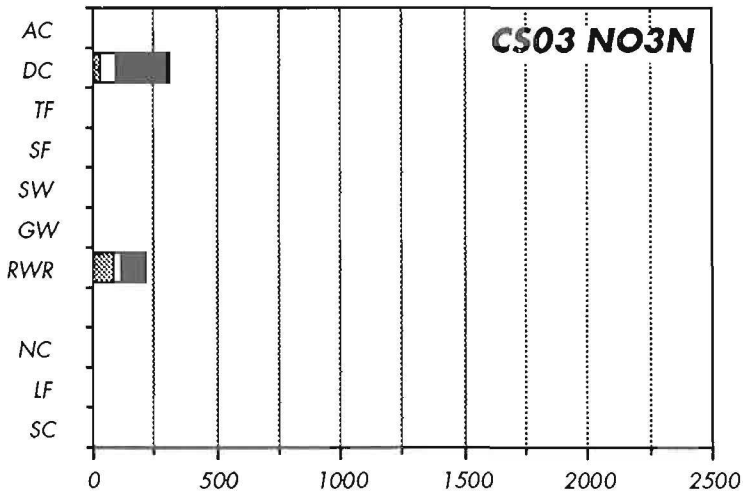
Montaneous Central (CS03,CS04,DE01,CH01)

The area of Jezeri (CS03) in the Czech Ore Mountains is quite out of range compared to other areas. Measurements indicate precipitation peaks > 250 µeqv/l/month and correspondingly high runoff concentrations. Temporal precipititation peaks, although much lower, are also recorded at Erlentobel (CH01), while precipitation values are low at Forellenbach (DE01). In Forellenbach throughfall data show an enrichment factor of 2 if compared with precipitation. Topsoil water concentrations exceed those of groundwater here, and the mineral topsoil itself has high concentrations (spatial average ca 400 meqv/kg).



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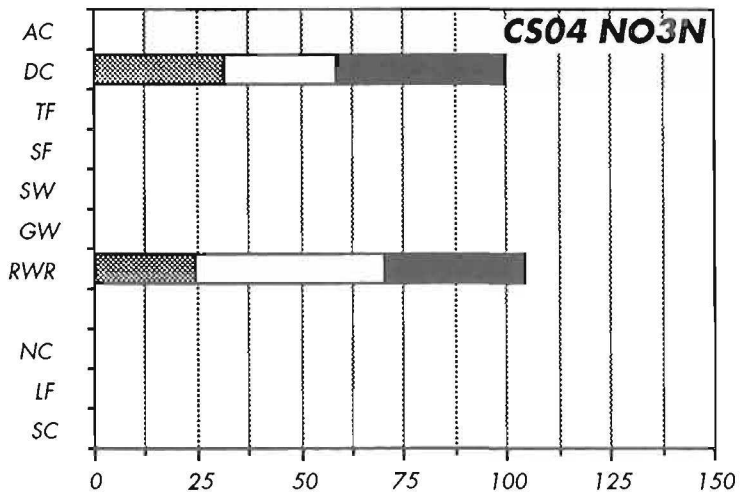

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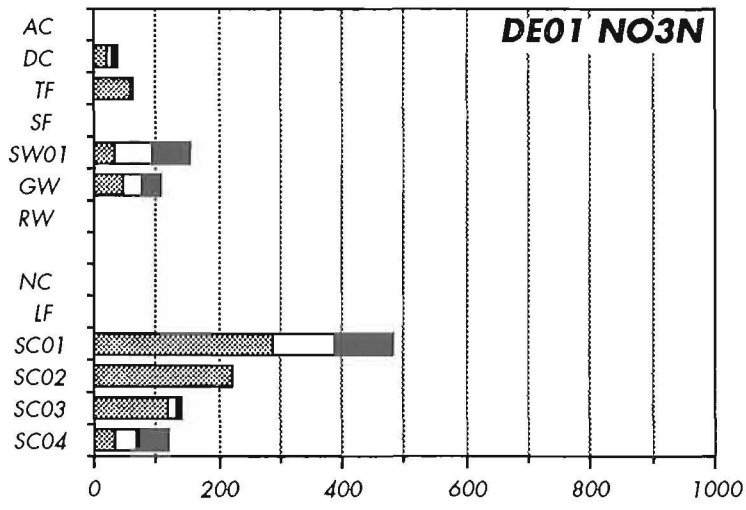

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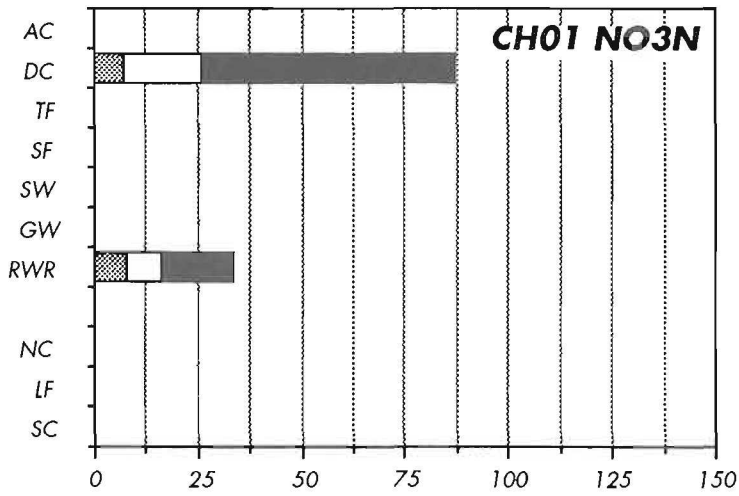

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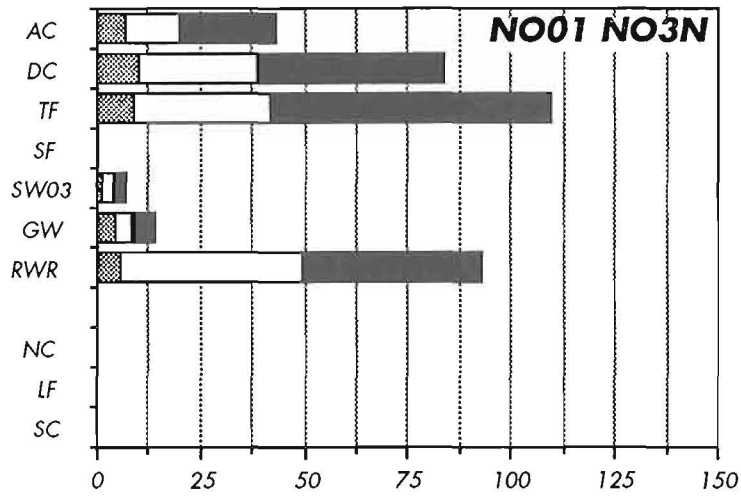
SC	0 0

Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

Precipitation values range between 10 - 80 µeqv/l/month with a slight decline towards north. Some temporal peak values up to 200 µeqv/l/month are recorded at Valday (SU15). Throughfall concentration levels exceed precipitation levels at least at Gårdsjön (SE04) and Valday, whereas they are close to another at Birkenes (NO01). Normally, in areas of glacial till and superficial bedrock, runoff concentrations exceed groundwater concentrations which in turn exceed soil water concentrations as shown in Birkenes. In Valday percolation of nitrate to groundwater is high. Topsoil concentrations are also quite high, ca 400 meqv/kg.



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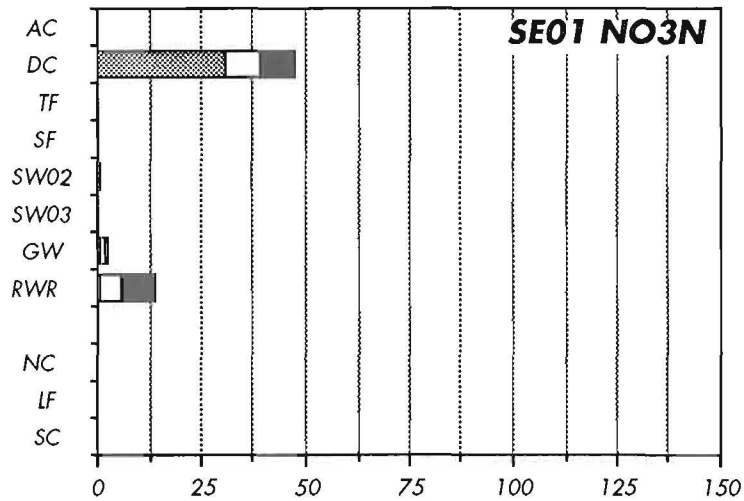

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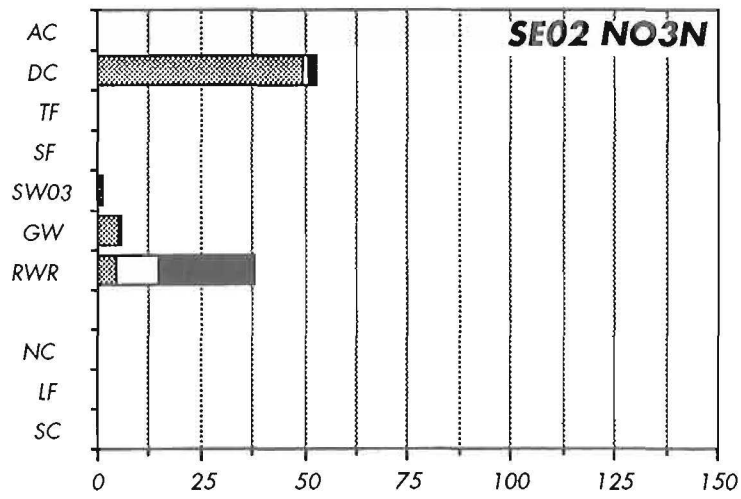

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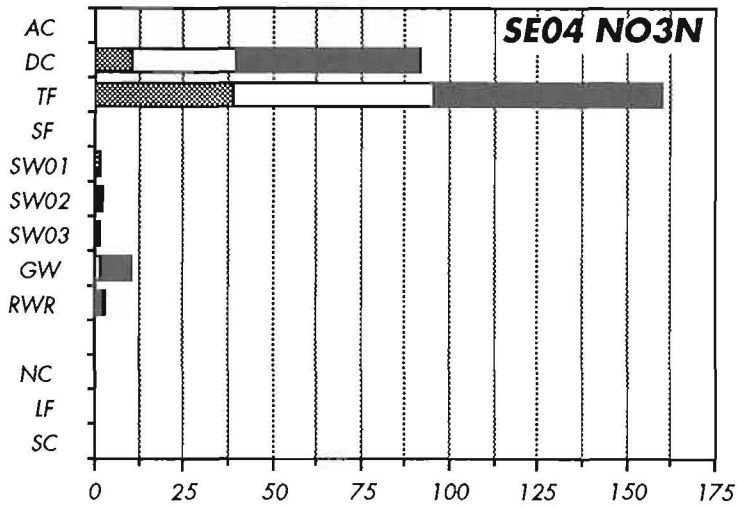

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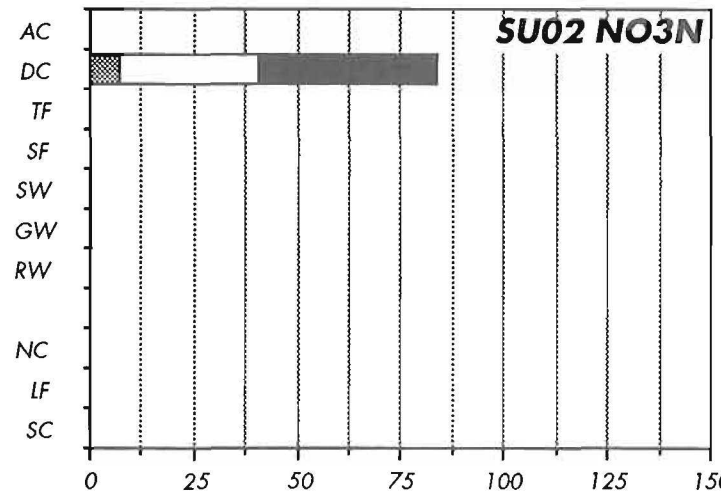

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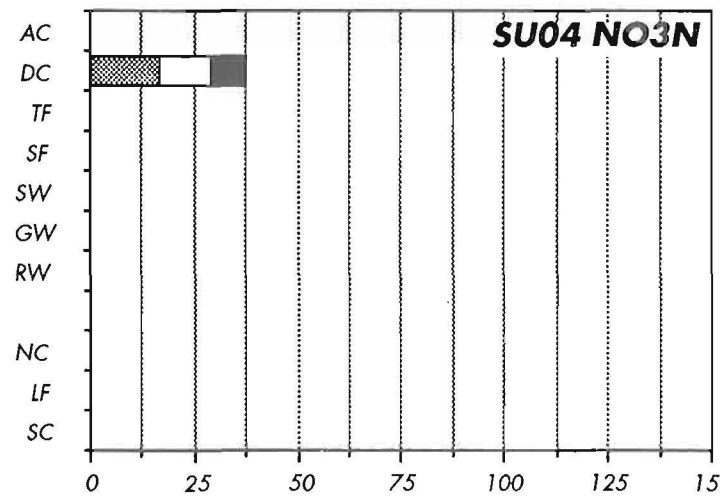

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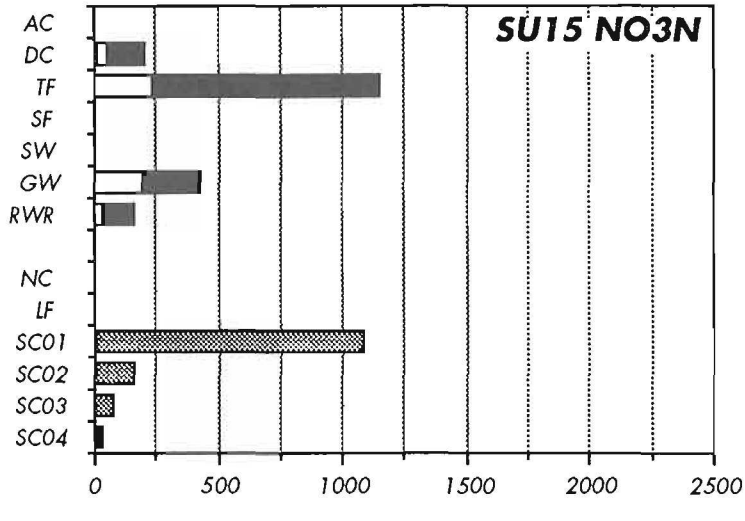

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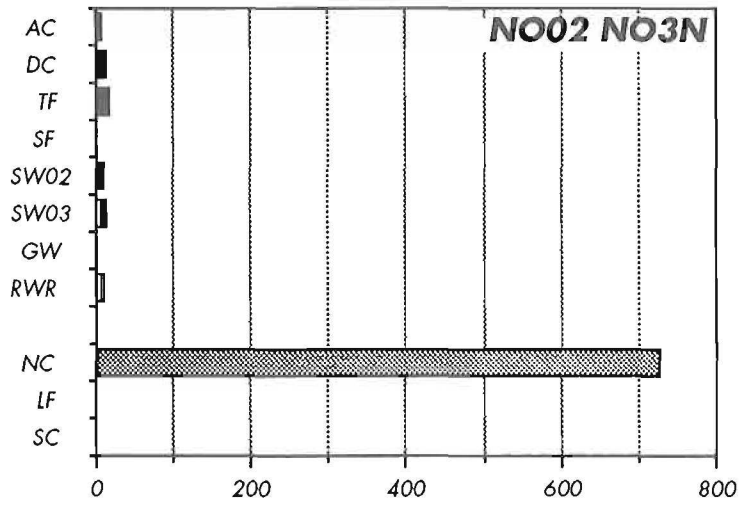
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

Uptake by biota is high as emphasized by needle concentrations and availability by topsoil concentrations in Valkeakotinen (FI01) and Pesosjärvi (FI04). Nitrogen becomes a limiting factor more to the north as seen by Vuoskojärvi (FI05). In the west, at Kårvatn (NO02), nitrogen nitrate levels are almost the same for every measured media. In Finland annual mean levels rise passing from precipitation to throughfall to stemflow. In Valkeakotinen the monthly variation show temporal concentration peaks in throughfall, stemflow and runoff water during the growing season. In Vuoskojärvi peaks in precipitation indicate long-range transports.



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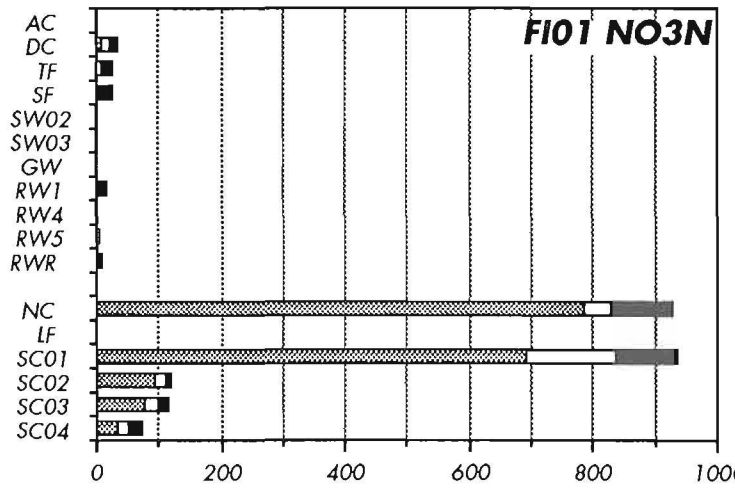

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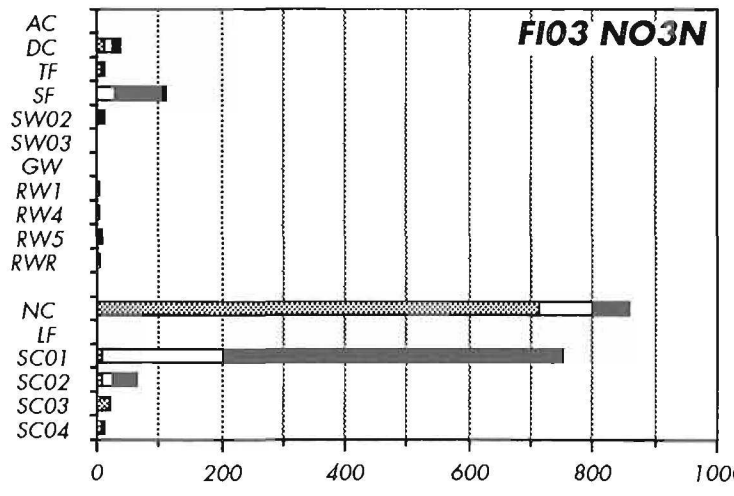

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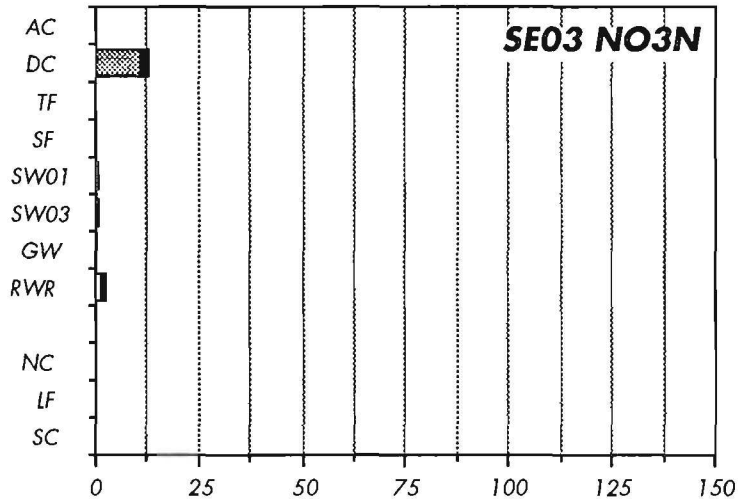

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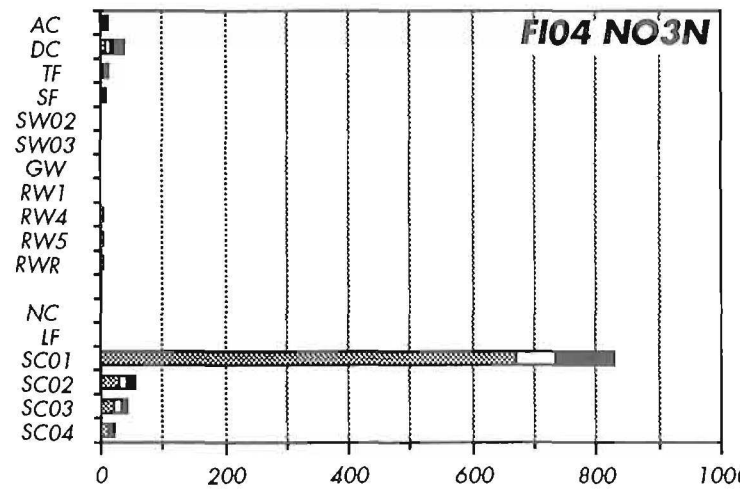

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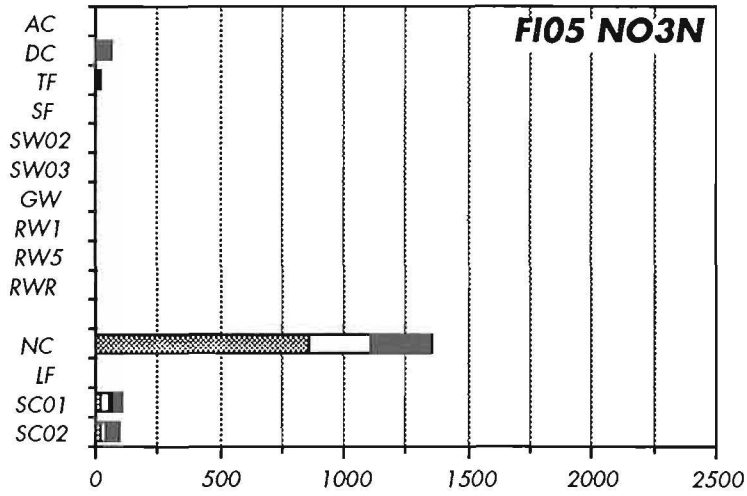

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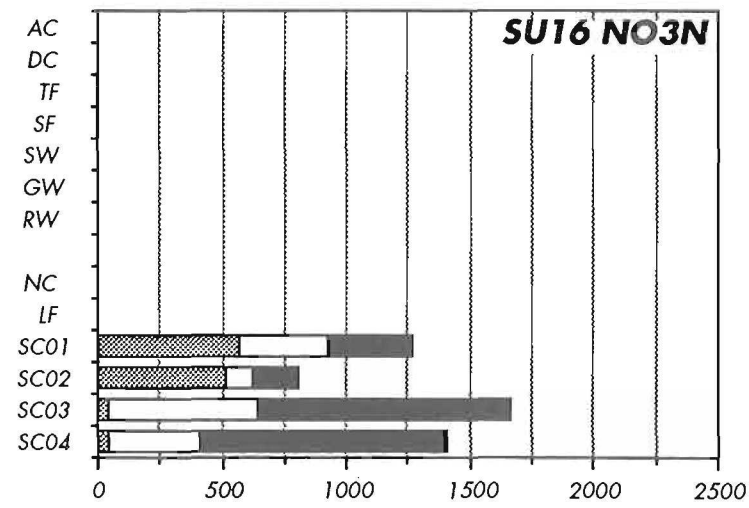

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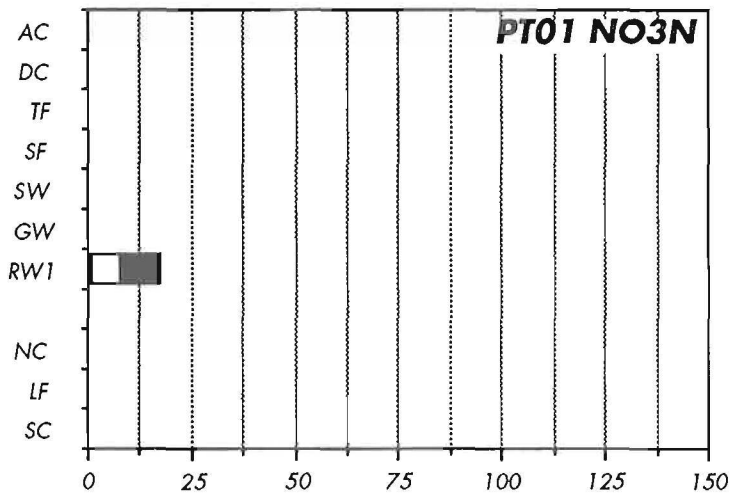
SC03	03 01 8908 8908
SC04	03 01 8908 8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

In Alentejo (PT01) lake surface concentrations are higher than in the Boreal region, but lower than in the Boreonemoral. In Komlosi (HU01) enrichment takes place from precipitation to throughfall to stemflow. The stemflow enrichment factor is 1.5 in comparison to throughfall. Temporal peaks up to 650 µeqv/l/month in stemflow clearly promotes algal growth upon stems (which causes the bright green colour of the local poplar trunks). The permeable soil at Komlosi promotes seepage to (deep) groundwater.



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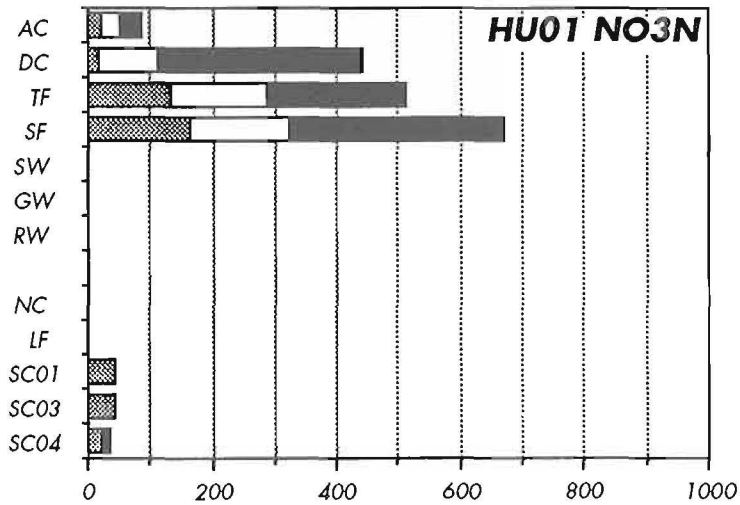

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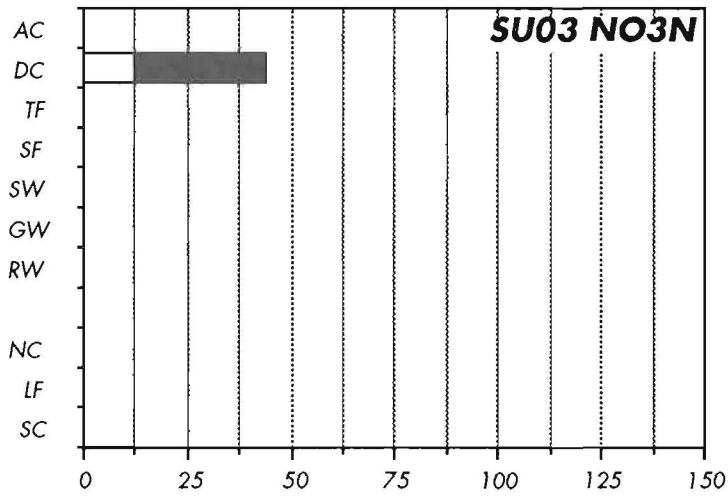
SC01	01 01 8801 8801
SC03	01 01 8801 8801
SC04	01 01 8801 8801

Montaneous East (SU03,SU05)

Precipitation concentrations are low, at maximum ca 60 µeqv/l/month. Throughfall concentrations does not differ much from these. Nitrate concentrations are low in the groundwater and slightly rise in runoff water.

Nearctic Nemoral (CA01)

Precipitation levels at Turkey Lakes (CA01) resemble those of Boreonemoral/Southern Boreal European regions. They are lower than along the Atlantic east-coast and in the central orobiomes and much lower than the levels recorded in the European Nemoral region.



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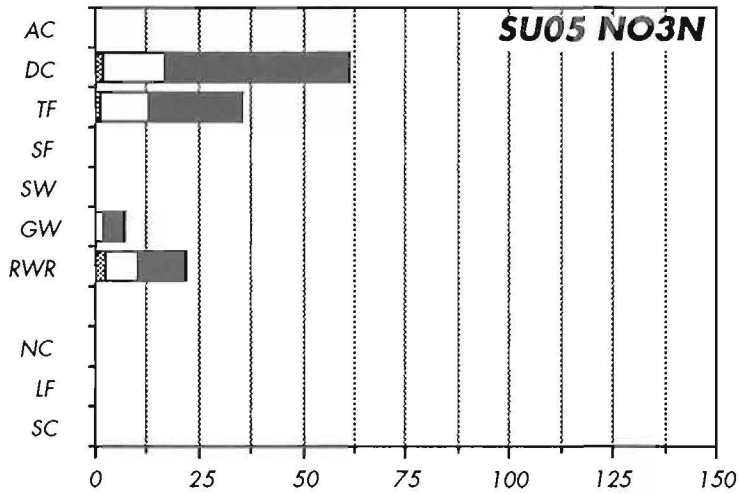

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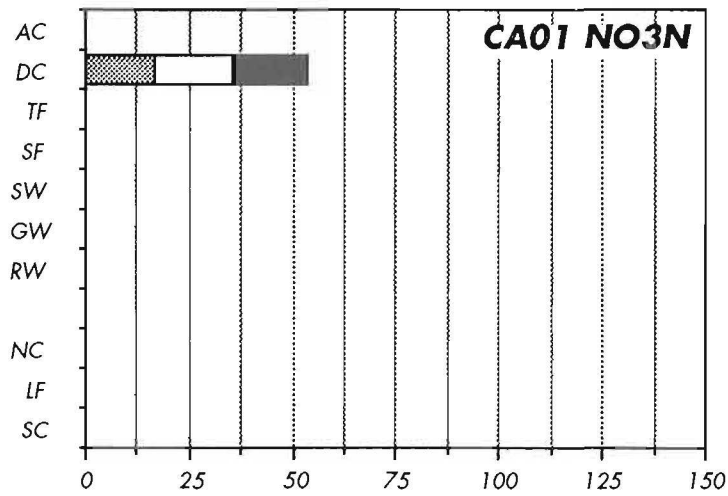

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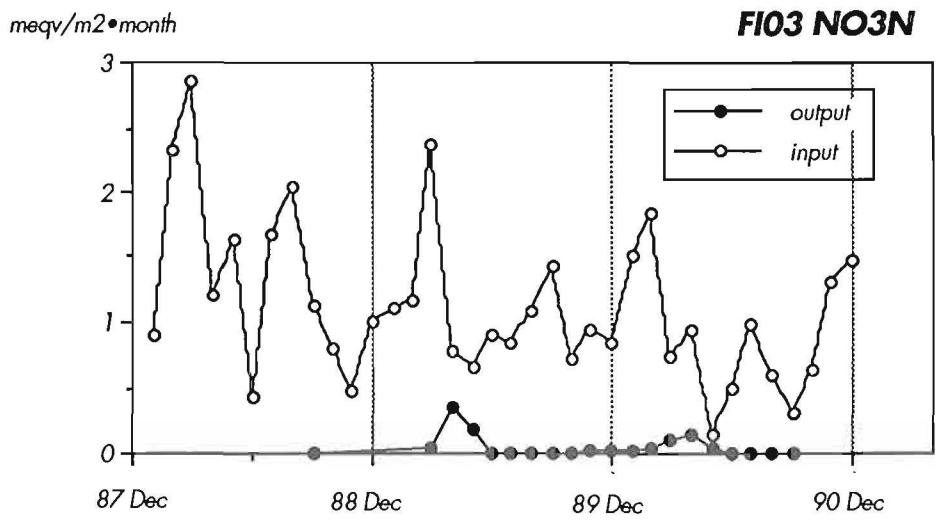
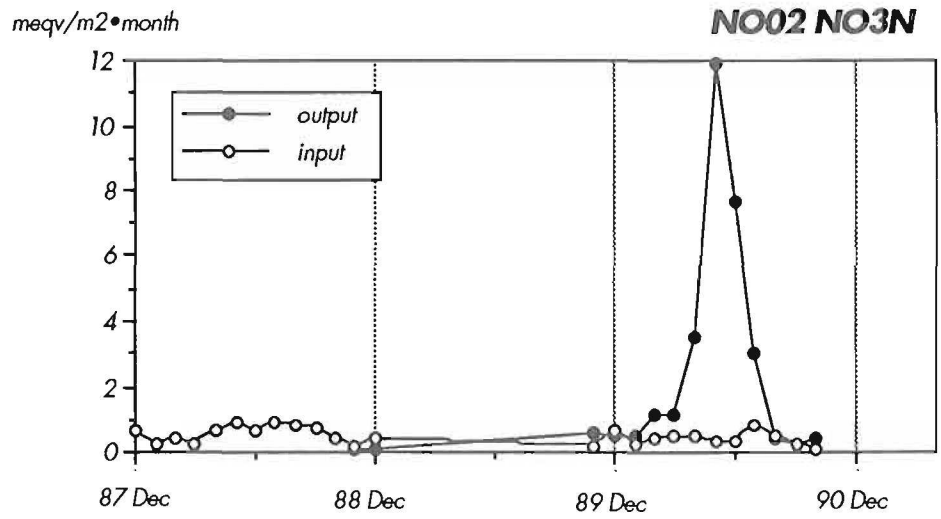
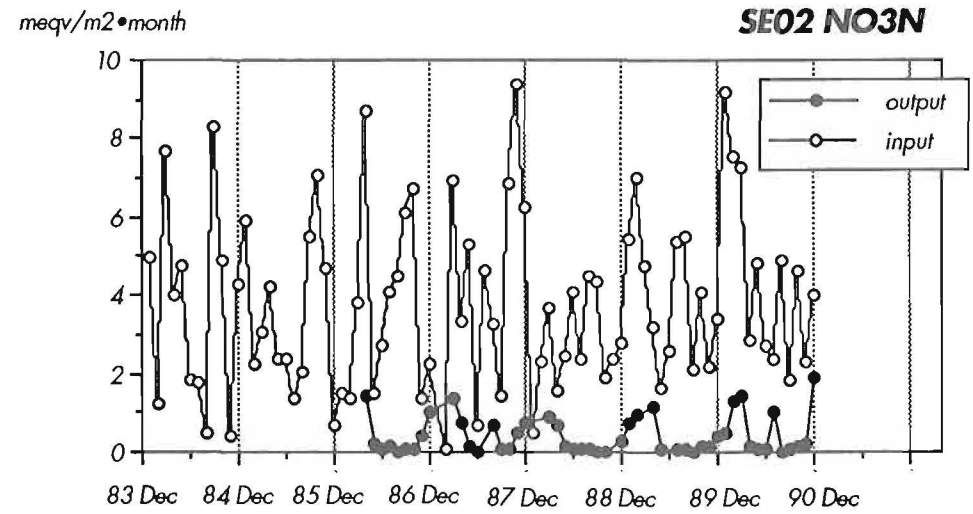
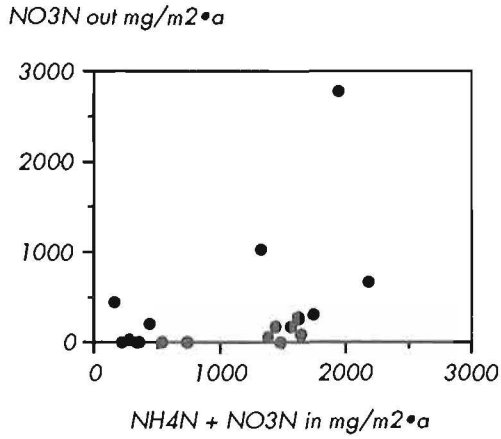
3.3 Long-term temporal variation

In this section, time series of monthly fluxes of nitrate nitrogen expressed as meqv/(m^2•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02).









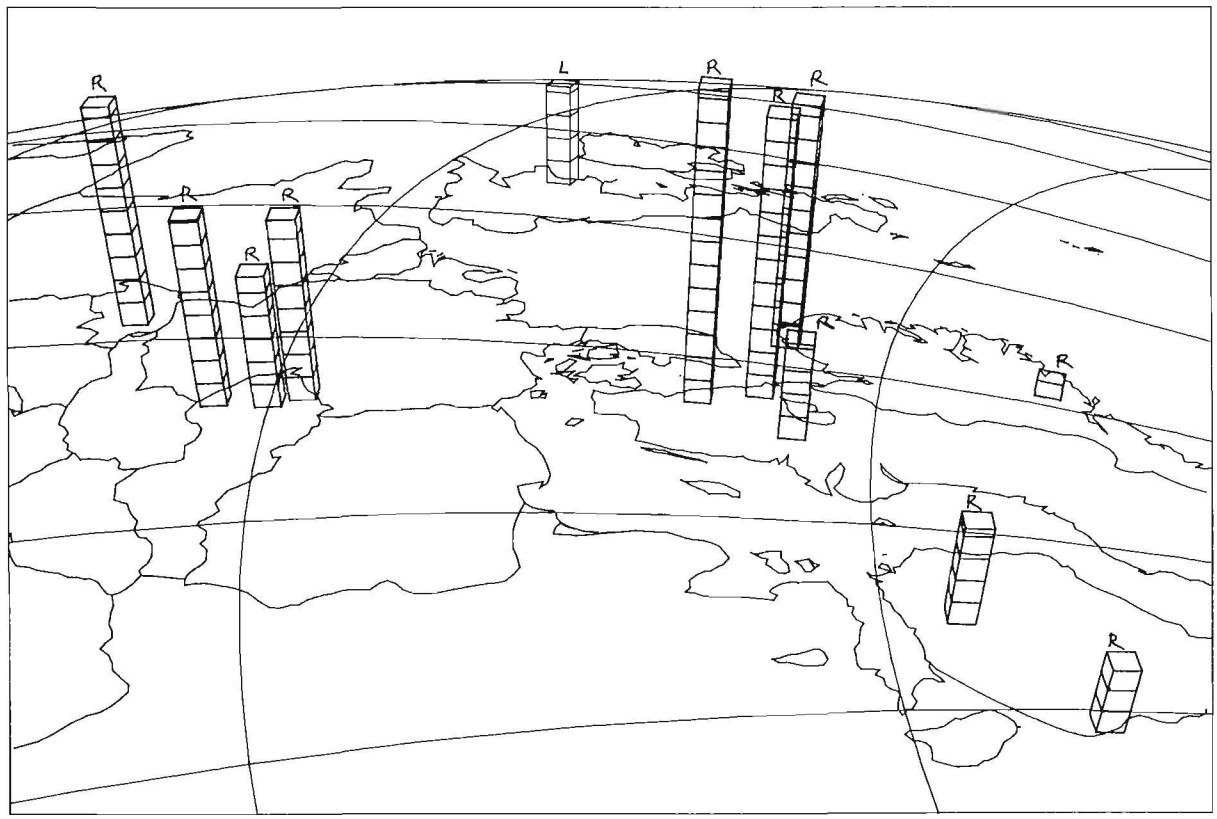
In the figure above the output of nitrate nitrogen is plotted versus the sum of inputs of nitrate nitrogen and ammonium nitrogen, expressed as mg/(m²•a). The strong nitrogen retention at low loads is loosened with increasing load. The area NO02, Kårvatn, which received the lowest load (1989-90) is an interesting anomaly in this framework possibly due to nitrogen fixing vegetation. Area GB02, Afon Hafren, with an output of a little over 1000 mg/(m²•a), owes its high leaching to tree-felling operations. Again is the Birkenes area in the extreme regarding leaching (cf. the corresponding sulphur figure in section 2.4).

3.4 Mass balances

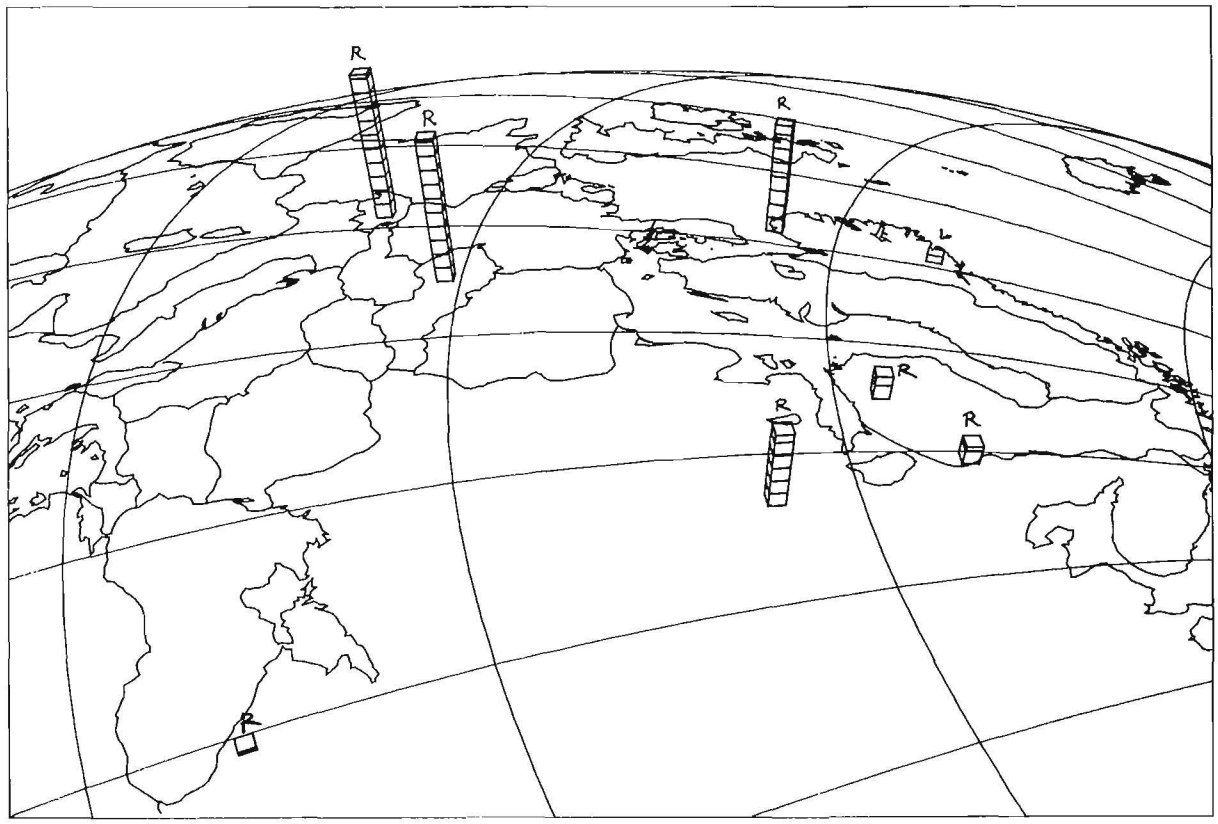
Nitrogen nitrate displays retention almost throughout Europe (and Canada). Only in two areas leaching is found, in Afon Hafren (GB02) where it is caused by loss in uptake of the biomass due to tree-felling (Alan Jenkins, oral communication) and in Kårvatn (NO02) where probably some of the nitrate loss may be associated with alder grooves of the area. The relative retention (and N-volatilization) ranges in in the Nemoral Region and in the oceanic part of Boreonemoral Ecotone between 70 - 90 % but in the Boreal Region and more continental Boreonemoral Ecotone it is > 95%.

The C/N ratio of the topsoil is shown in table 1. According to the figures high - moderate biological activity, C/N < 27, would only be found in Komlosi (HU01), Forellenbach (DE01) and Berg (SE02 in 1982) whereas other areas have low biological acitivy to being biologically inactive, C/N > 27. These values are however not too indicative and must be verified by microbiologic monitoring (which has been started in some areas already).

NO_3N 1988-89, scale unit 100 mg/ m²•a



NO_3N 1989-90, scale unit 100 mg/m²•a

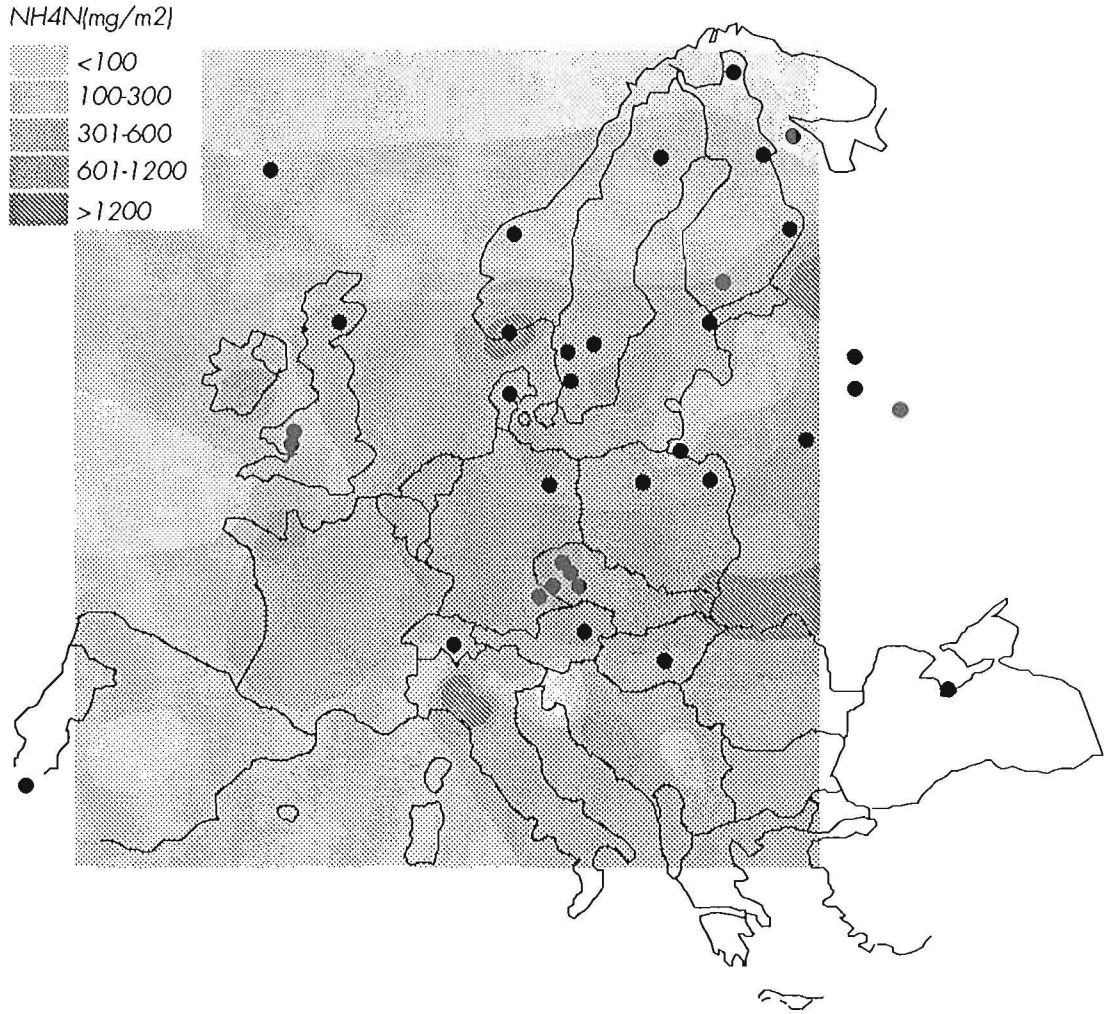


CHAPTER 4

Nitrogen ammonia

4.1 Fields of deposition

Most emissions stems from evaporation of excrements of husbandry; also application by N-fertilizers might increase ammonia levels. The area coverage is not especially good since the most effected area in the Netherlands (poorly shown by the map) is not covered by the network.

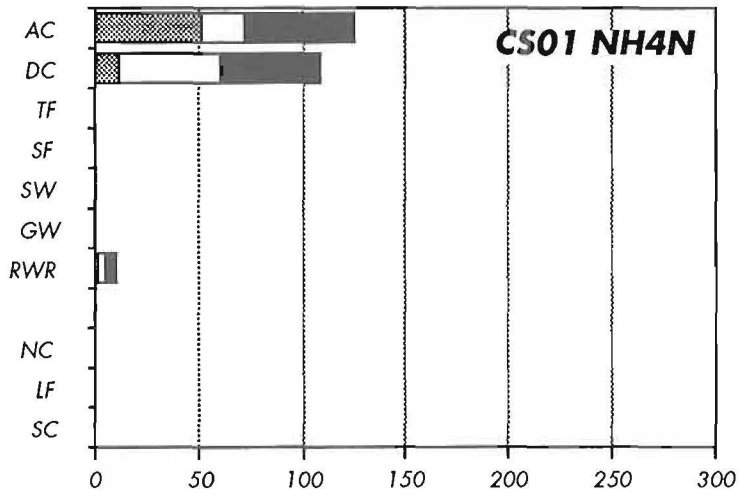


Field of deposition of NH_4N (mg/m^2) in 1988 acc to EMEP (CCC 4190).

4.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,SU11,GB02)

Concentrations in both ambient air and precipitation are high in the eastern parts, e.g. levels exceed 200 ueqv/l/month in Mlynaruv (CS02) and Preila (SU11). Proportionally high runoff concentrations are also noted for Anenske (CS01) and lake surface water levels in the alder-rich Lekuk Lake area (PL01). The Polish areas also indicate the enrichment with lake depth and depletion of oxygen.



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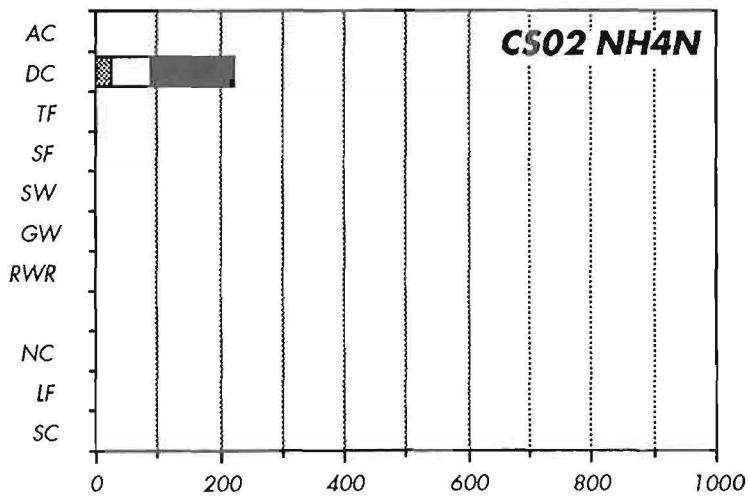

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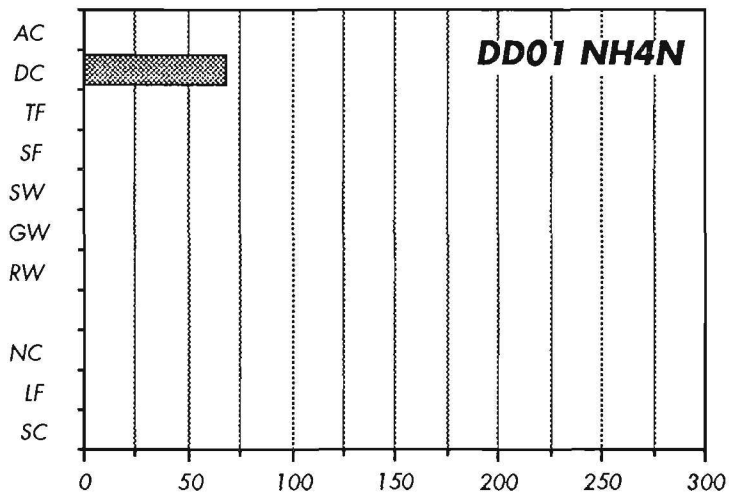

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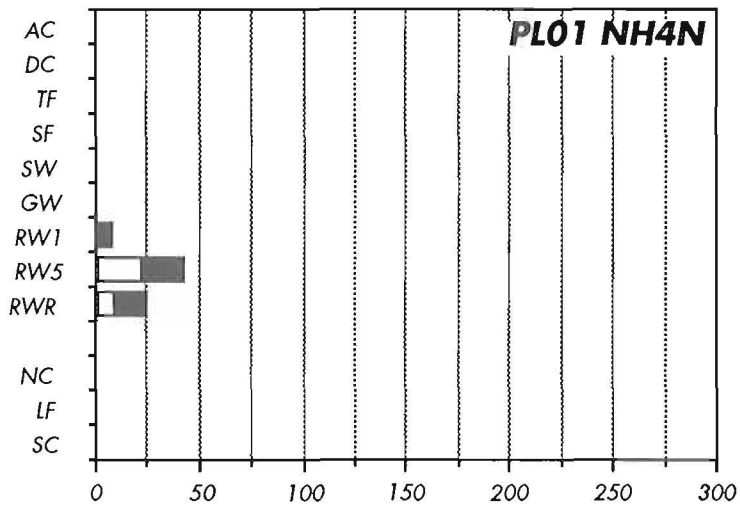

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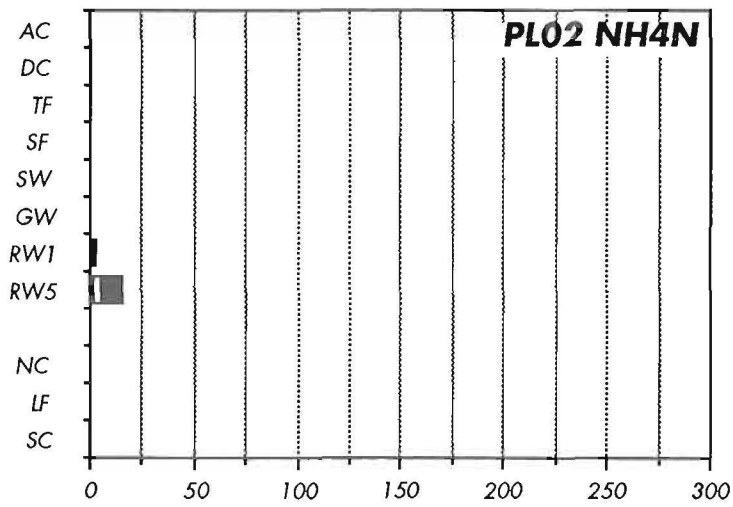

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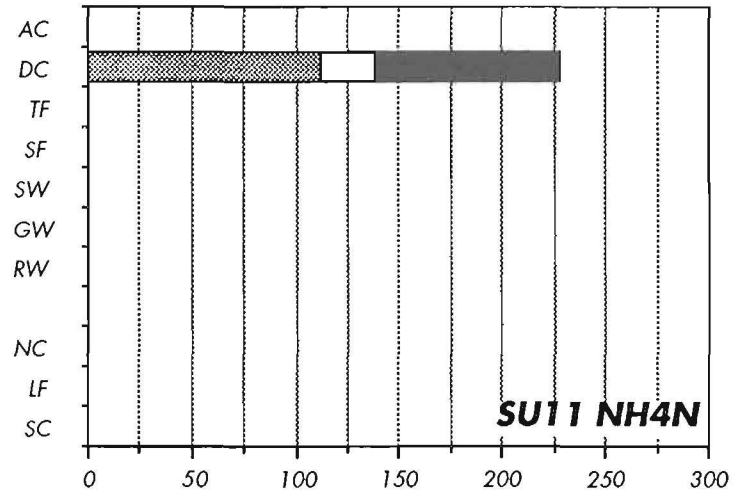

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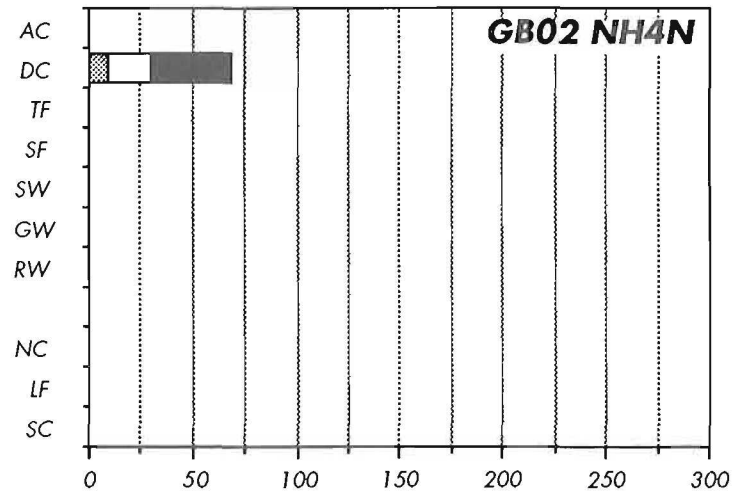

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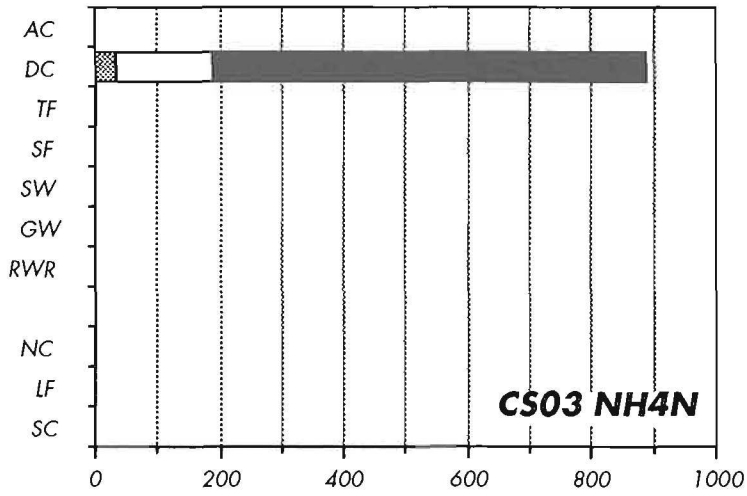
Montaneous Central (CS03,CS04,DE01,CH01)

Annual mean levels in precipitation in the mountains of Czech and Slovak Federal Republic do not differ much from lowland values, but the temporal peaks are higher, > 300 µeqv/l/month for Liz Sumava (CS04) and > 800 µeqv/l/month for Jezeri (CS03). Data from Forellenbach (DE01) indicates enrichment with a factor of 1.5 ... 2 from precipitation to throughfall. Contamination of soil water (max > 150 µeqv/l/month) and groundwater is evident for this area.



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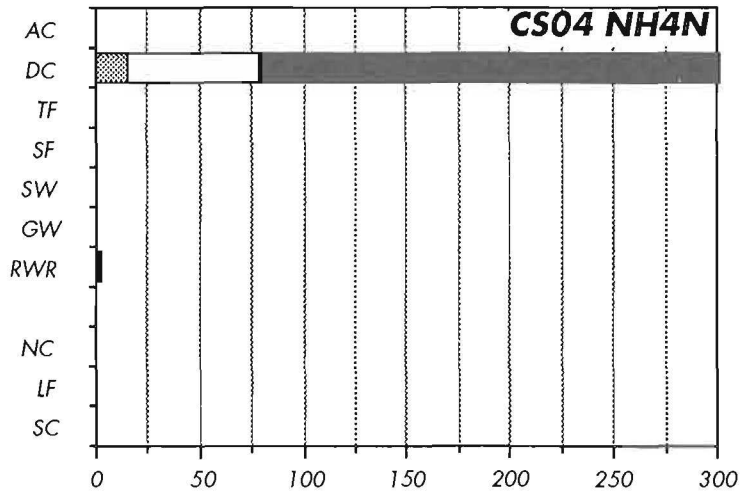

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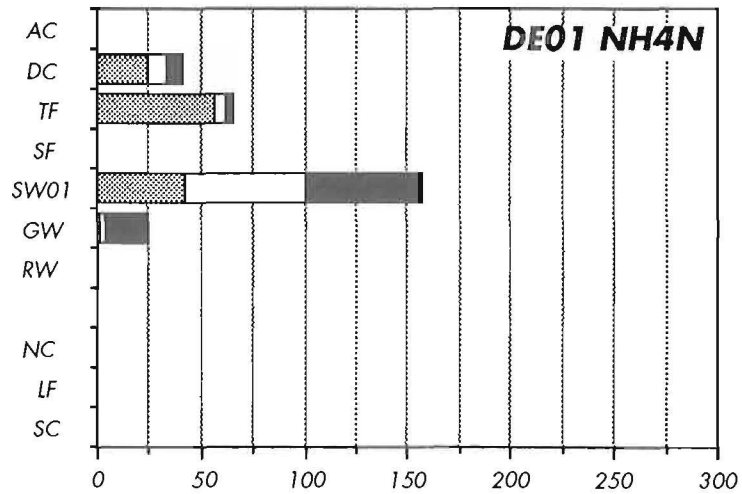

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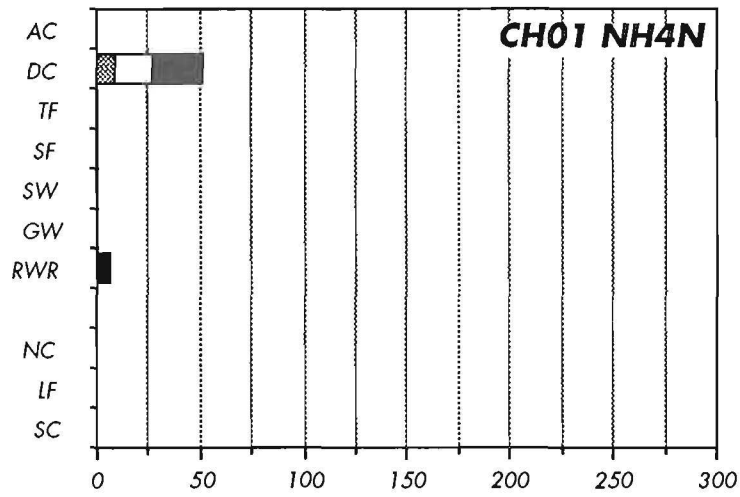

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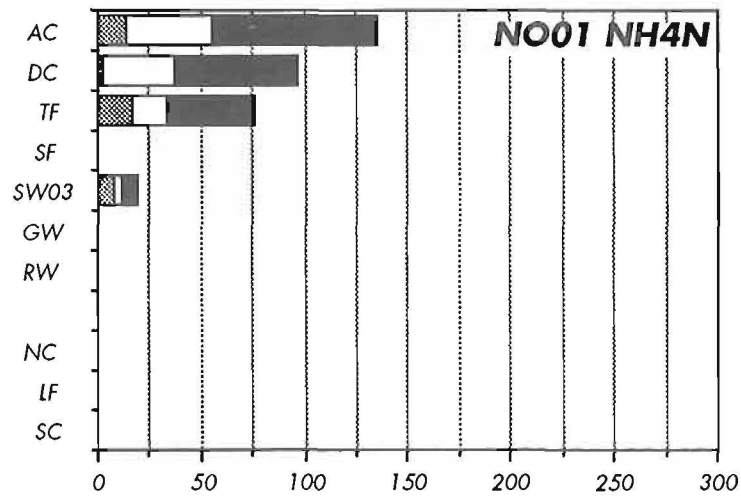
Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

Levels in precipitation might be lower or higher than throughfall levels. The geographic picture indicates a decline towards north and east. Flow concentrations vary depending on soil type: in Berg (SE02) there are relatively high runoff water concentrations, in Tiveden (SE01) there are relatively high groundwater concentrations. In Soviet temporal peaks in precipitation are recorded, up to 250 µeqv/l/month in Berezina (SU02) and up to 300 µeqv/l/month in Valday (SU15). In Valday the enrichment factor for throughfall is close to 4, and temporal peaks during the growing season are discernable in both groundwater and runoff water.



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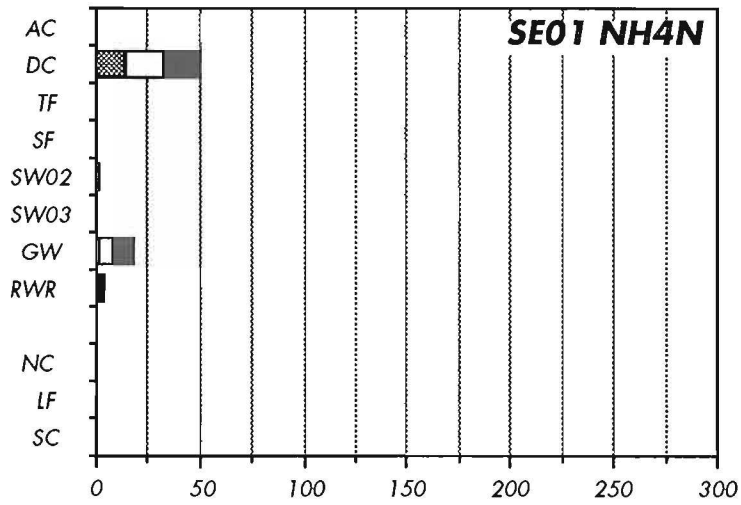

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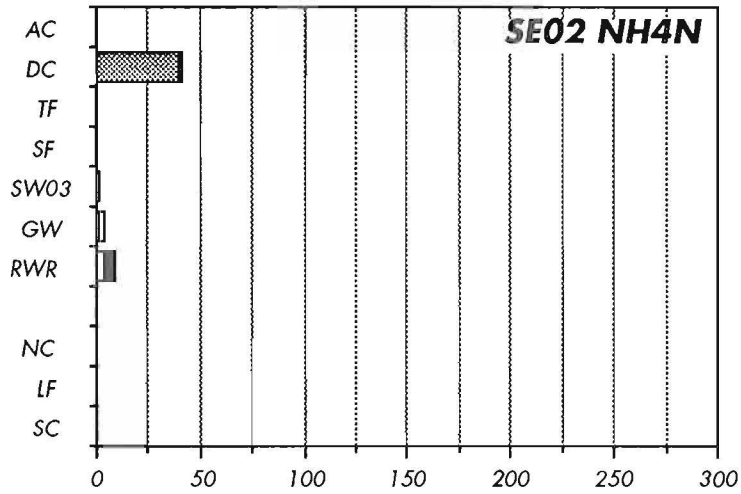

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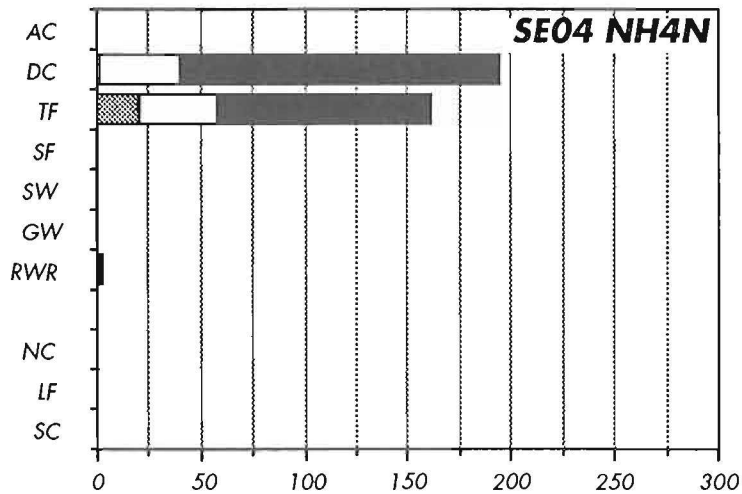

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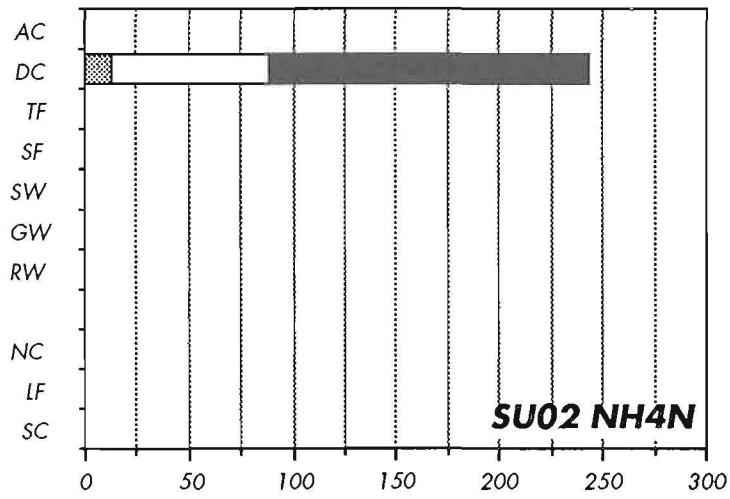

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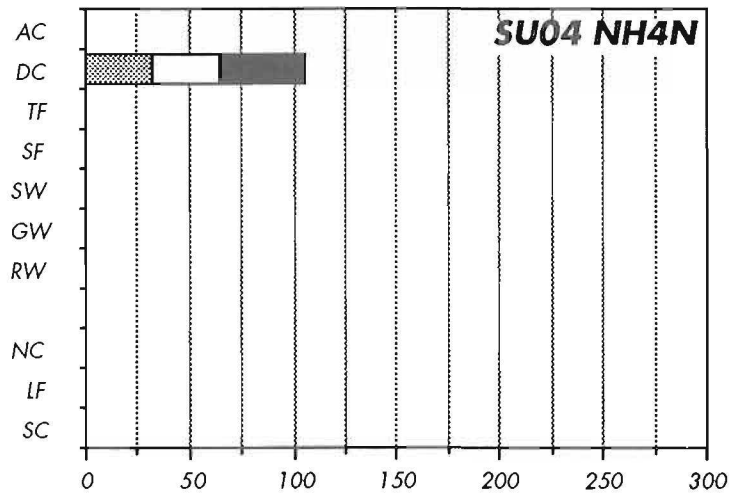

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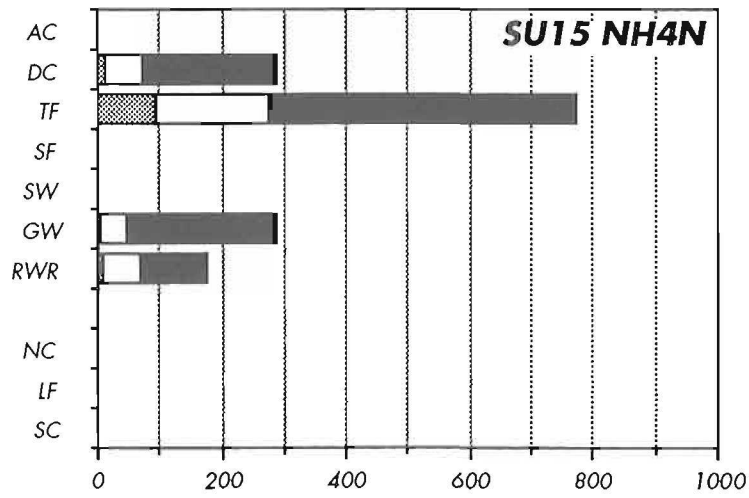

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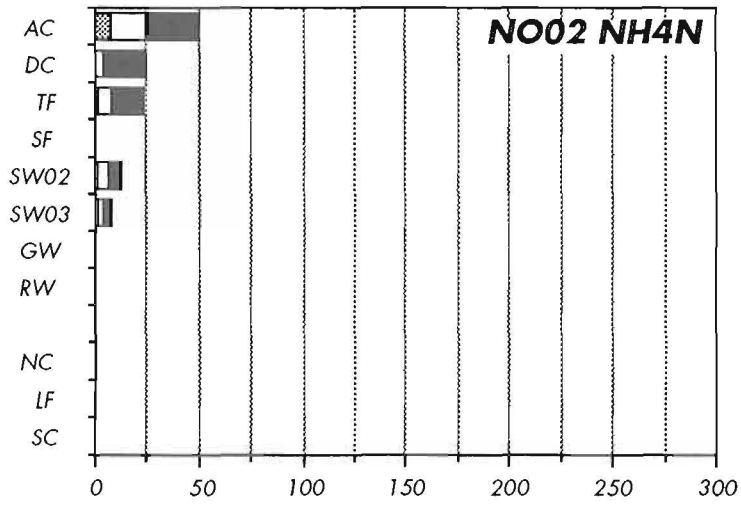
LF	0 0
SC	0 0

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05)

The concentrations become much lower in this region, in particular in the west at Kårvatn (NO02). The lakes of the Finnish areas indicate enrichment of ammonia levels with depth as in the Polish lakes of the Central Nemoral. Concentrations in throughfall might be higher or lower than in rainfall. Stemflow concentrations are normally high and show large variations, probably due to contamination from internal sources (insects, bird droppings etc.). Towards north the concentrations of ammonia become quite insignificant - only temporal peaks like in ambient air at Pesosjärvi (FI04) and in rainfall at Vuoskujärvi (FI05) stand out.



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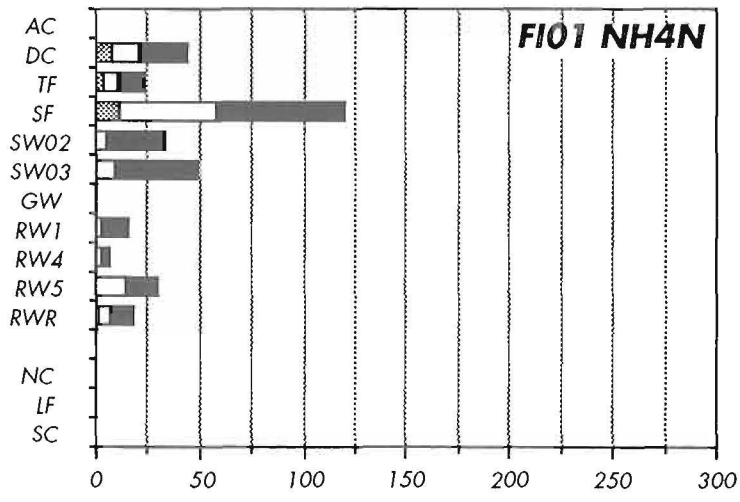

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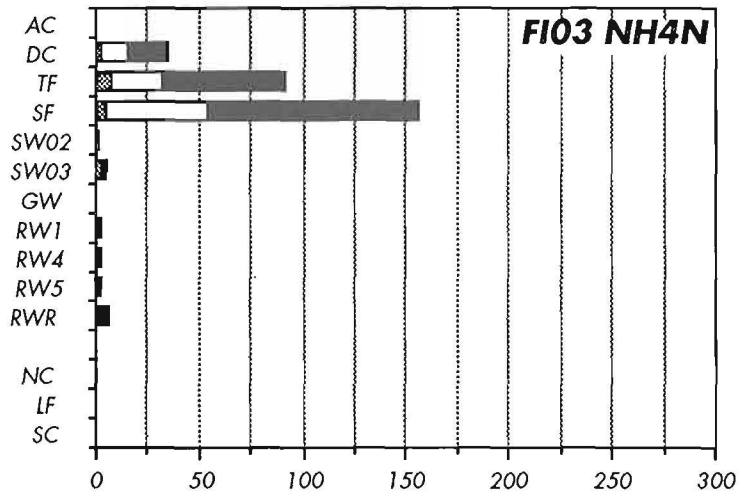

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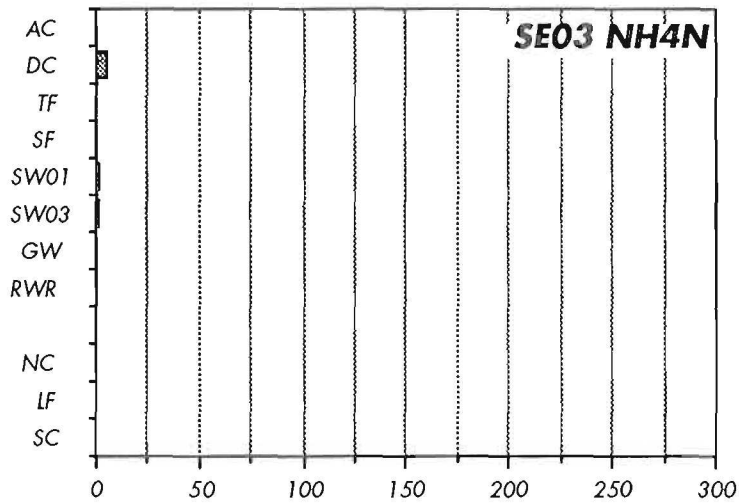

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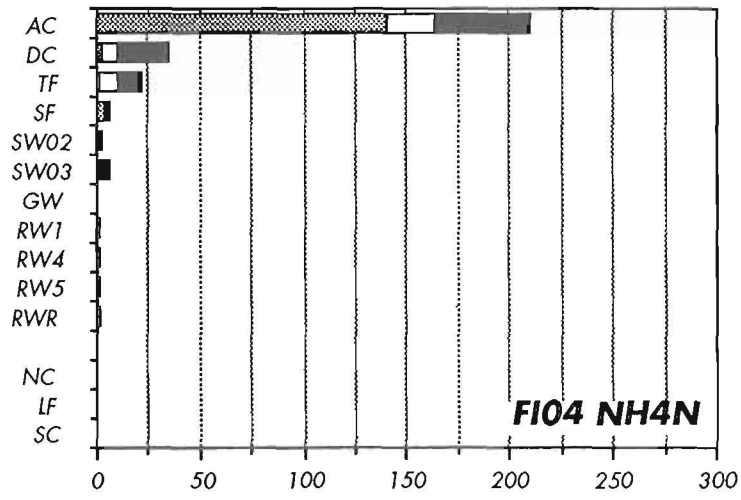

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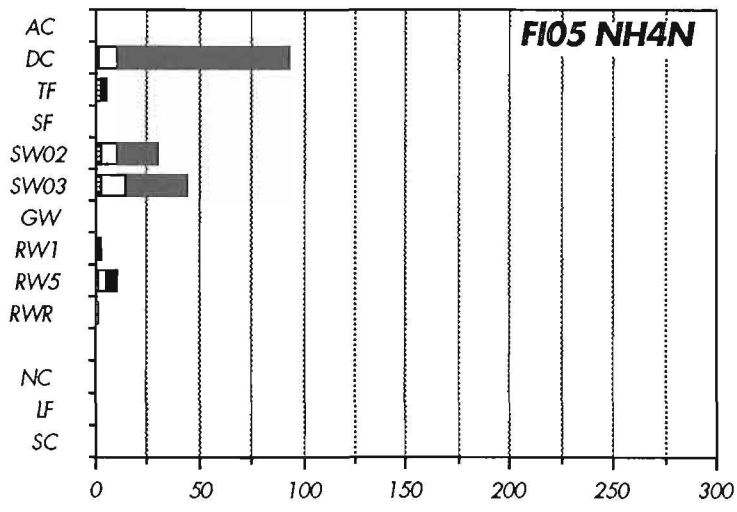

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SW03	02 03 8908 8910
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RW1	01 04 8912 9004
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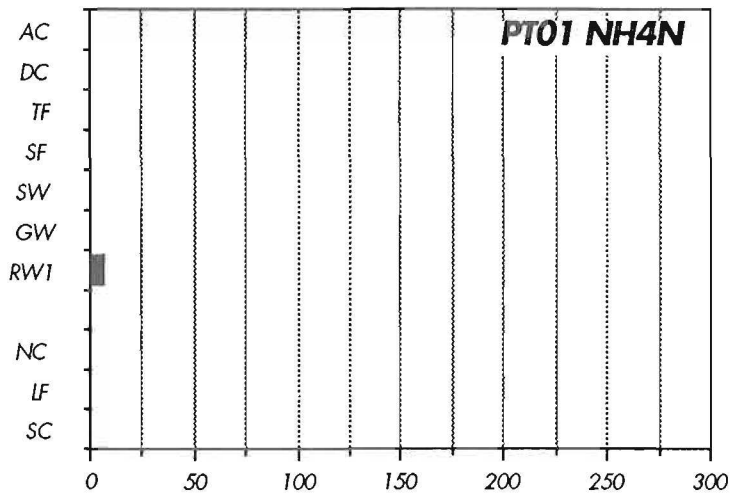
RWR	01 10 8912 9010
NC	0 0
LF	0 0
SC	0 0

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

The concentrations in surface water in Alentejo (PT01) are low. Quite low concentrations of air and rainfall are recorded in Komlosi (HU01) but the enrichment in throughfall and stemflow is extreme due to high evaporation (factors by >500 and >1000...5000).



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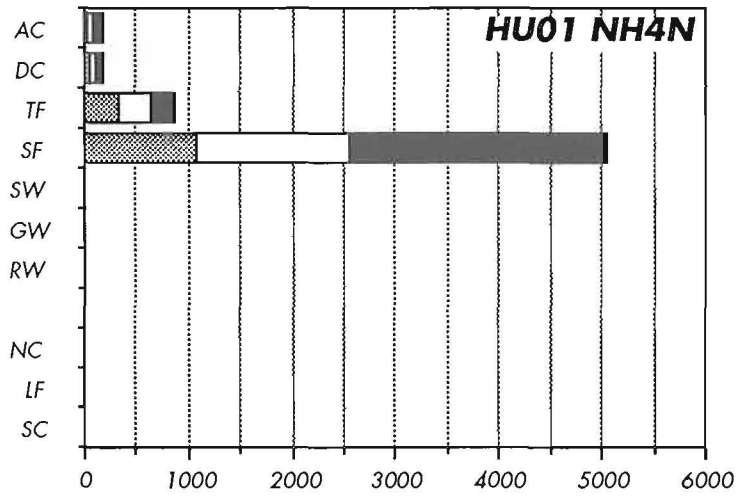

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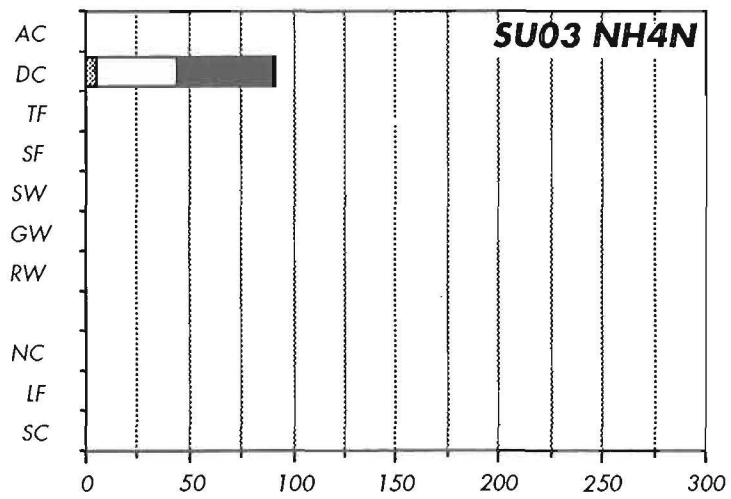
LF	0 0
SC	0 0

Montaneous East (SU03,SU05)

The concentrations are quite insignificant but for rainfall and throughfall in the areas of Caucasus BR (SU03) and Juga Massif (SU05).

Nearctic Nemoral (CA01)

The levels are most similar to those of the nemoral areas of United Kingdom and Tiveden (SE01) in the Boreonemoral ecotone.



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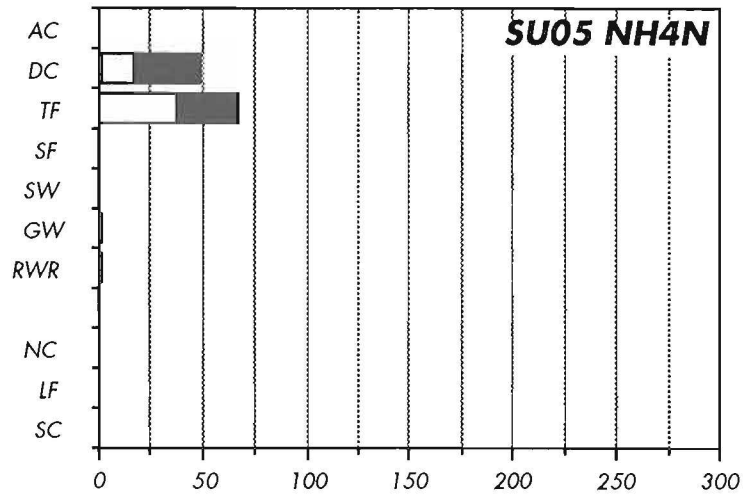

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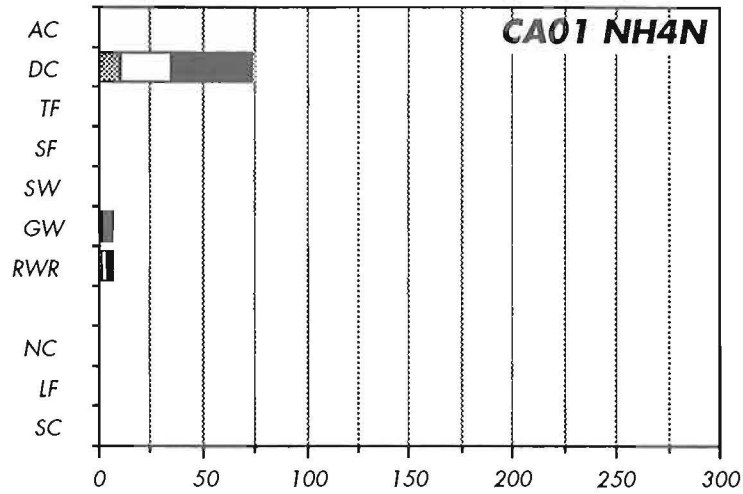

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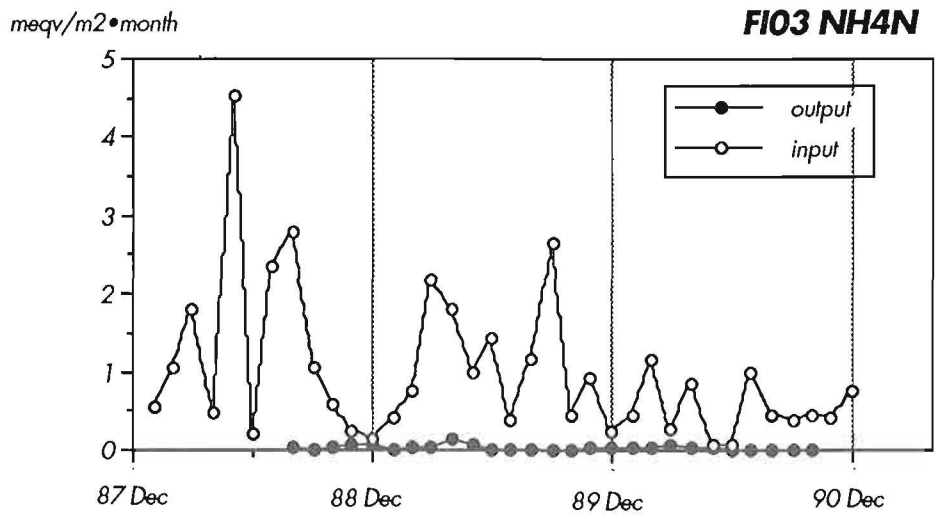
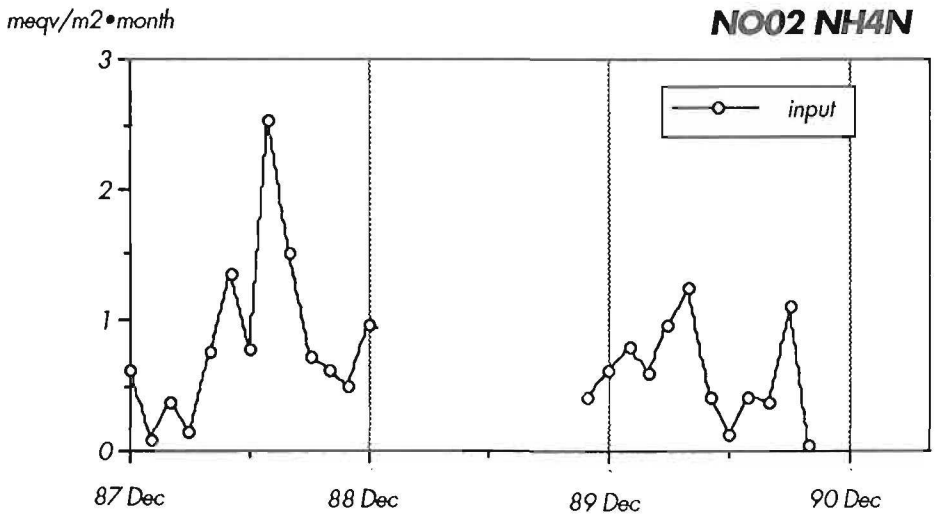
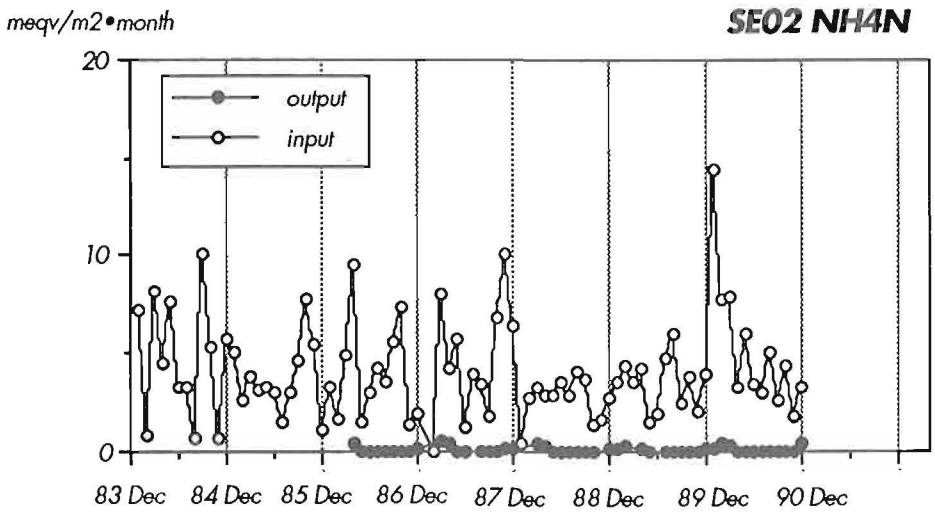
SC	0 0

4.3 Long-term temporal variation

In this section, time series of monthly fluxes of nitrogen ammonium expressed as meqv/(m²•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02).



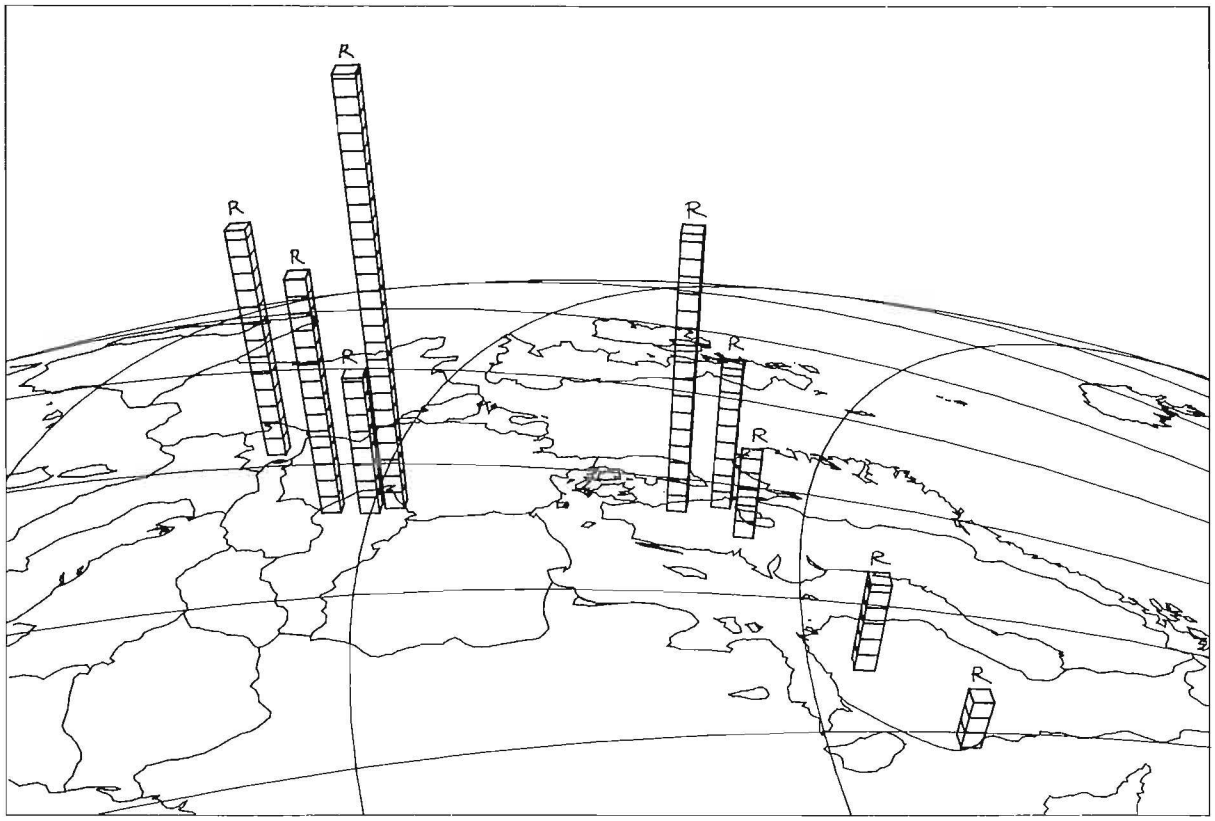




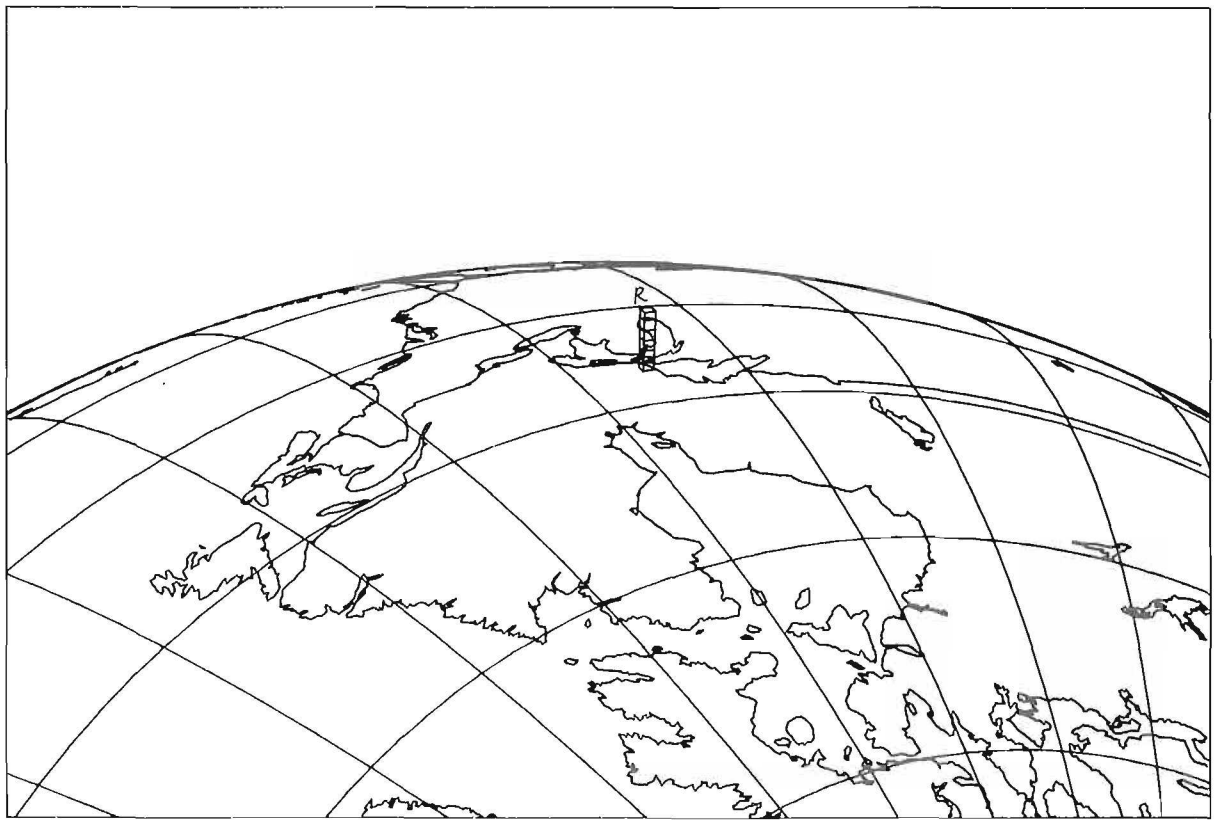
4.4 Mass balances

Net retention/nitrification of nitrogen ammonia occurs in all monitored areas. The relative retention is normally 99-100% of the deposition. Only in areas with a large lake percentage the relative retention figures are somewhat lower 95-97%.

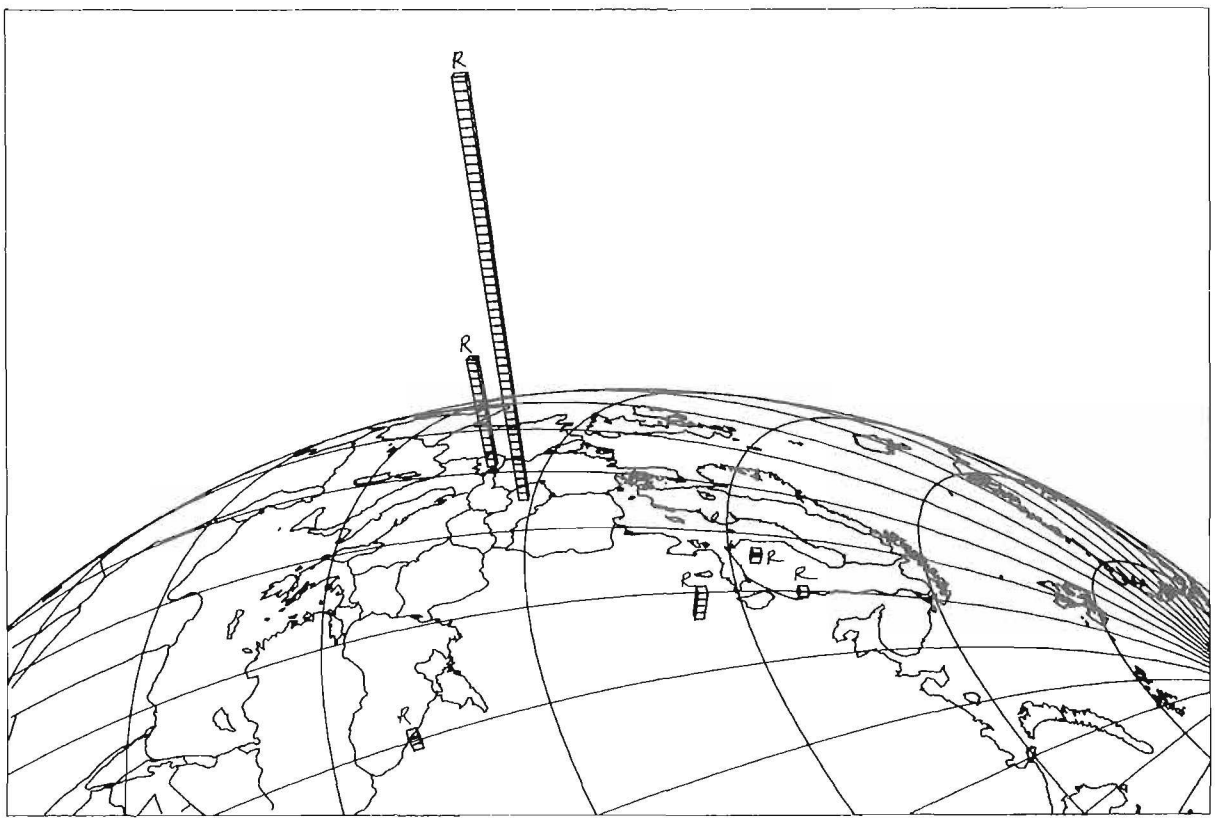
NH_4N 1988-89, unit scale 100 mg/m²•a



NH_4N 1988-89, scale unit 100 mg/m²•a



NH_4N 1989-90, scale unit 100 mg/m²•a

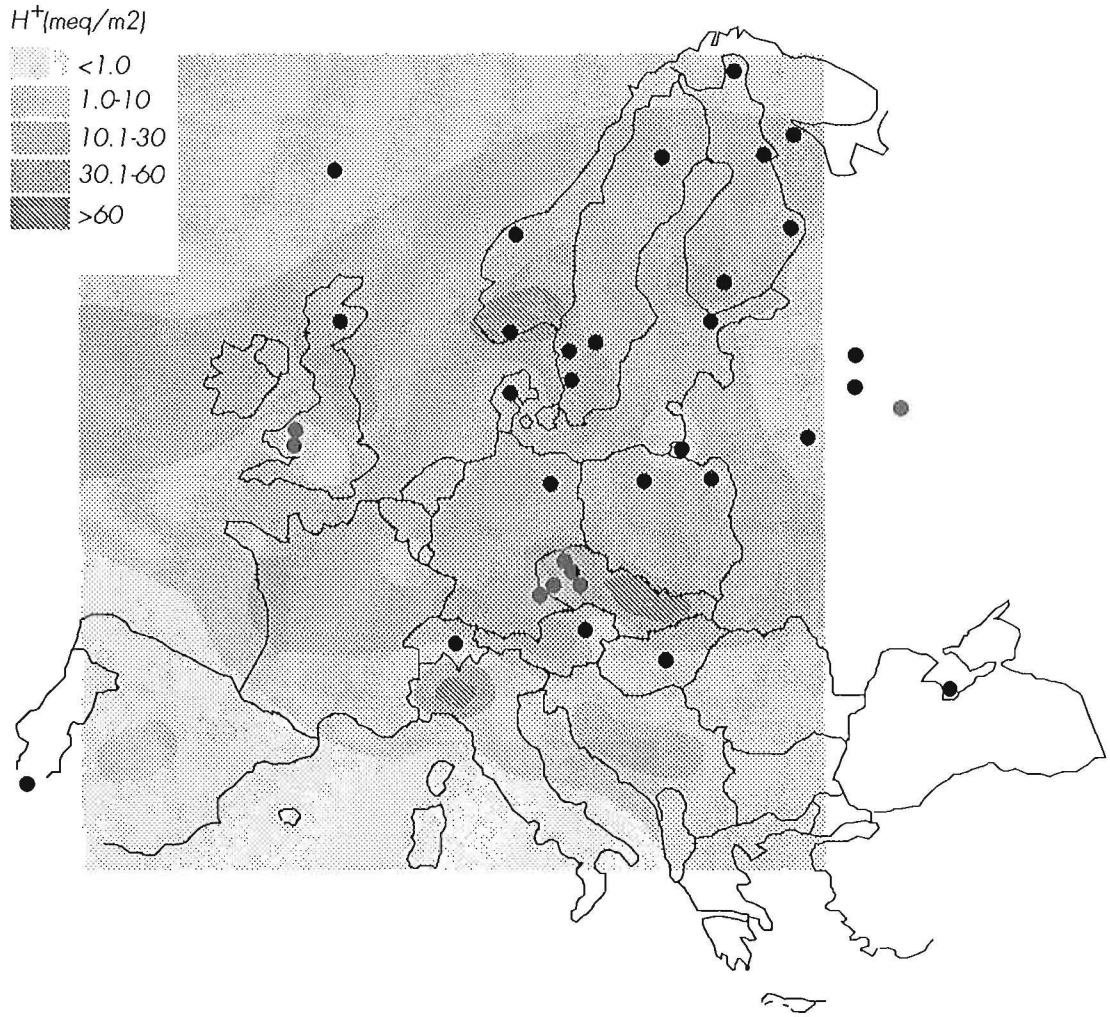


CHAPTER 5

Hydrogen/pH

5.1 Fields of deposition

High deposition areas are associated with southernmost Scandinavia and the mountains of Central Europe. With the exception of northern Italy, the network has a quite sufficient coverage.

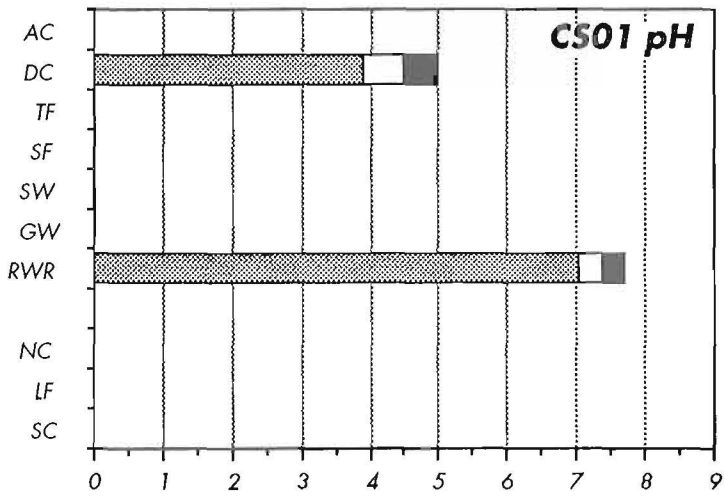


Field of deposition of H^+(meq/m²) in 1988 acc to EMEP (CCC 4190).

5.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,SU11,GB01,GB02)

The acidity of precipitation ranges between pH 4 and pH 5, except for Anenske (CS01) where lower temporal values are recorded, and Afon Hafren (GB02) and Preila (SU11) where higher temporal values are recorded. Values of lakes samples and runoff samples are much higher, > pH 7; even > pH 8 in the Polish areas. Commonly the surface waters are well beyond the critical level of pH 5.8 for hydrobiological activity and diversity, with the exception of occasional drops below this level in Afon Hafren (GB02) and Allt-a-Mharcaidh (GB01). In Stechlin (DD01) and Gardliczno (PL02) the pH is 3.5 ... 4 in organic and mineral topsoil but increases with depth to 4.5 ... 5.5.



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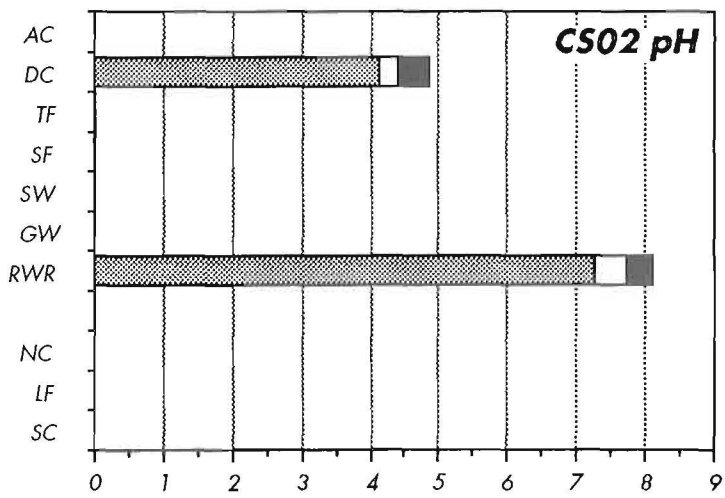

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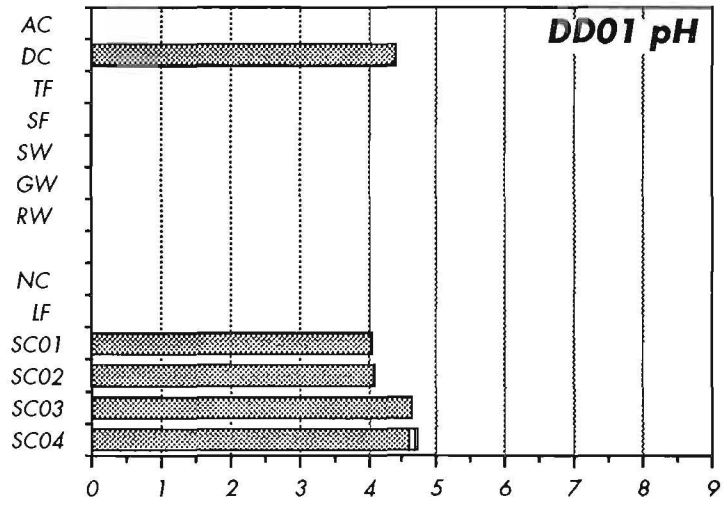

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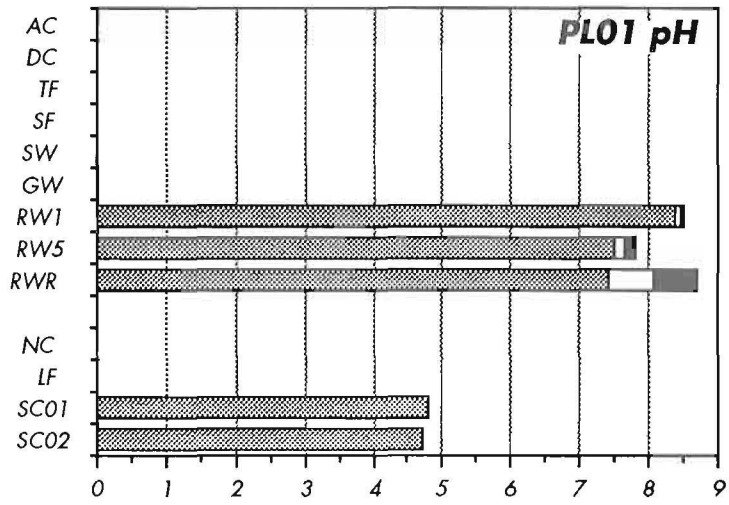
SC03	01 01 8905 8905
SC04	01 01 8905 8905



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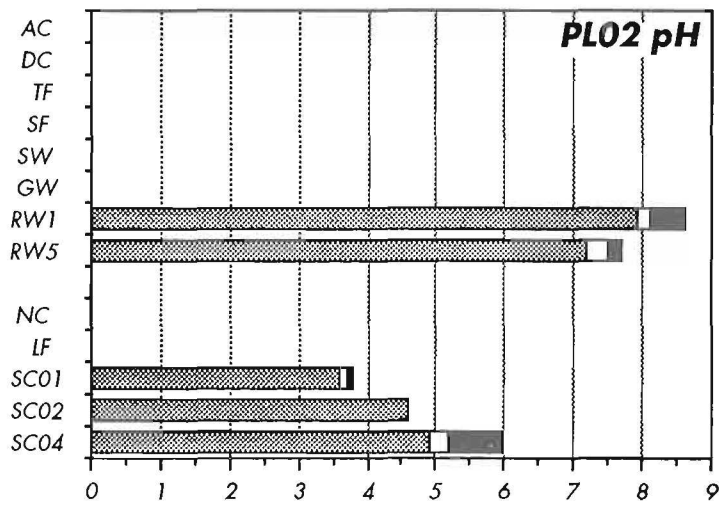

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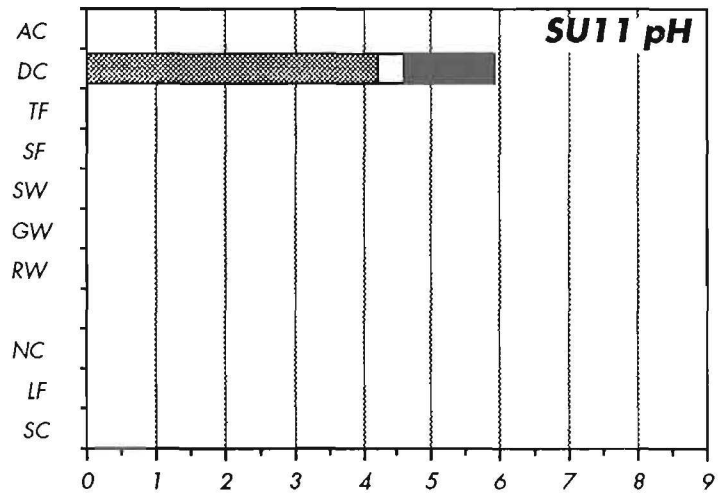

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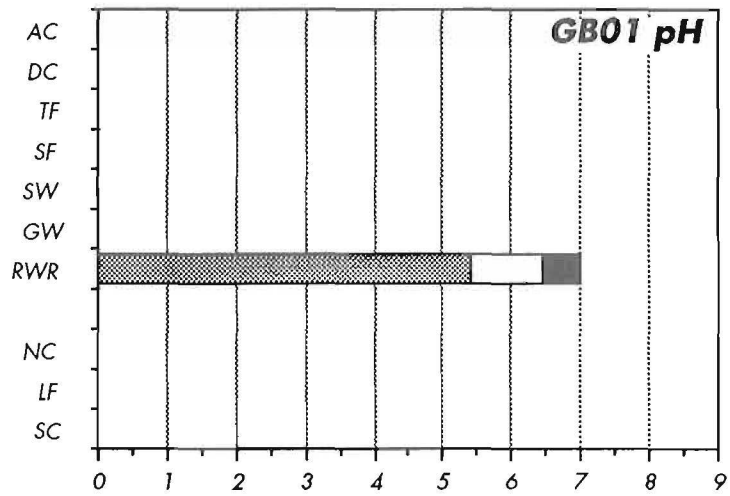

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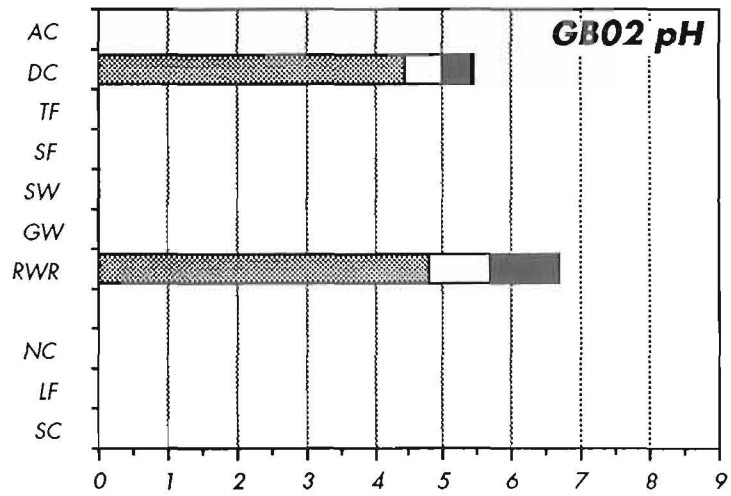

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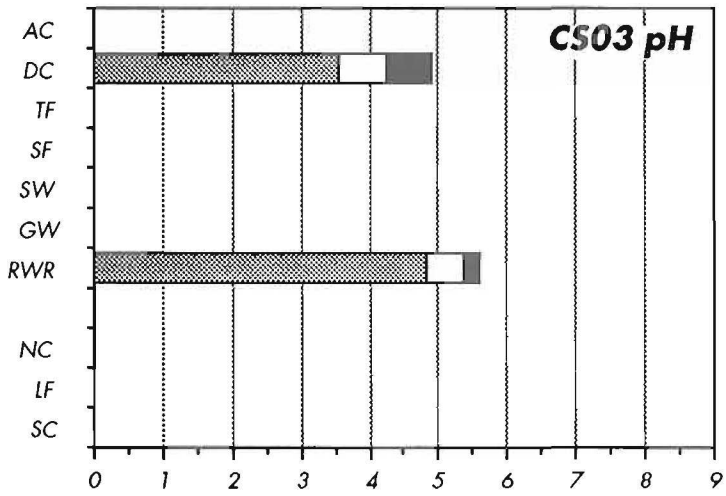
Montaneous Central (CS03,CS04,DE01,CH01)

The acidity of precipitation ranges between pH 4 ... pH 5, but may temporarily rise as high as pH 7 under the influence of alkaline dust/ fog interception at Liz Sumava (CS04). At Jezeri (CS03), one of the most polluted areas in Europe, pH in precipitation is below 4. Recordings in Forellenbach (DE01) indicate a gradual increase of acidity from rainfall to throughfall to soil water. pH values of groundwater and runoff water is > 6, except in Jezeri where it is constantly below the biological critical level. pH (water) values of the mineral topsoil in Forellenbach is 3.5 ... 4 and increase with depth, but not exceeding 5.



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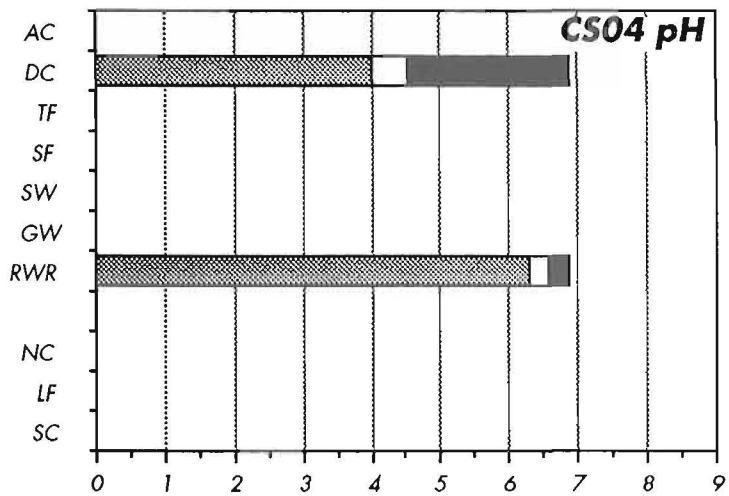

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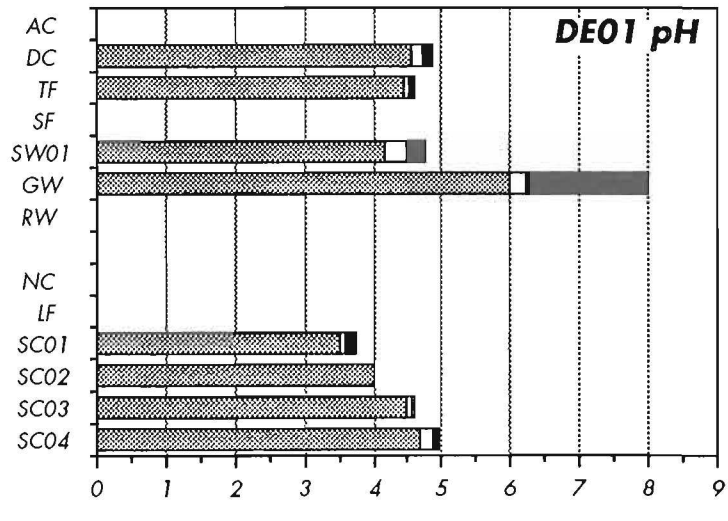

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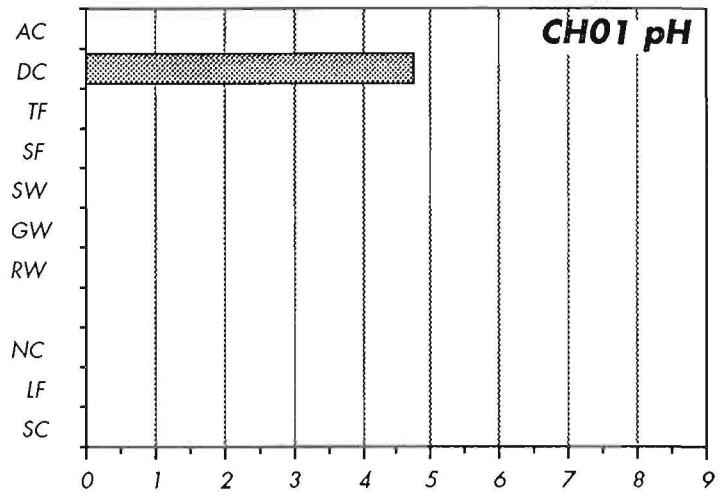

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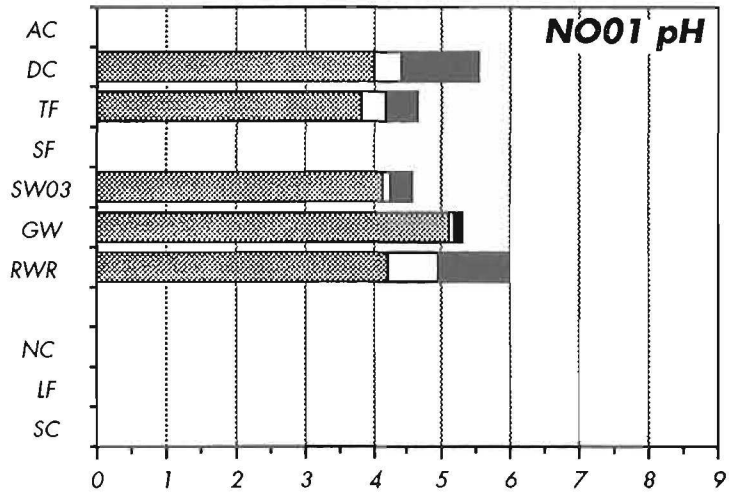
Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

Even in this region pH values of the precipitation range between 4 and 5. The values grow towards east (Soviet areas). Recordings show a decline of pH after passing the canopies and in soil water, except in Valday (SU15), which is influenced by calcareous soil. The pH level again rises in groundwater and runoff water but does not reach above the critical pH 5.8-level in Birkenes (NO01), Gårdsjön (SE04), Berg (SE02), nor in Tiveden (SE01). Only in Valday pH-levels are higher. Here the organic topsoil layer is less acid than the underlying mineral soil layers to a depth of some 20 cm.



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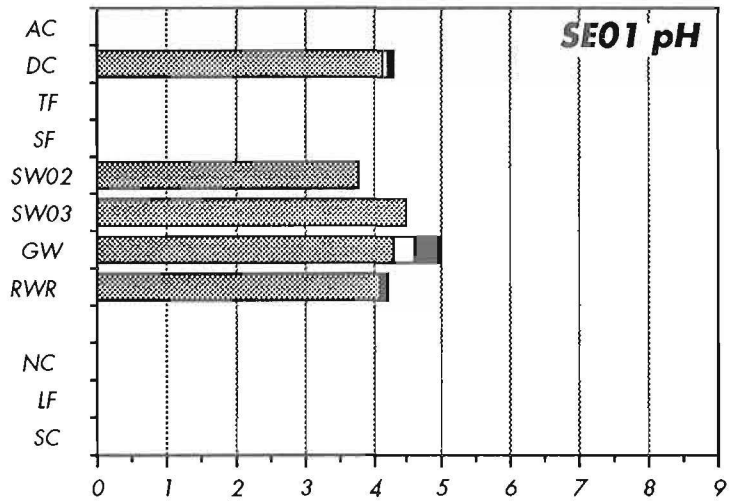

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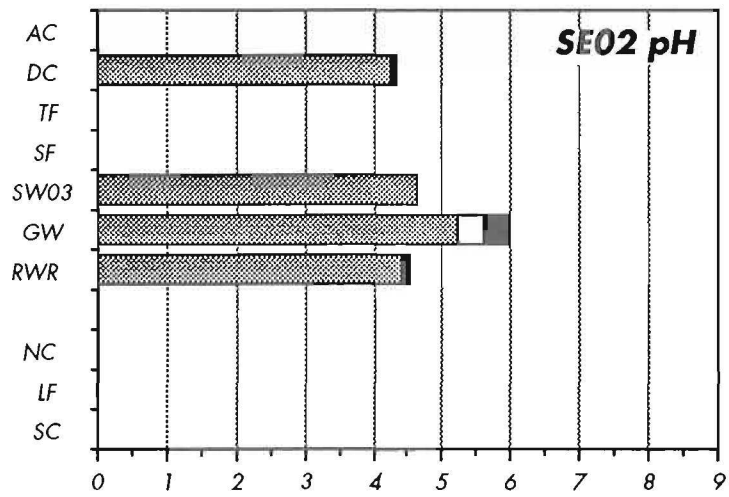

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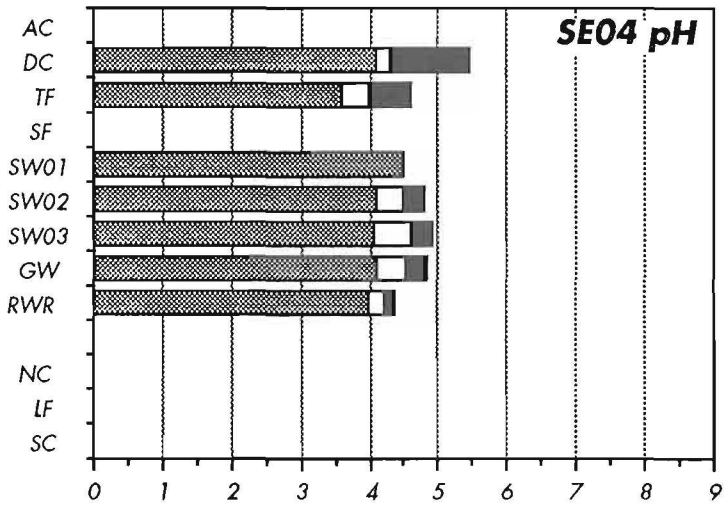

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RWR	01 12 8711 8810
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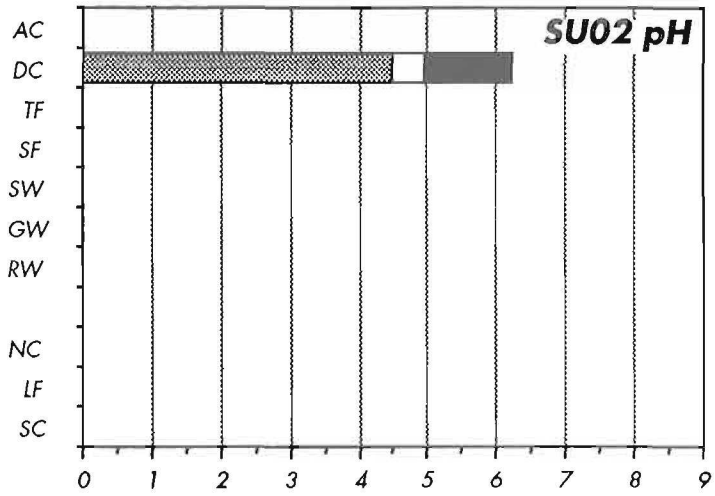

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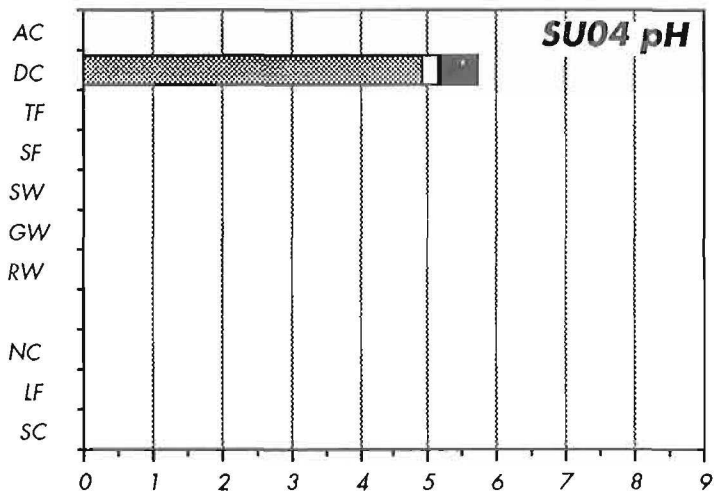

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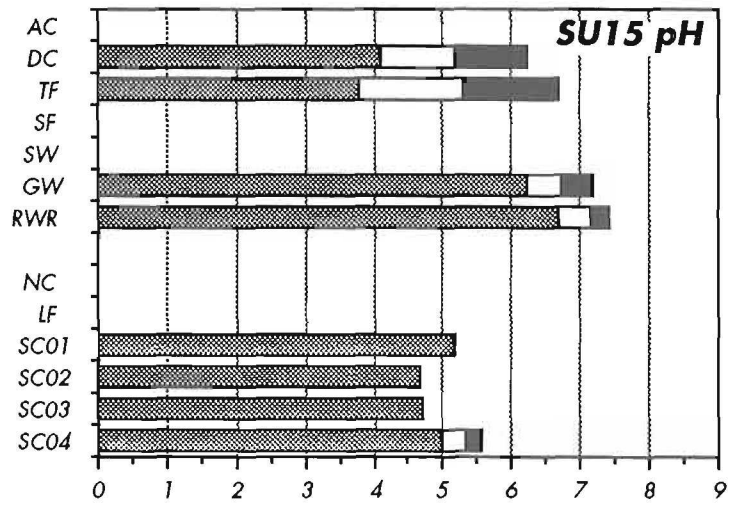

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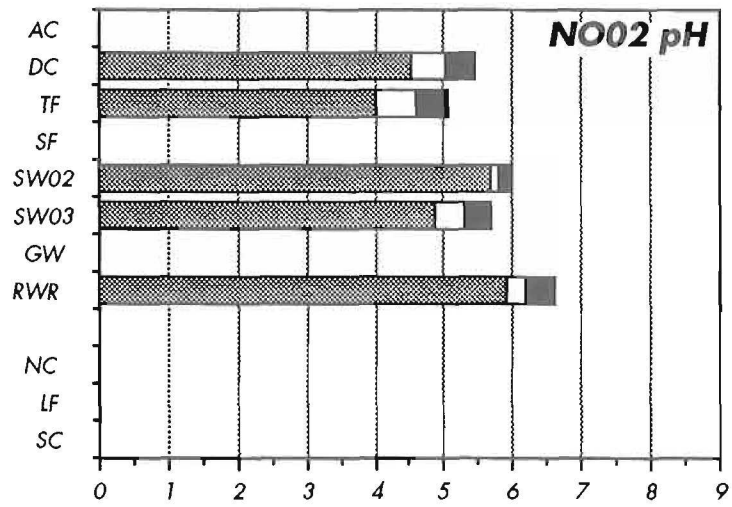
LF	0 0
SC01	01 01 9008 9008
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

In the western part of this region pH of precipitation is about 5, in eastern and northern parts between 4 ... 4.5. Passing the canopies it (stand precipitation) becomes either more acid as in Kårvatn (NO02) and Vuoskojärvi (FI05), or less acid as in Hietajärvi (FI03) and Pesosjärvi (FI04). In the lastmentioned eastern Finnish areas the influence of alkaline dust (dry deposition) from adjacent regions in Soviet neutralizes water by passage. Increasing acidity is recorded in stemflow in this region where pH-values range between 3.5 ... 4. Acidic shocks to trunk epiphytes must be quite common, even during summer months.

In Vuoskojärvi (FI05) pine stemflow values as low as pH < 3 have been recorded. Soil water and surface water pH-values are higher than those of precipitation. Soil water pH (water) is normally between 5 ... 6, running water pH-values from between 6 ... 7 in the western parts, to < 5 in some interior parts (e.g Valkeakotinen, FI01) and increase to 6 ... 7.5 for some northern areas. In the soil column pH-values increase with depth (except on the Velikiy Island, SU16). At their minimum, in the organic topsoil layer, they are slightly < 4 (Valkeakotinen, Pesosjärvi) or slightly > 4 (Hietajärvi, Vuoskojärvi).



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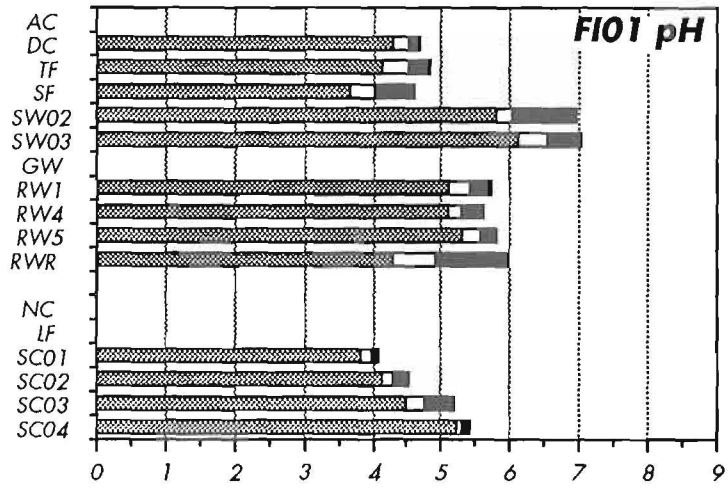

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SC02	05 01 8900 8900
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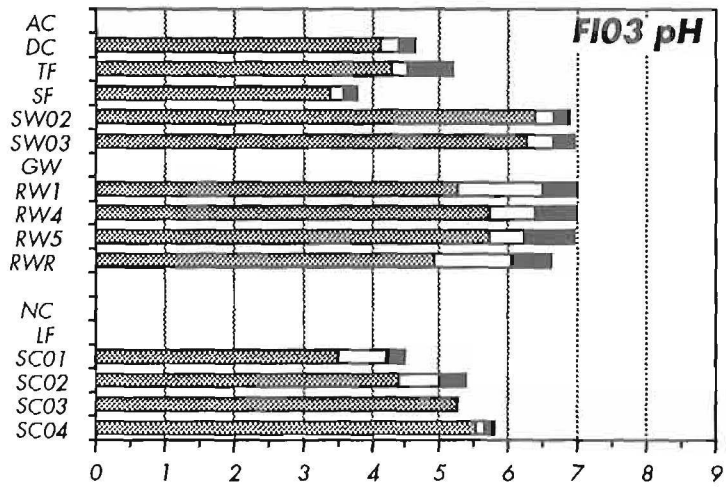
SC04	02 01 8900 8900



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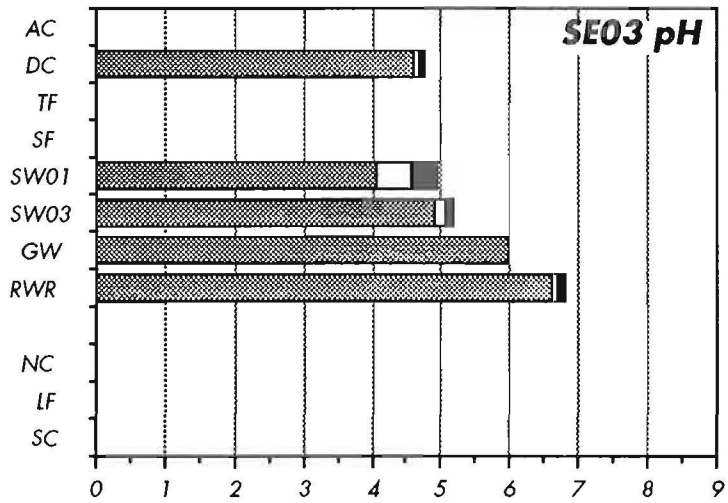

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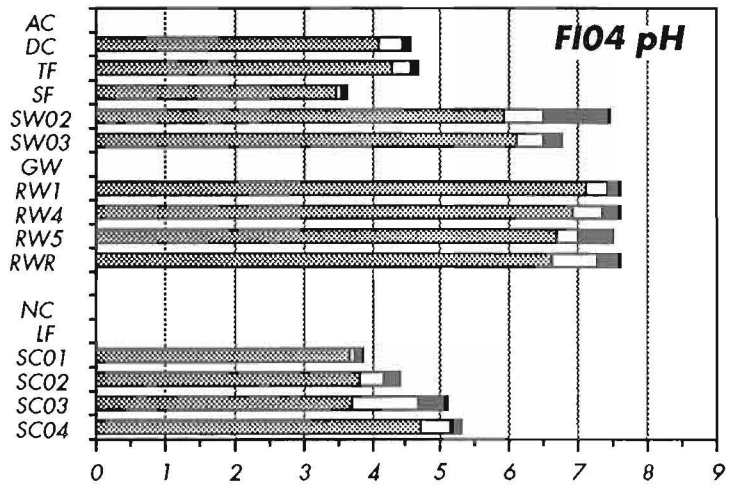

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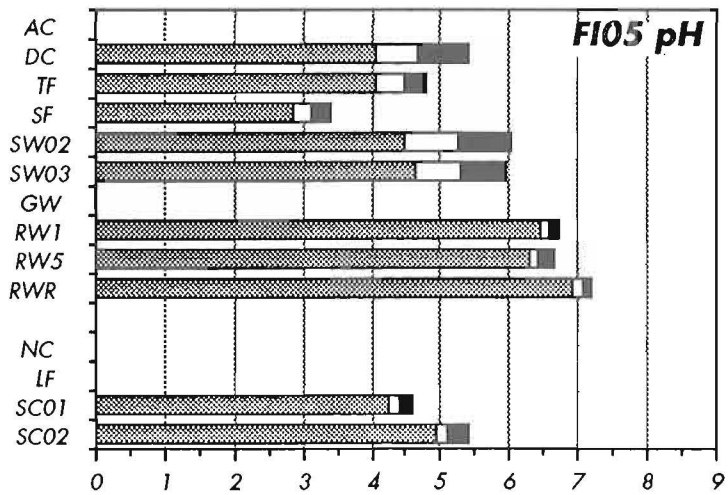

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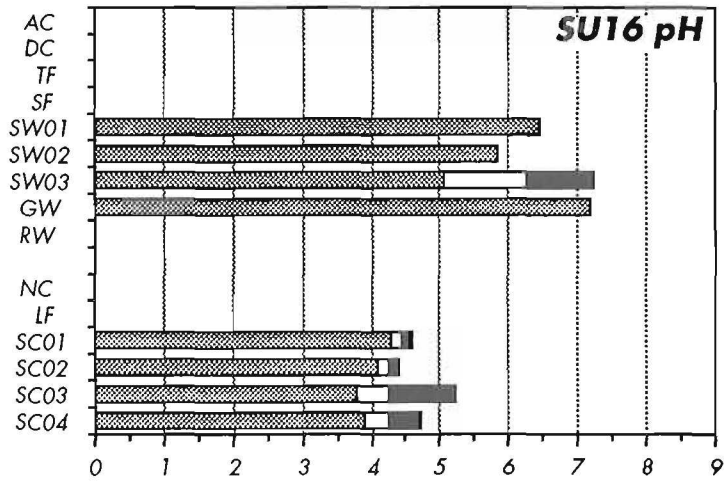

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RW	0 0
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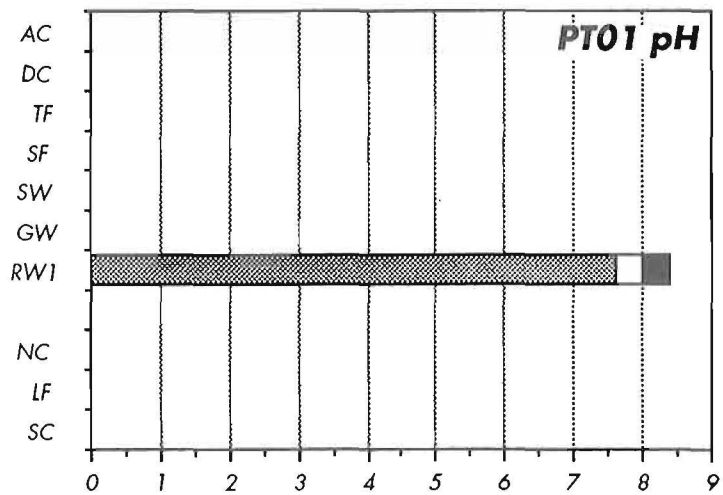
SC01	03 01 8908 8908
SC02	02 01 8908 8908
SC03	03 01 8908 8908
SC04	03 01 8908 8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

The surface waters in Alentejo (PT01) are alkaline (pH 8) due to the calcareous regolith. In Komlosi (HU01) the pH of the precipitation is ca 6 and become more acid upon passing the canopies and along stems, but does not drop below 4. The soils are very alkaline (pH 7.5 ... 8) due to inclusion of calcareous loess.



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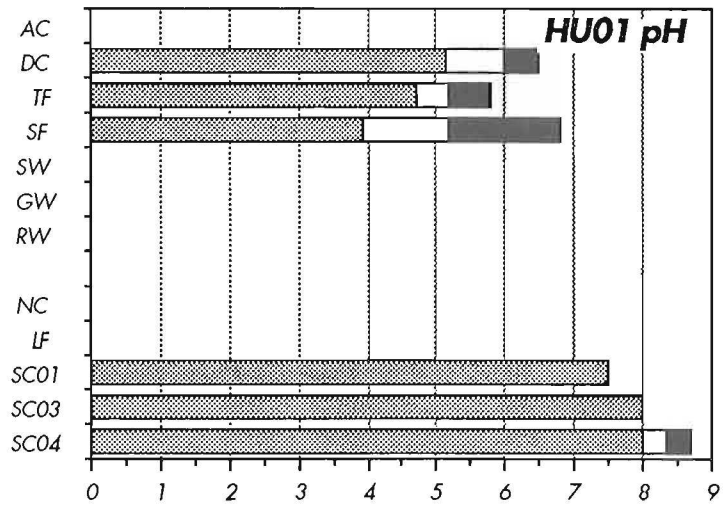

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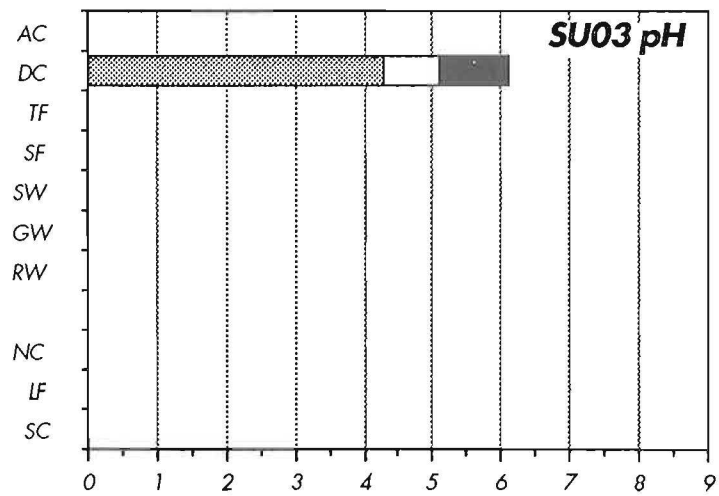
SC01	01 01 8801 8801
SC03	01 01 8801 8801
SC04	01 01 8801 8801

Montaneous East (SU03,SU05)

The pH of precipitation in the Caucasian chain of mountains is between 5 and 6. Groundwaters and runoff waters in these areas show pH-values between 6 and 7.

Nearctic Nemoral (CA01)

The pH-characteristics of precipitation, groundwater and runoff water in Turkey Lakes (CA01) resemble those of the European Nemoral.



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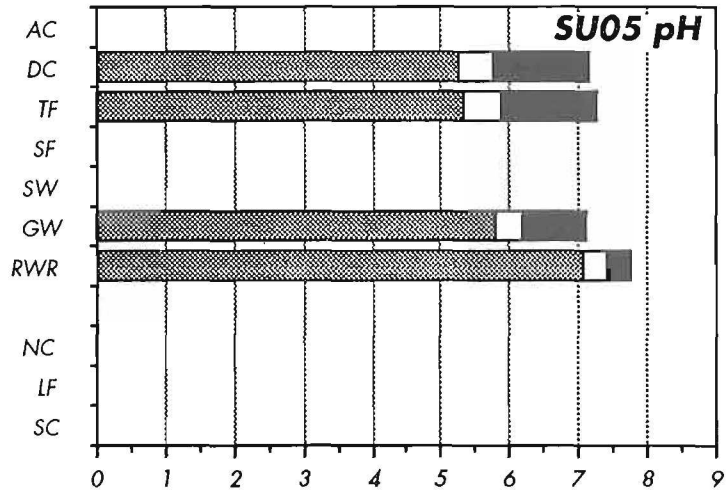

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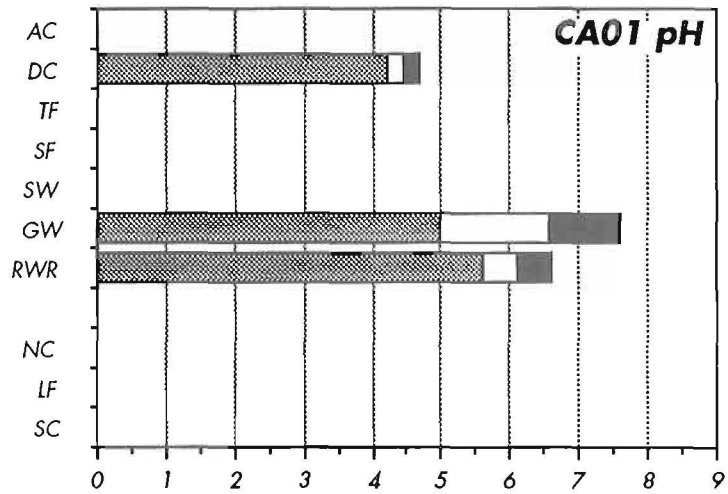

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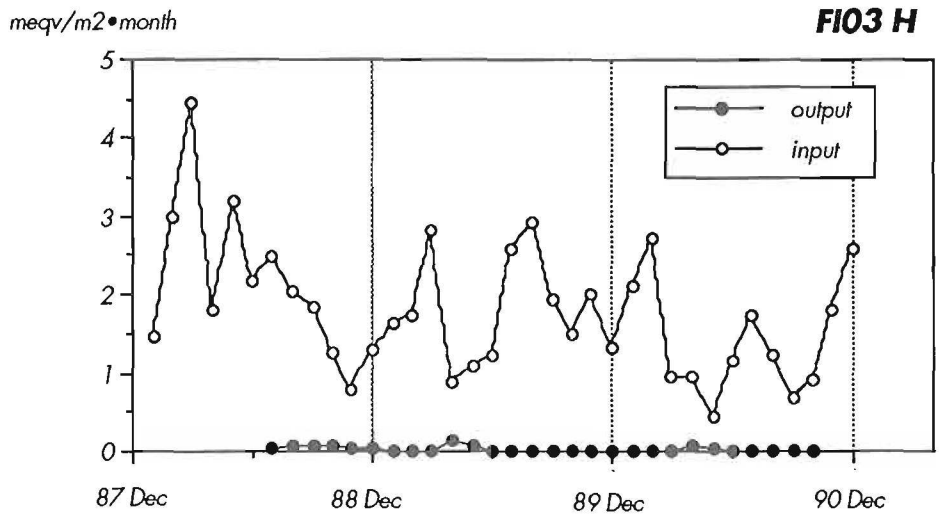
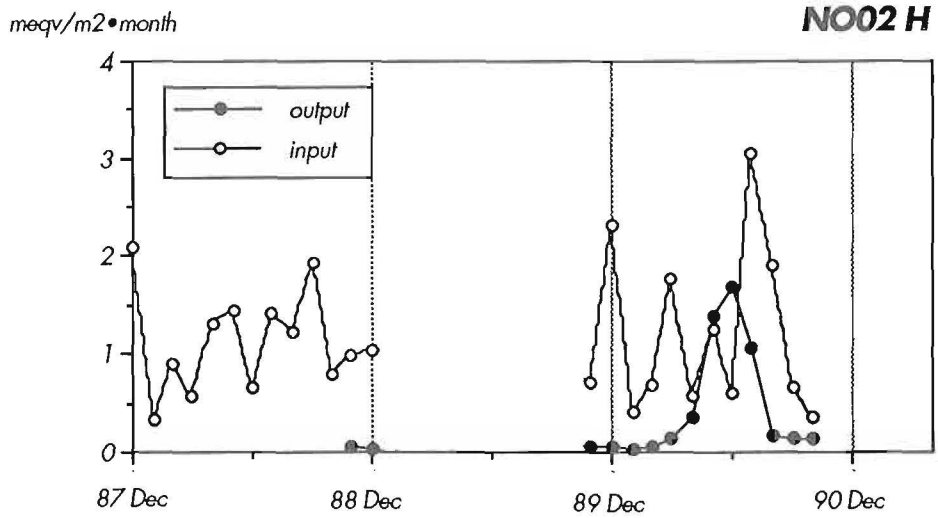
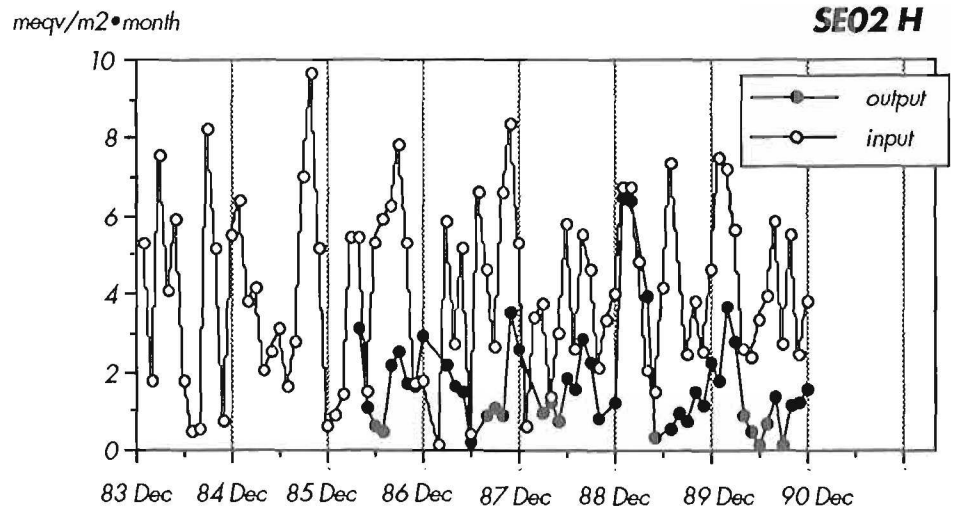
SC	0 0

5.3 Long-term temporal variation

In this section, time series of monthly fluxes of protons expressed as meqv/(m²•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02).



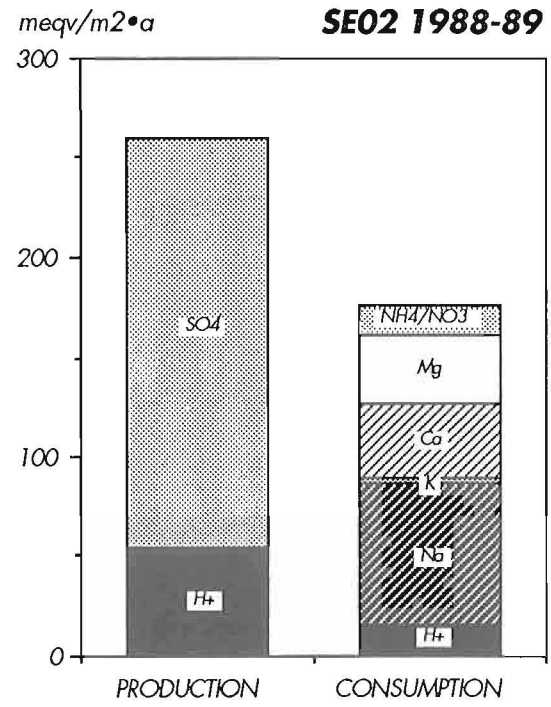


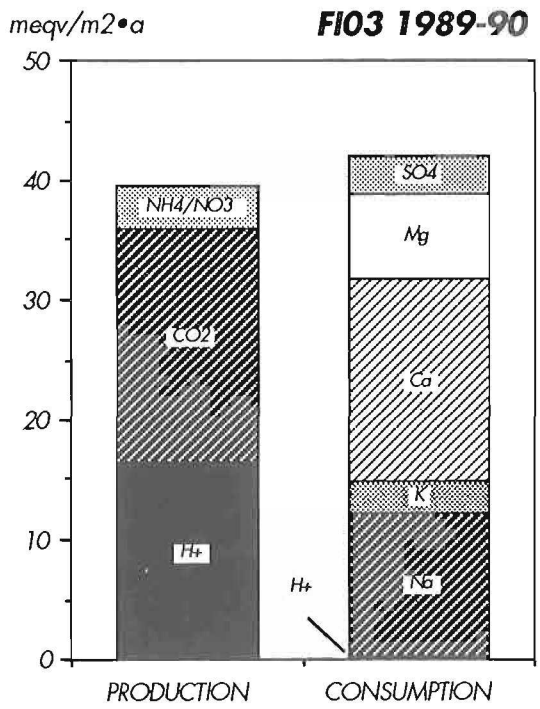


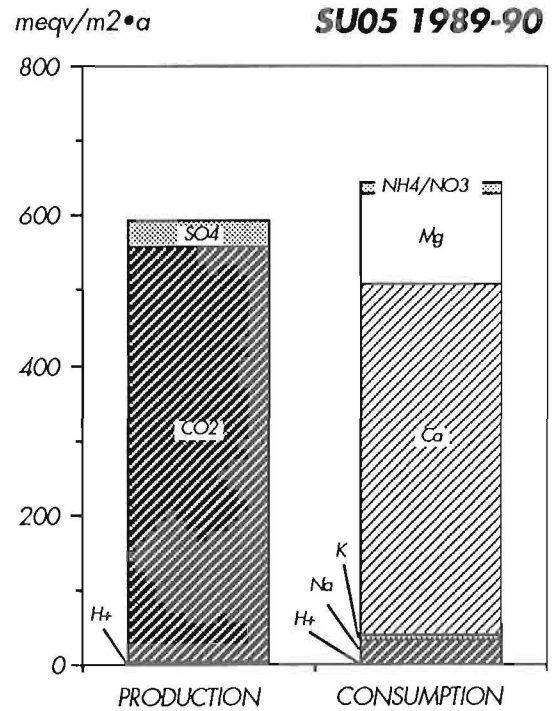
5.4 Proton budgets

Proton budgets can be calculated by studying in- and outfluxes of ionic species. There now exists sufficient data from some of the areas contained in the IM database to perform such calculations. Even a coarse estimation of the proton budget requires input/ output data of 7-10 species. The procedure used here is based on the annual influx and outflux of protons,NH4N,N03N,S045,alkalinity,Ca,Mg,K and Na. The method is conceptually the same as that used by Kallio and Kauppi (1990) (Ion budgets of small forested basins. Kauppi, P. et al (ed.) Acidification in Finland. Springer-Verlag). However, no attempt were made to correct for dry deposition, which in Kallio and Kauppi (1990) is achieved by using a sulphur deposition model, and estimates based on throughfall measurements. Here, the use of the chloride correction for dry deposition estimates is hindered by the fact that for some of the areas in which proton budget calculation otherwise is feasible, the influx of chloride was larger than the outflux, for the hydrological year studied.

A proton budget calculation based on only input/ output analysis leaves the contribution of internal processes - weathering,ion excange and possible retention, biological accumulation (and NH4/N03-dynamics in the case of nitrogen) - visible only as a net source or sink. Still even such a simplified analysis can give us valuable information on the variability in magnitude of the proton budget and ionic components of importance between different areas. The figures underneath can be seen as exemplifying this. Obvious sources of error are the facts that dry deposition is ignored, no estimation of the effect of organic anions or aluminium has been carried out, and that a period of only one hydrological year was studied.







CHAPTER 6

Calcium

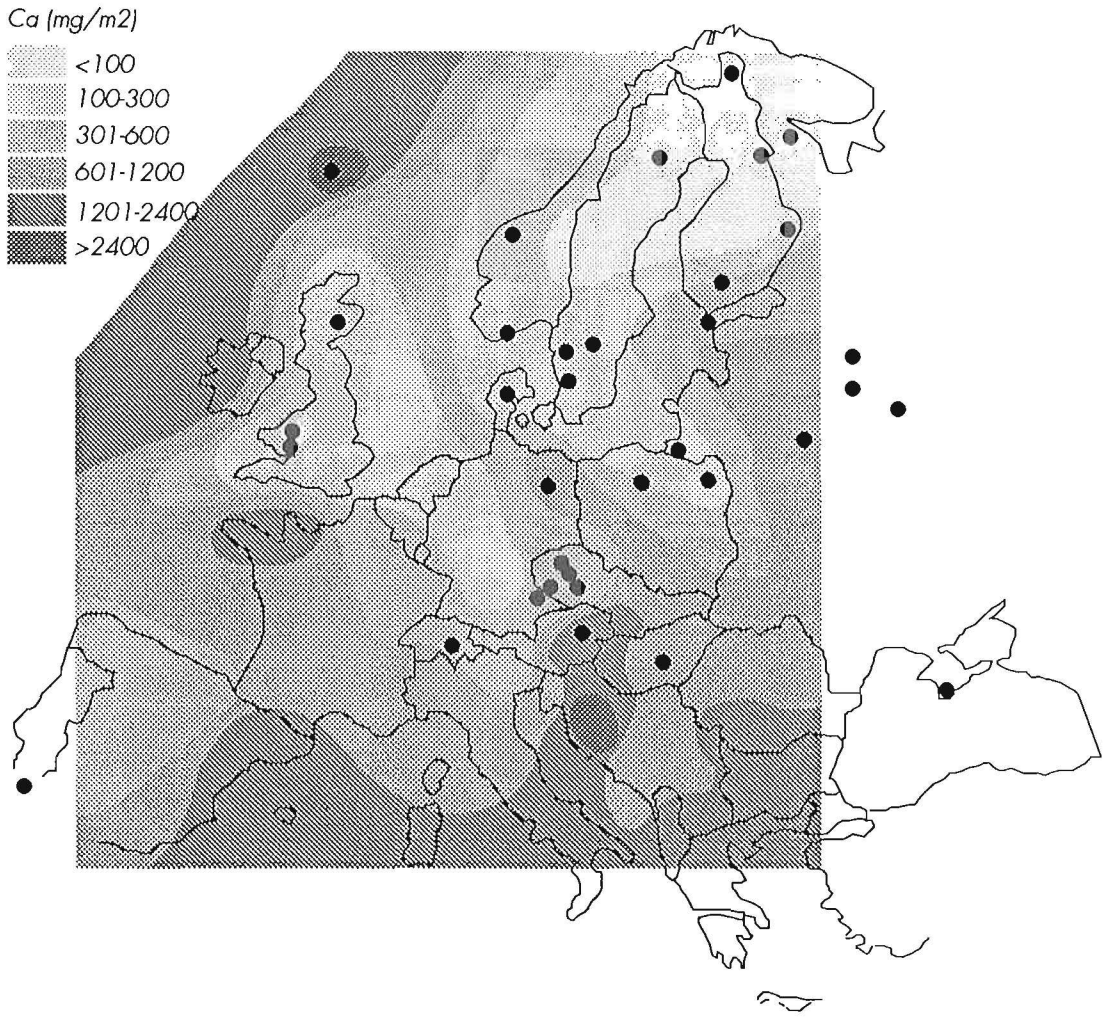
6.1 Fields of deposition

The main source of calcium is in the sea-spray or in dust-blows from arid areas (influence of Sahara in the south). The network covers the areas with the lowest deposition, not those influenced by long-range transport and high deposition.

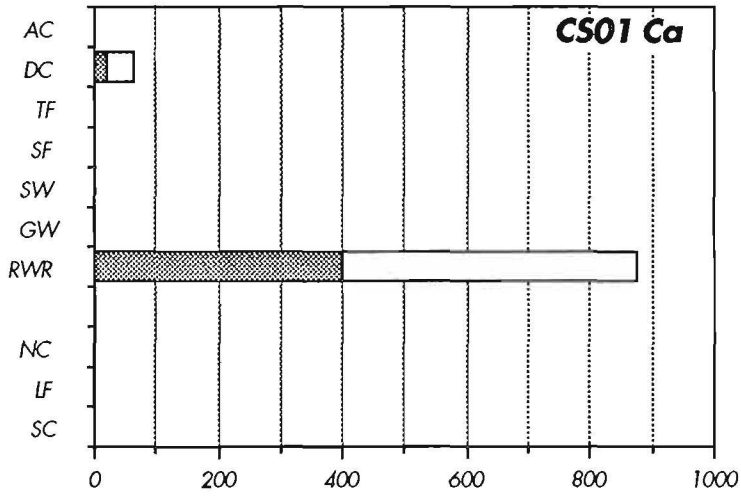
6.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,GB01,GB02)

The concentrations in rainfall are mostly insignificant, except for the areas of Anenske (CS01) and Stechlin (DD01) where the influence of dust particles from coal-burning is evident. The levels in runoff and surface water of lakes are much higher as displayed by the Czech and Polish areas. Very high values are also found in the topsoil in the Polish areas and in the needles of Lekuk (PL01).



Field of deposition of Ca (mg/m²) in 1988 acc to EMEP (CCC 4190).



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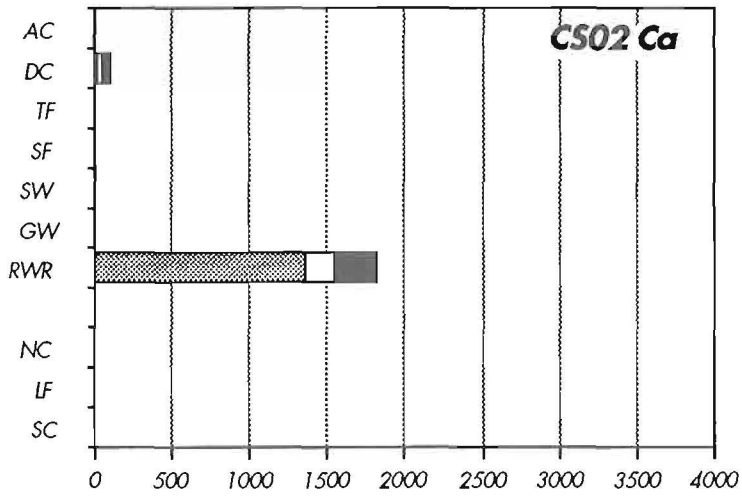

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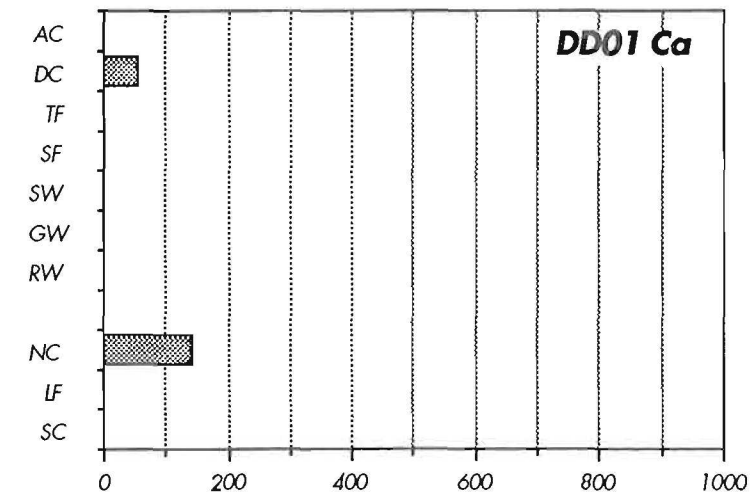

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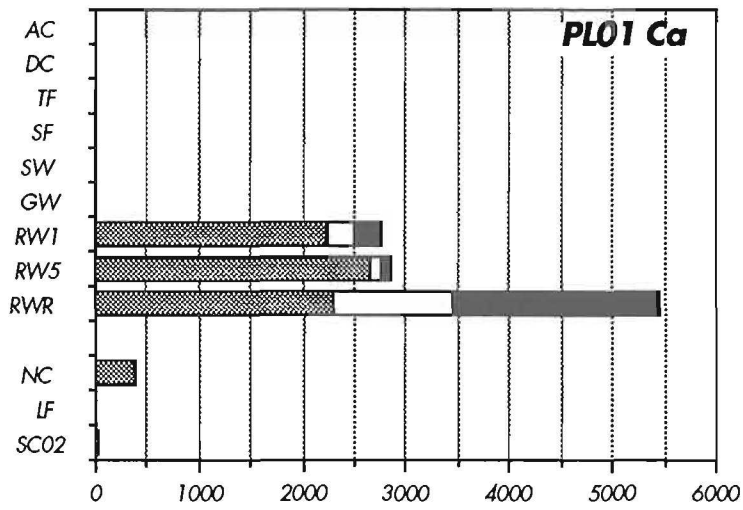

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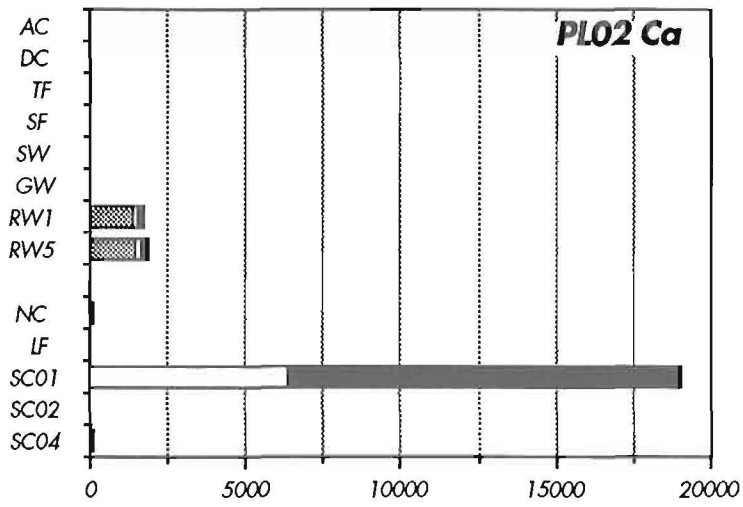

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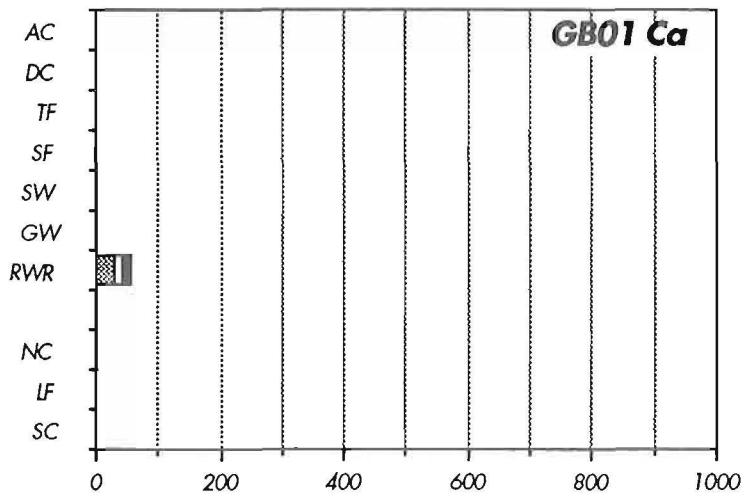

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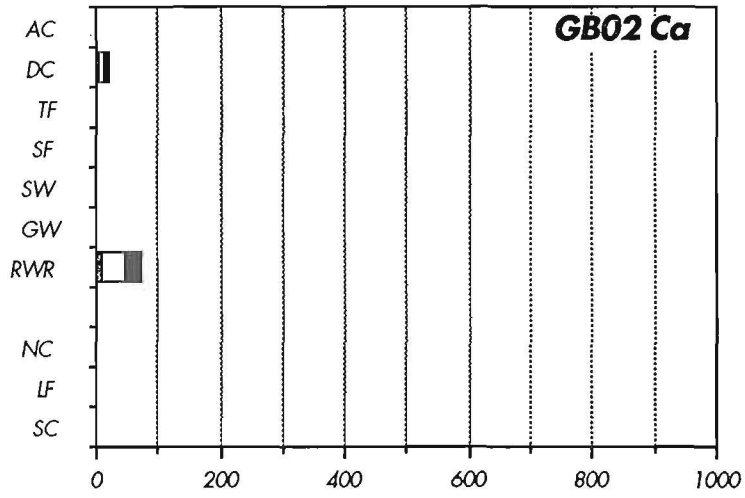

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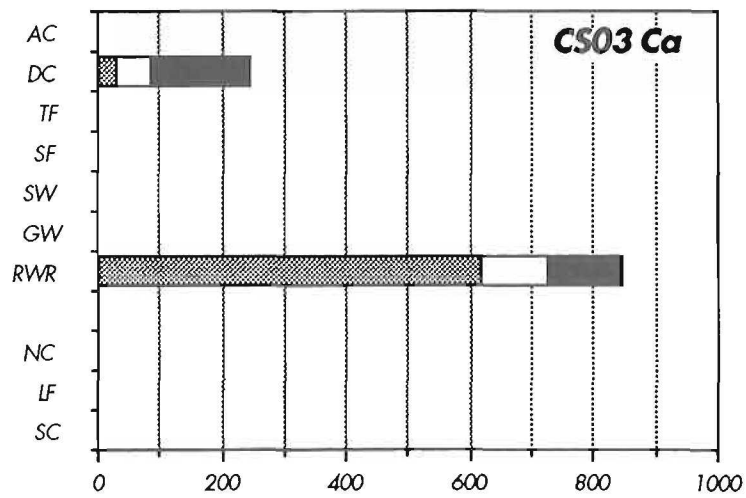
Montaneous Central (CS03,CS04,DE01,CH01)

Precipitation values are insignificant, except for the Jezeri (CS03) area influenced by Ca-rich coal-burning. Runoff values are high, reaching 200 ... > 800 µeqv/l/month in the Czech areas, and even above 2500 µeqv/l/month in Erlentobel (CH01) where the calcareous flysch affects the output. In Forellenbach (DE01) the levels in the groundwater may in some month exceed 1500 µeqv/l.



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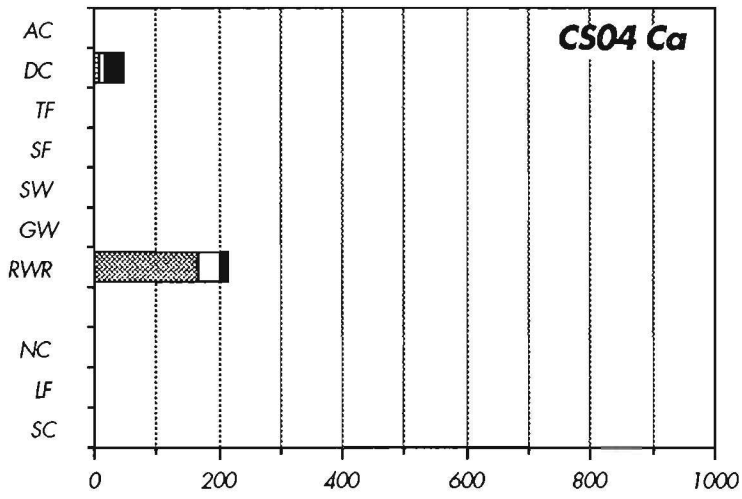

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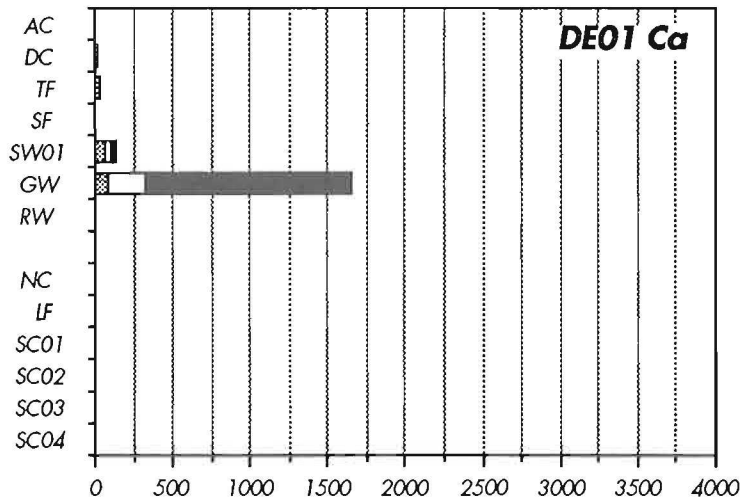

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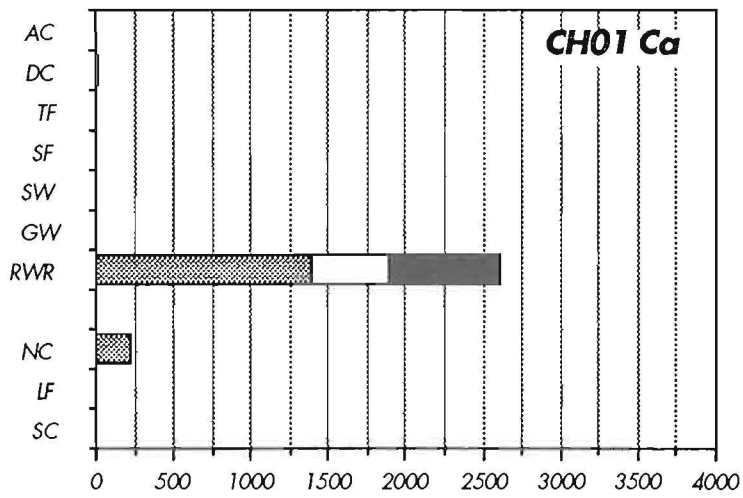
SC03	02 01 9008 9008
SC04	03 01 9008 9008



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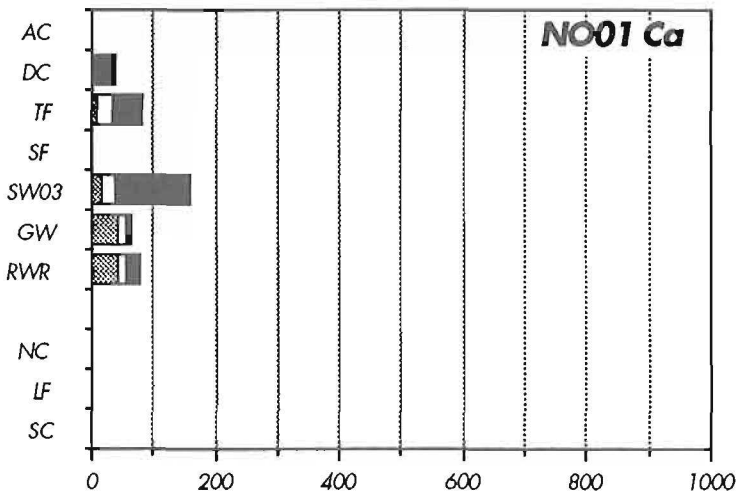
LF	0 0
SC	0 0

Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

Precipitation levels are very low. The enrichment in throughfall implies factors of 6 ... 10. With the exception of Birkenes (NO01) and Valday (SU15) throughfall levels exceed soil water levels. The groundwater concentrations are higher or equal to the soil water concentrations. Runoff water concentrations may be higher (SE02, SU15), similar (NO01, SE04) or lower (SE01) than the groundwater concentrations. In Valday groundwater concentration maxima may reach 2500 µeqv/l/month. The organic topsoil also show higher levels than do lower minerogenic soil-horizons, which also affect the pH-values.



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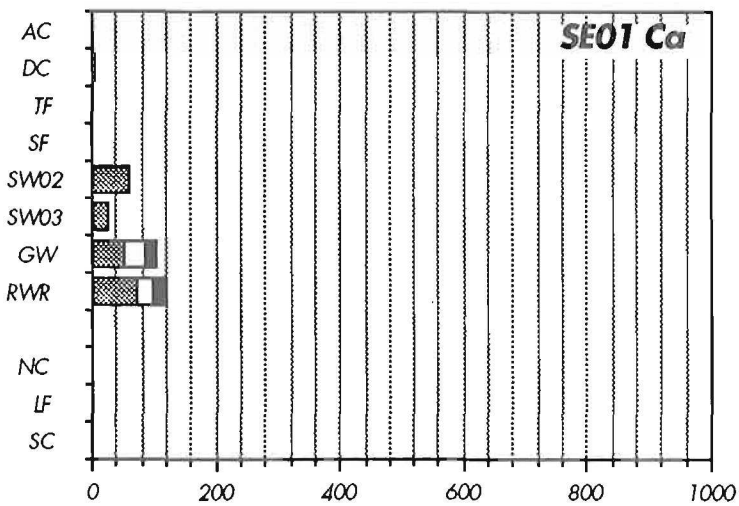

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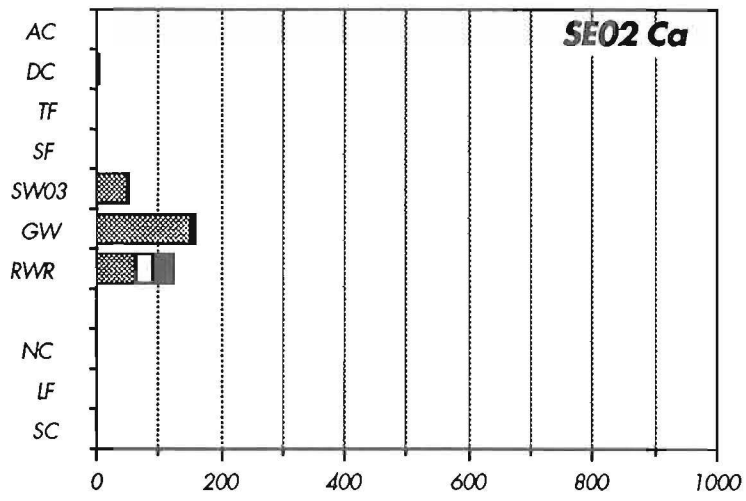

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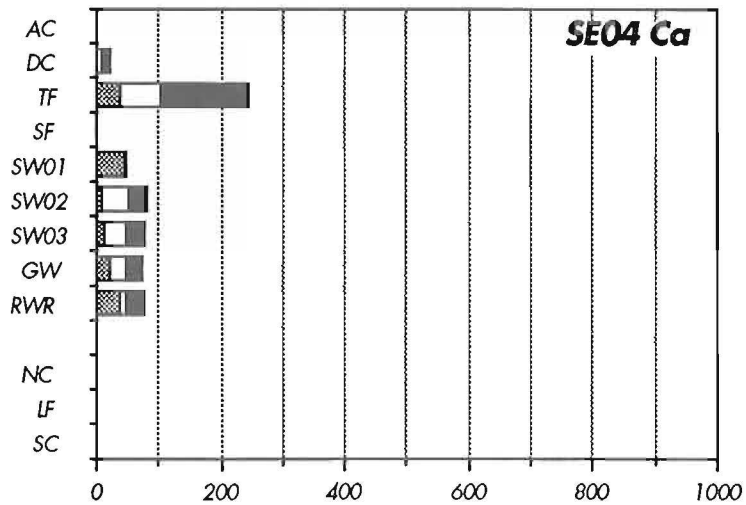

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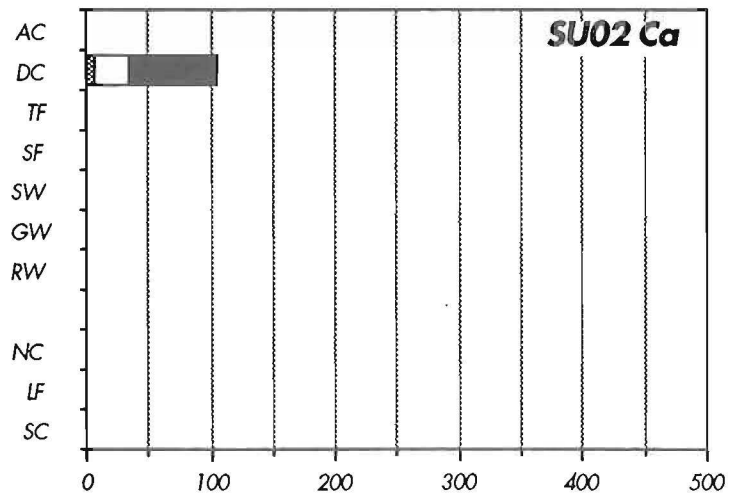

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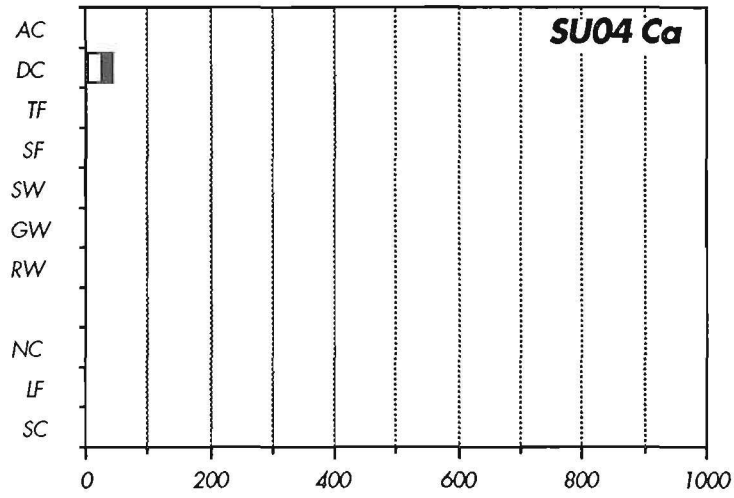

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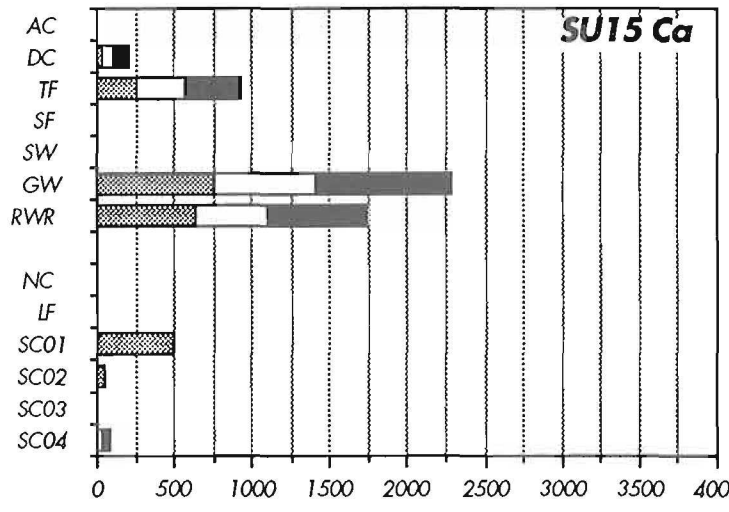

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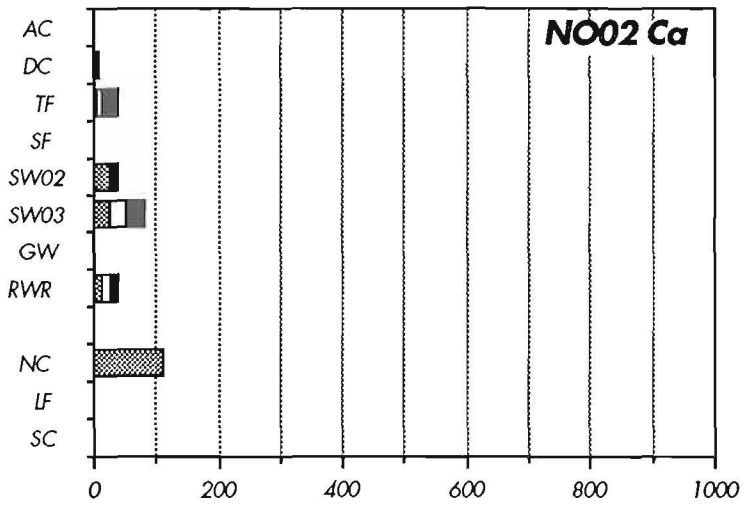
SC01	01 01 9008 9008
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

As a rule levels in precipitation are lower than in throughfall which again are lower than in stemflow. The concentrations increase in the soilwater and runoff water. The northernmost areas (SE03, FI04, FI05) show some discrepancies.



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SW03	01	06	9005	9010
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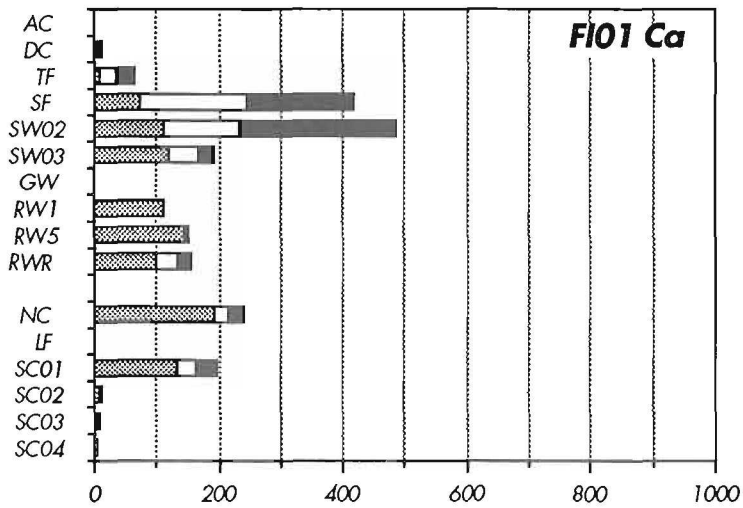

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SW03	02	04	8907	8910
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RWR	01	03	9002	9008
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LF	0	0		
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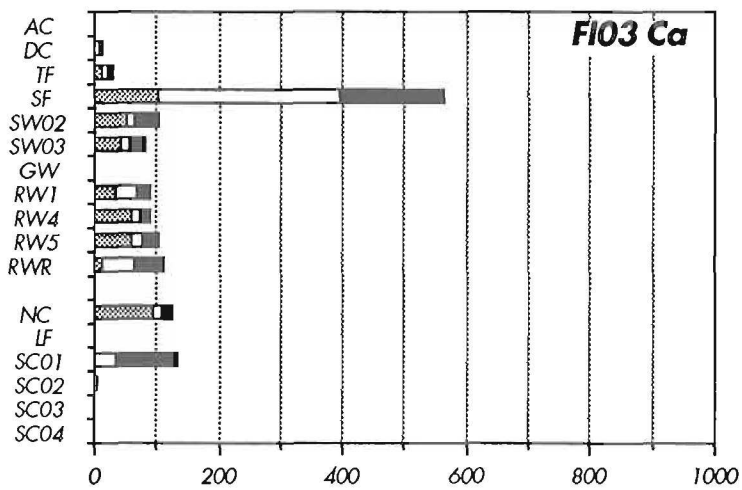

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SW03	02	03	8908	8910
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RW4	02	11	8912	9010
RW5	02	11	8912	9010
RWR	03	12	8911	9010
NC	06	01	8800	8800
LF	0	0		
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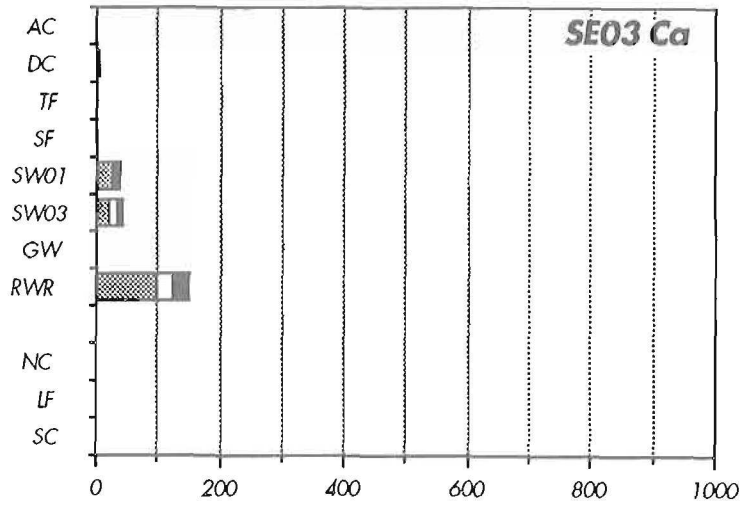

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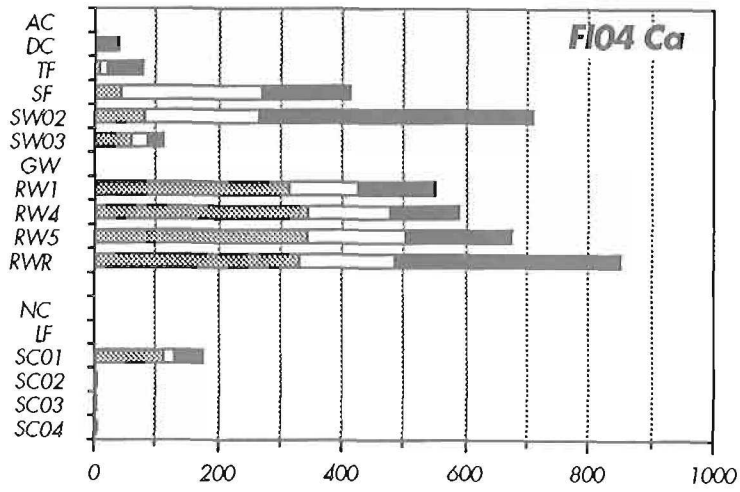

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RW4	01 03 9004 9009
RW5	01 03 9004 9009
RWR	04 12 8911 9010
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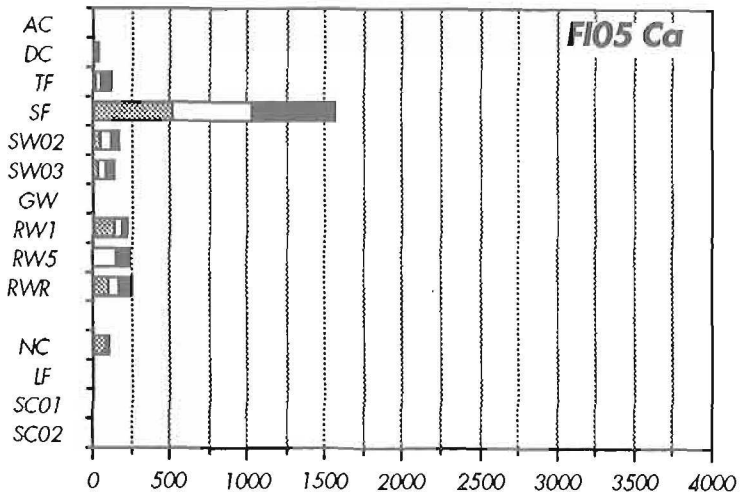
SC03	05 01 8900 8900
SC04	05 01 8900 8900



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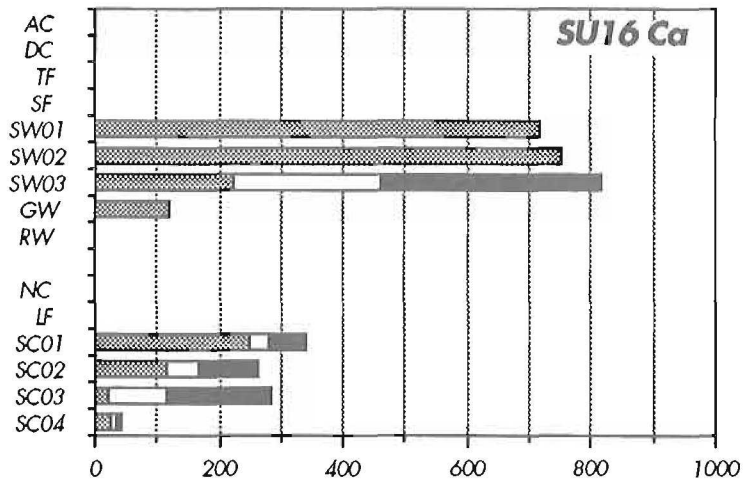

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RW	0 0
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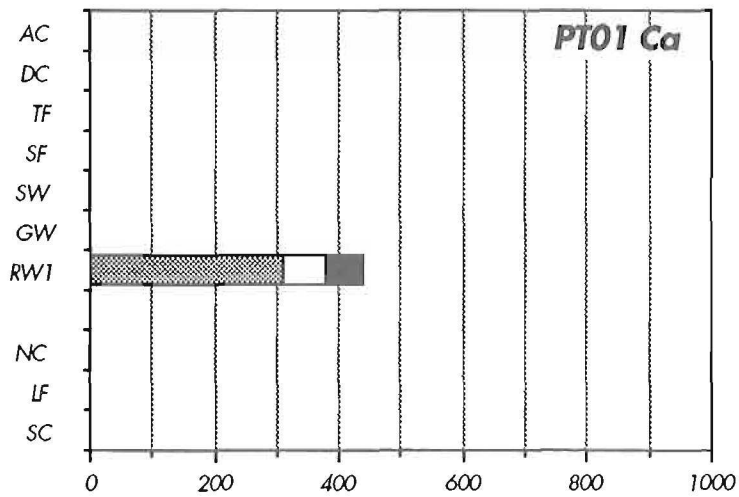
LF	0 0
SC01	03 01 8908 8908
SC02	02 01 8908 8908
SC03	03 01 8908 8908
SC04	02 01 8908 8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

The lake surface concentrations in Alentejo (PT01) are high and influenced by inflow of soluables from the calcareous regolith. In Komlosi (HU01) enrichment proceeds from precipitation to throughfall to stemflow. In the latter, temporal values up to 2000 µeqv/l/month are recorded.

Montaneous East (SU03,SU05)

The precipitation concentrations in the Caucasus are relatively high. In the Juga Massif runoff water temporarily show concentrations in excess of 600 µeqv/l/month.



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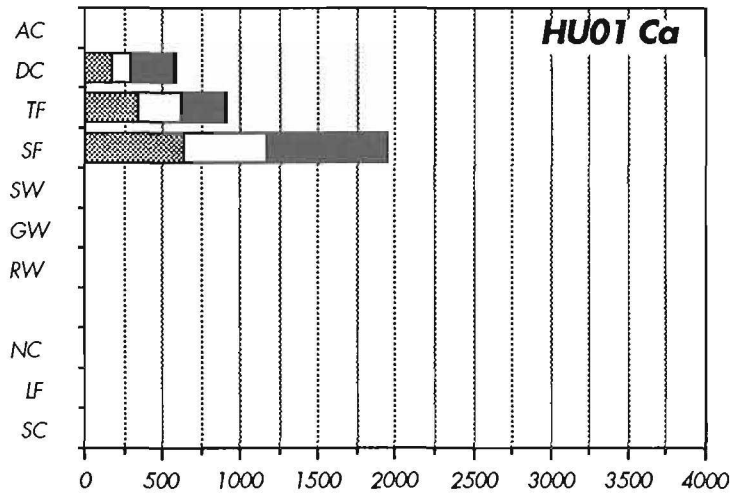

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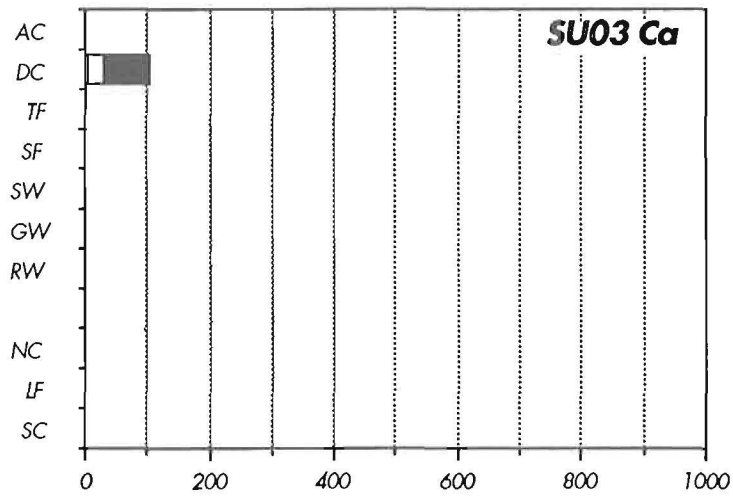

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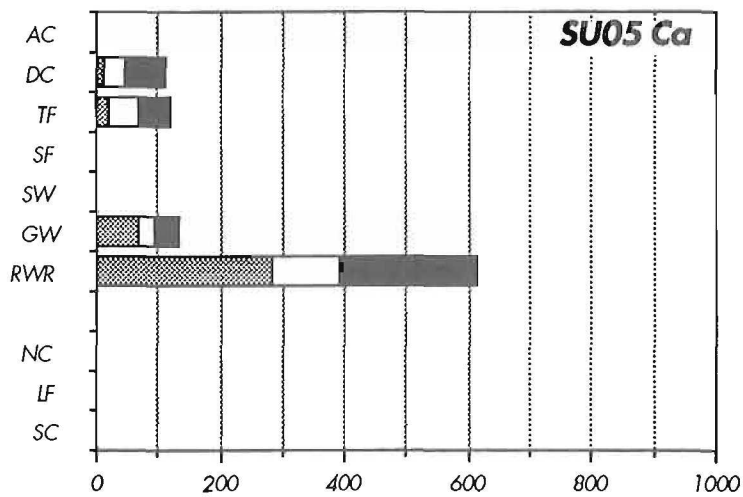

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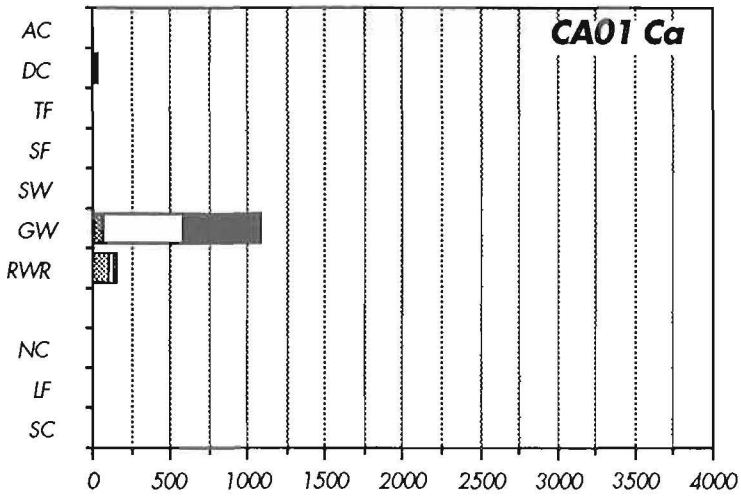
SC	0 0

Nearctic Nemoral (CA01)

The most notable feature in the Turkey Lakes area (CA01) is the high calcium variation in groundwater.



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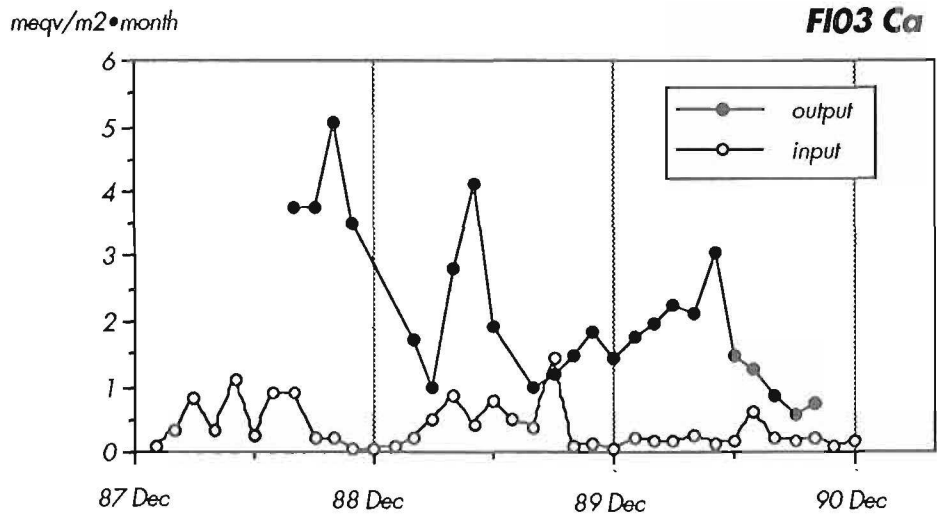
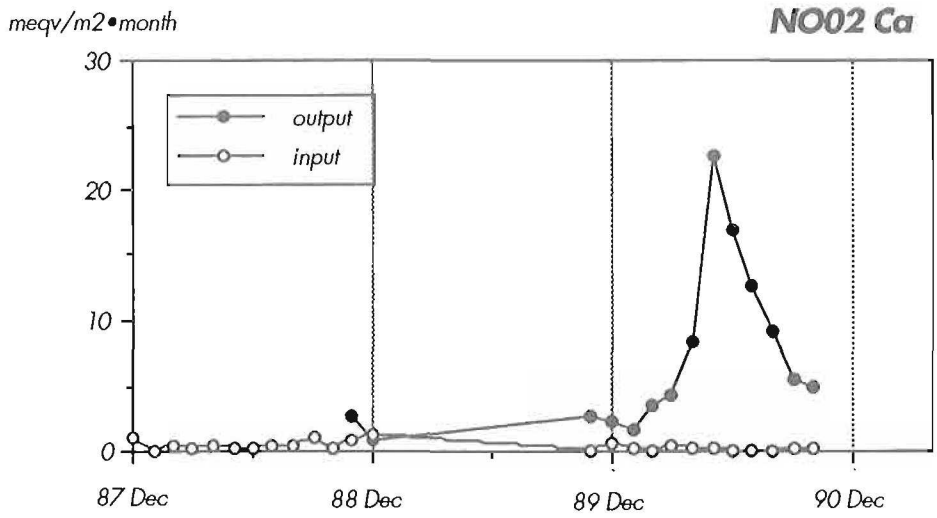
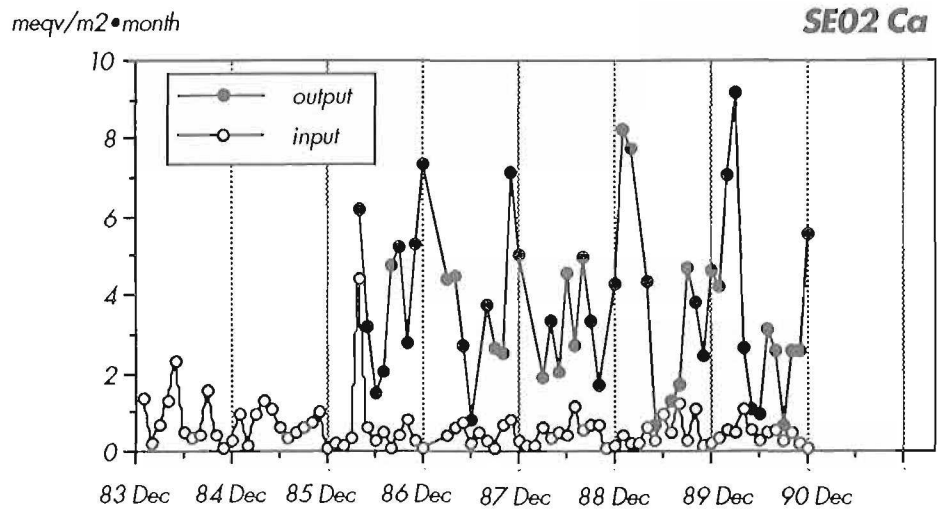
SC	0 0

6.3 Long-term temporal variation

In this section, time series of monthly fluxes of calcium expressed as meqv/(m^2•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02). N.B. Not corrected for sea-salts.







Soil chemistry

Following table contains available information on cation exchange capacity and base saturation in soils.

SOIL CHEMISTRY

AREA	DATE	SOIL LEVEL	BASA	CEC	COR/NTOT	COR/STOT
DE01	9008	SC1	6.8	119.0	22.7	225.4
		SC2	3.9	121.8	26.8	415.0
		SC3	2.2	81.2	23.0	625.0
		SC4	2.2	41.5	18.6	262.3
FI01	8900	SC1 *	83.4	258.8	35.5	278.5
		SC2	29.8	42.7	26.6	242.0
		SC3	26.5	23.0	22.1	89.3
		SC4	47.7	7.7	17.0	58.3
FI03	8800	SC0	76.0	208.7	49.6	362.0
		SC1 *	32.8	67.4	47.7	203.7
		SC2	28.2	6.3	46.1	112.5
		SC3	43.6	3.6	30.0	45.0
		SC4	40.6	2.0	15.0	25.0
FI04	8900	SC1 *	78.2	250.7	51.0	379.2
		SC2	32.1	21.7	33.2	215.0
		SC3	31.8	12.9	26.2	118.0
		SC4	36.2	7.2	21.3	48.0
FI05	8800	SC0	75.7	233.4	42.1	311.8
		SC1	25.2	23.1	36.9	187.5
		SC2	32.2	8.3	28.3	115.0
HU01	8801	SC1	.	.	8.8	.
		SC3	.	.	6.5	.
		SC4	.	.	4.5	.
PL01	8810	SC2	23.1	.	7.3	58.2
PL02	9006	SC1	70.9	.	43.1	89.5
		SC2	40.4	.	23.6	.
		SC4	75.7	.	.	.
SU15	9008	SC1 *	96.0	578.7	27.2	.
		SC2	68.0	71.5	12.6	.
		SC3	26.0	35.1	13.0	.
		SC4	64.7	52.8	10.0	.
SU16	8908	SC1 *	40.1	.	33.0	2610.0
		SC2	25.7	.	.	.
		SC3	34.5	.	27.7	100.5
		SC4	37.4	.	13.7	59.8

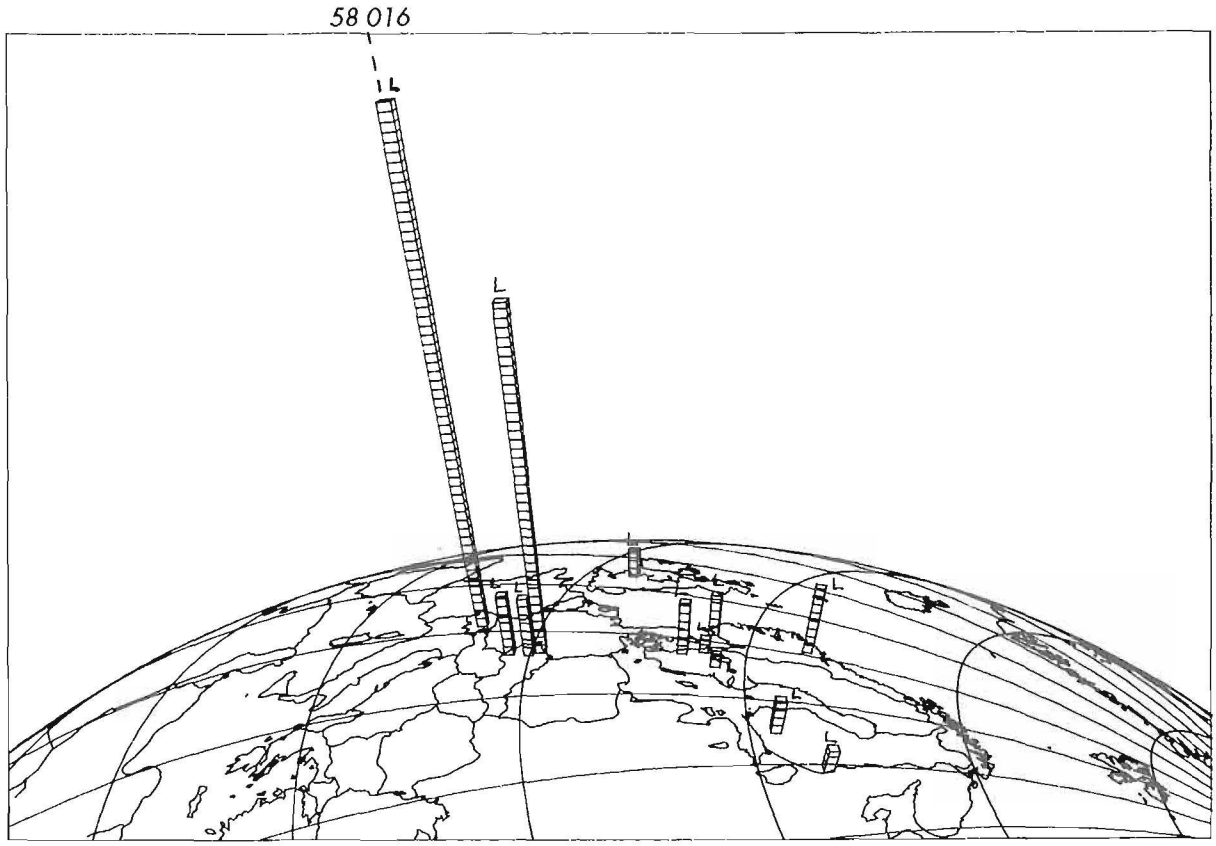
level 0 = PODZ_OH, PODZ_OFH
** includes also PODZ_OH, PODZ_OFH, PODL_O, PODZ_O1*

6.4 Mass balances

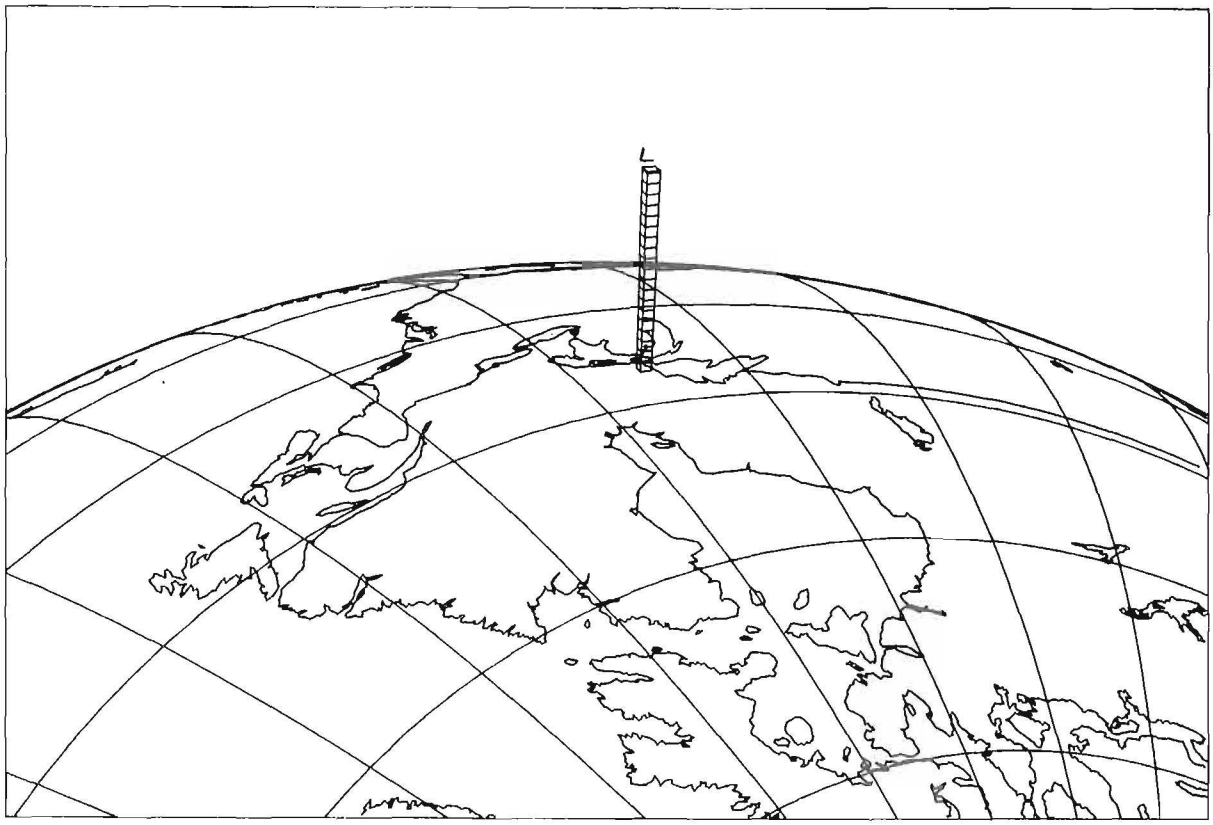
Calcium is leached from all monitored areas. The amounts vary a lot, being highest in limestone rich areas and smallest in petrological regimes of acid rocks. Extreme leaching is displayed by the Erlentobel catchment (CH01) where the two consequtive periods indicate a leaching rate of 5.5 - 6 kg/ha/yr.

Calcium (together with magnesium) plays an important role in the buffering capacity of the soil. Some base saturation (BASA) and cation exchange capacity (CEC) values are listed in table 1. It may be seen that the base saturation is very low in Forellenbach (DE01) compared with other areas. The saturation is also lowered in the Polish areas and in Velikiy (SU16) close to the Kola peninsula. The highest base saturation and cation exchange capacity is found in the Valday catchment (SU15) on Cretaceous limestone.

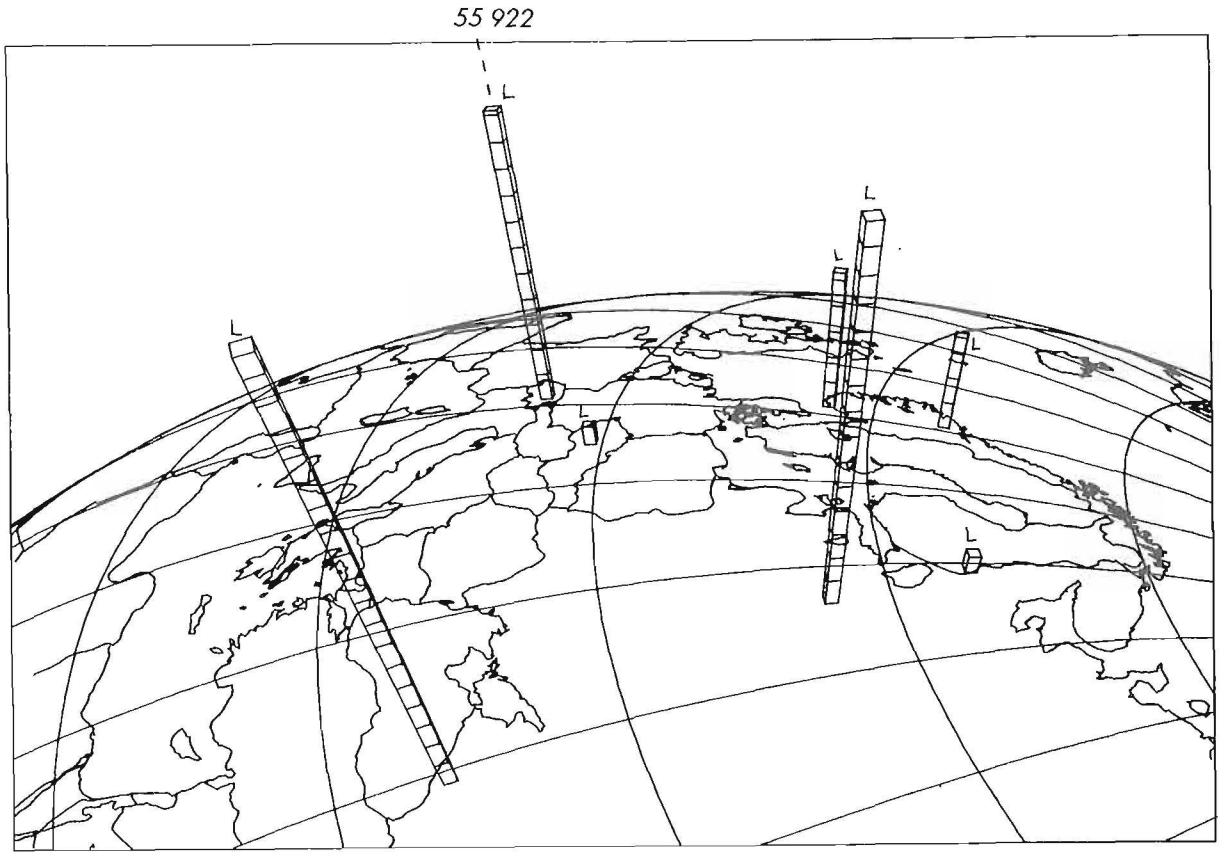
Ca 1988-89, scale unit 100 mg/m²•a



Ca 1988-1989, scale unit 100 mg/m²•a



Ca 1989-90, scale unit 500 mg/m²•a



CHAPTER 7

Sodium

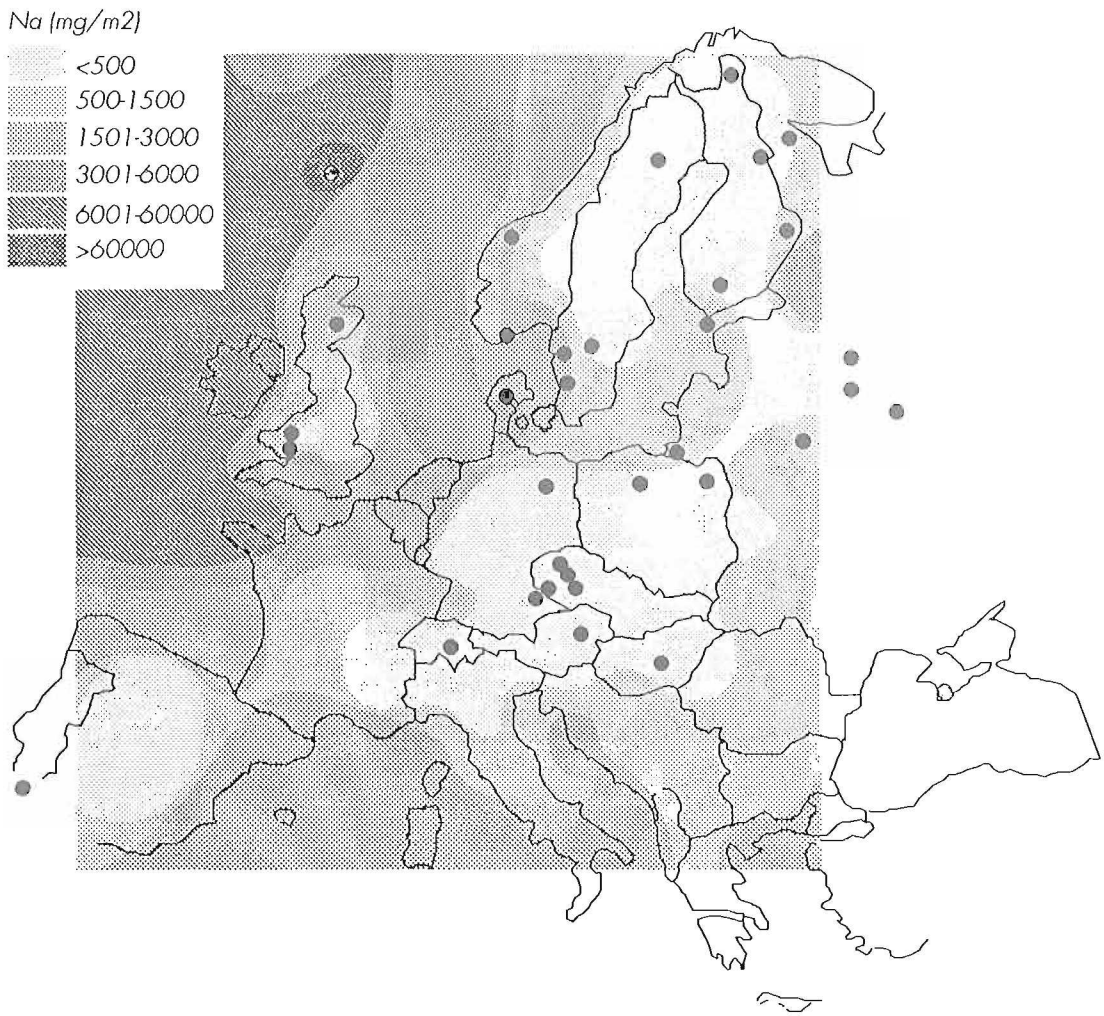
7.1 Fields of deposition

The main source of sodium is in sea-spray. The network coverage is rather good, provided that monitoring can be started in the north Atlantic islands too.

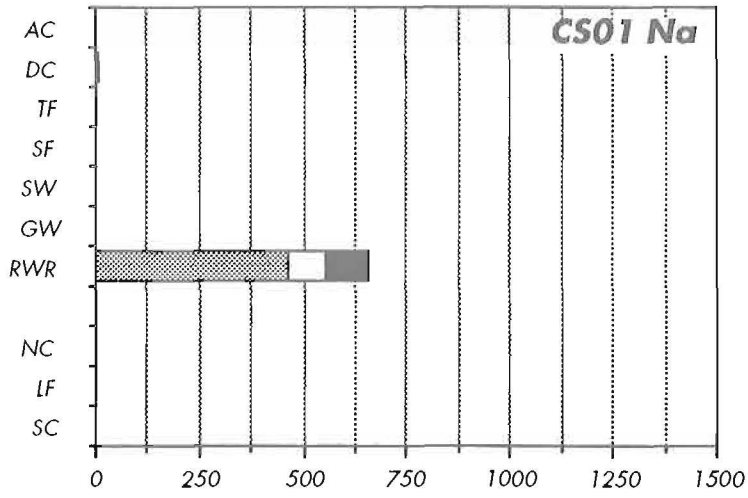
7.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,GB01,GB02)

Precipitation concentrations are low and runoff water concentrations high (some possibly anthropogenically influenced by road-salts) in the central areas; towards west, in United Kingdom, the sodium concentrations in precipitation increase with the influence of sea-salt spray. Gardliczno (PL02) show high concentrations in the topsoil.



Field of deposition of Na (mg/m²) in 1988 acc to EMEP (CCC 4190).



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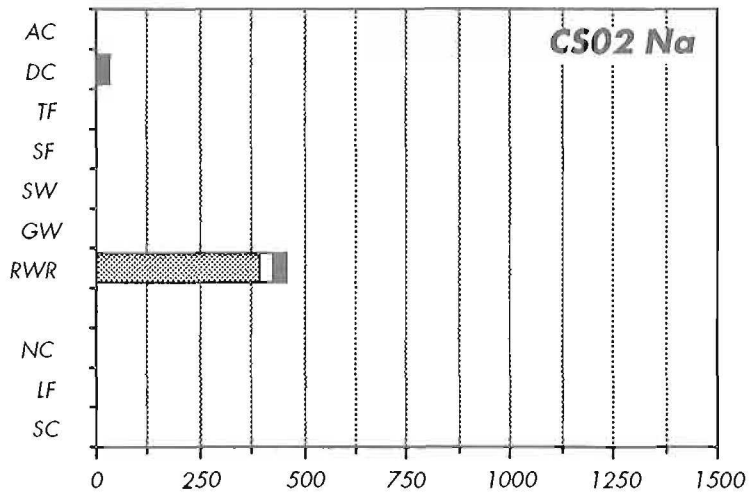

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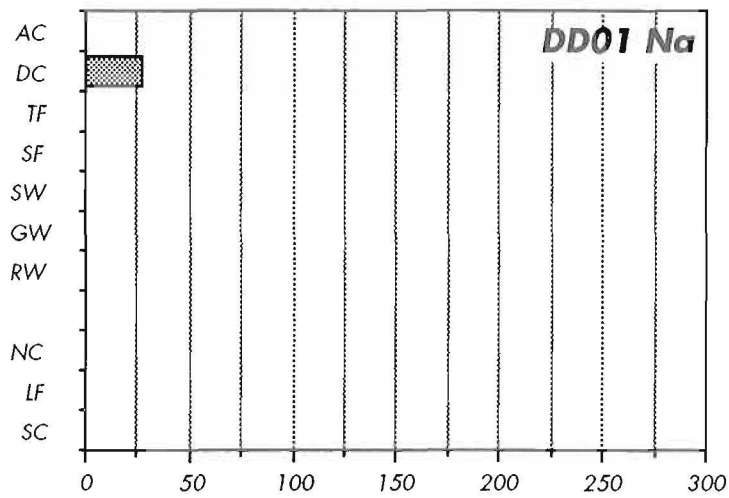

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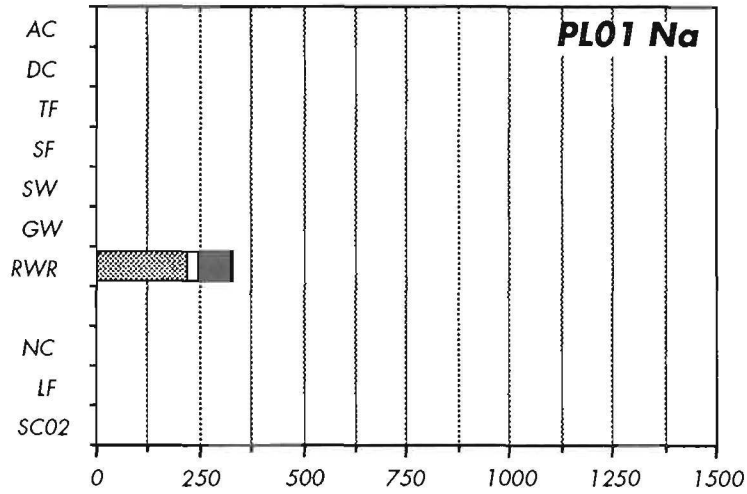

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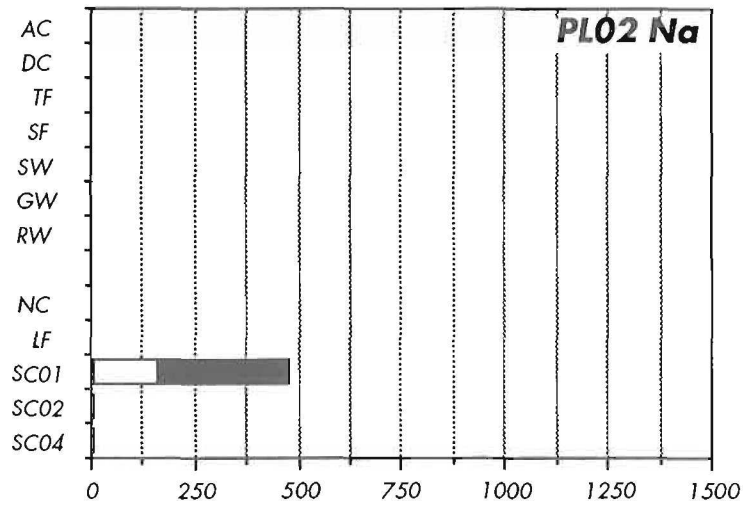

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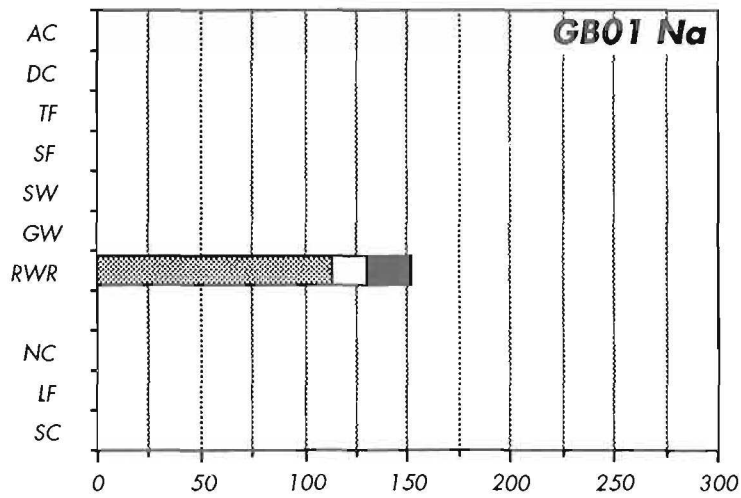

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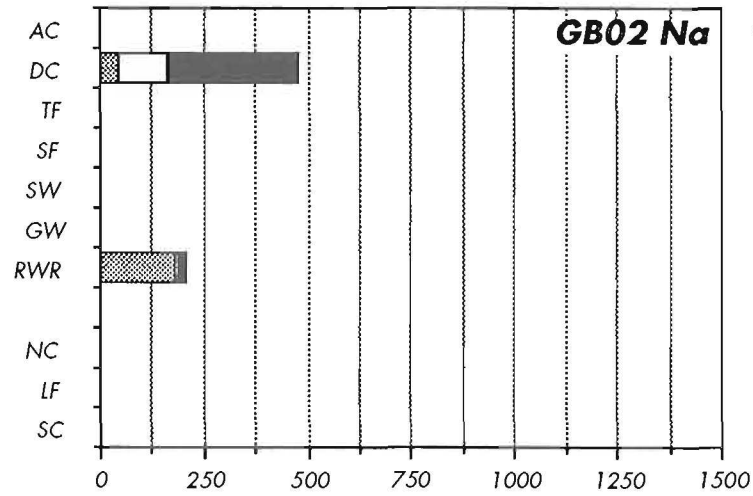

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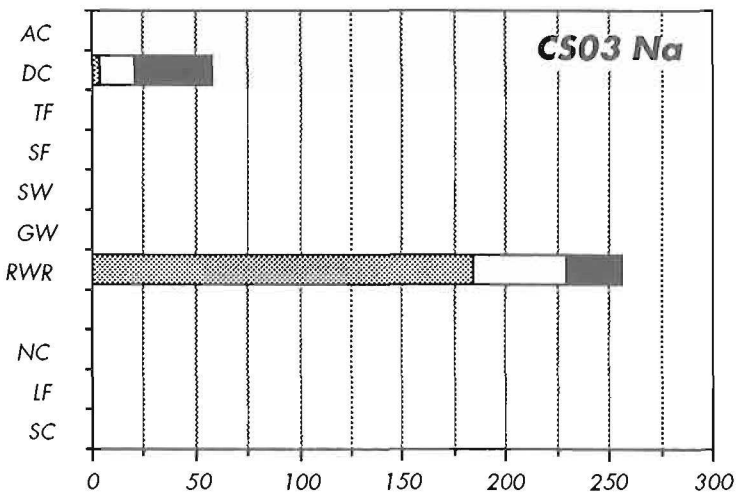
Montaneous Central (CS03,CS04,DE01,CH01)

Concentrations in precipitation are low compared to those in runoff and groundwater, implying internal ecosystem sources.



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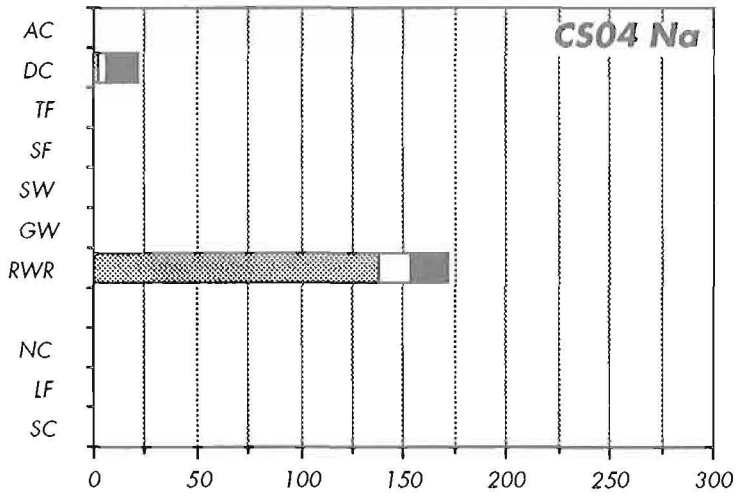

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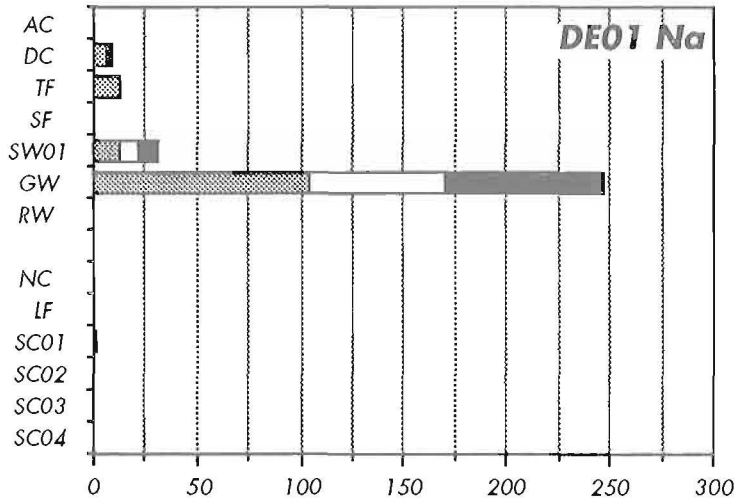

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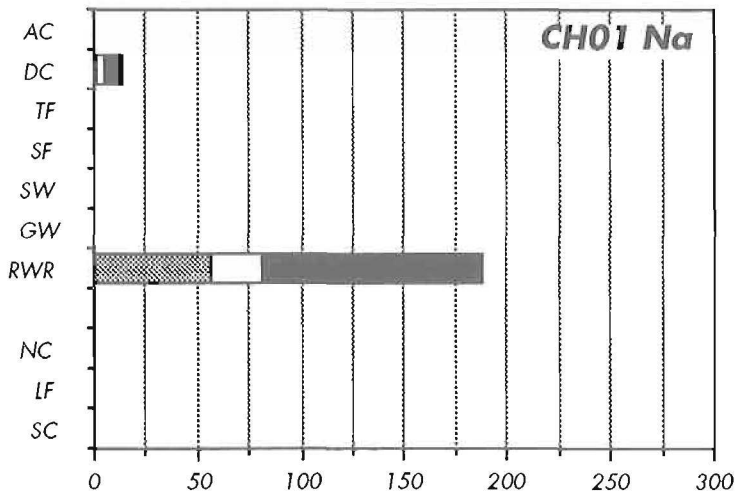

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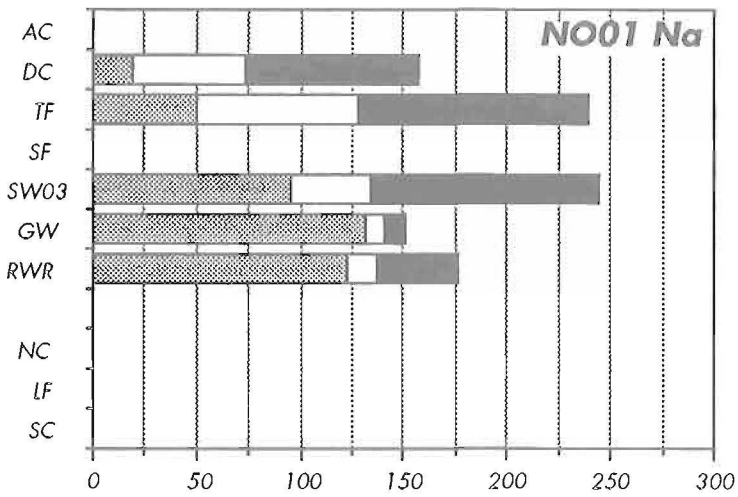
LF	0 0
SC	0 0

Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

The concentrations in precipitation are highest close to the Atlantic coast (NO01) and decrease towards north and east. In Birkenes (NO01) concentrations are high also in throughfall and in the soilwater. The concentrations decrease passing through the ecosystem, except for in Berg (SE02) where they rise in the soil water.



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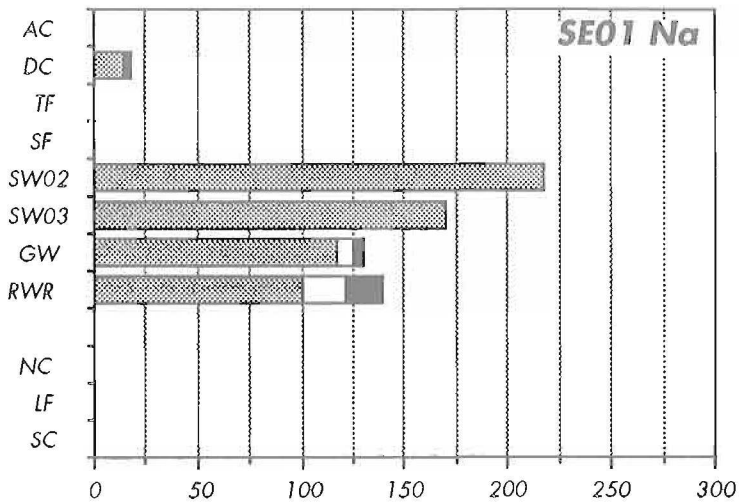

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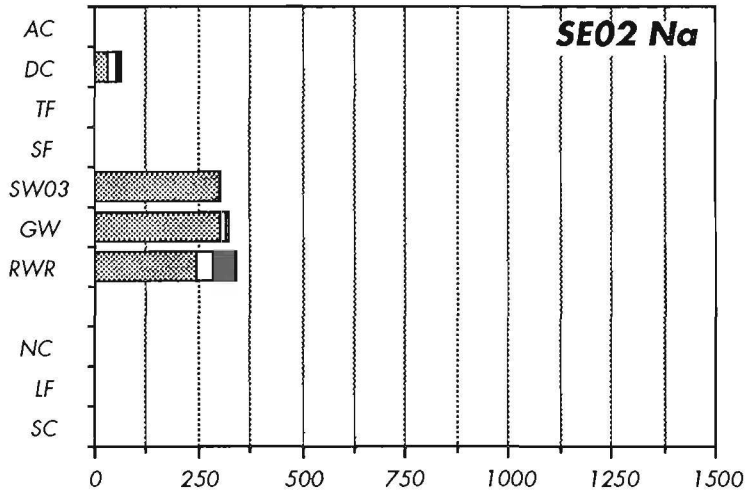

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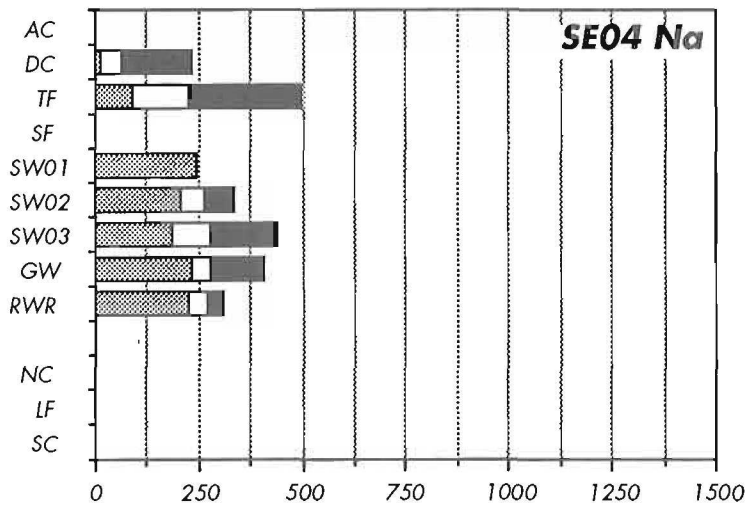

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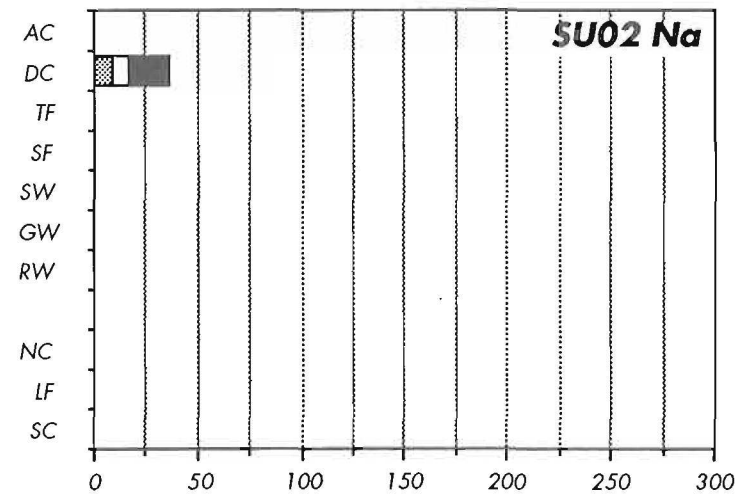

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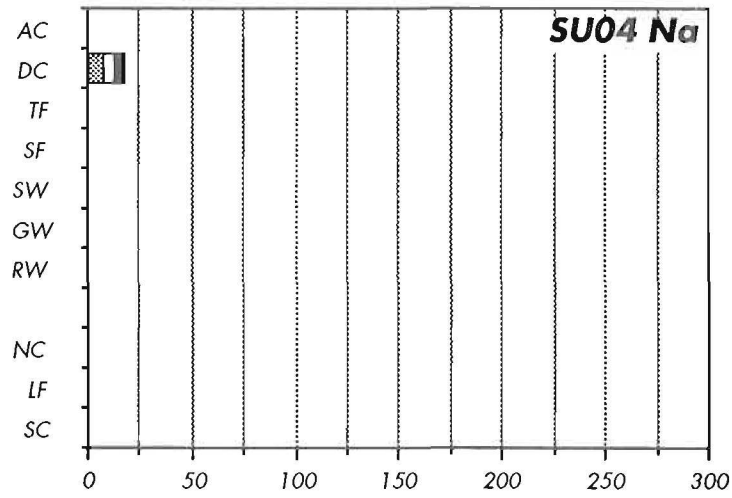

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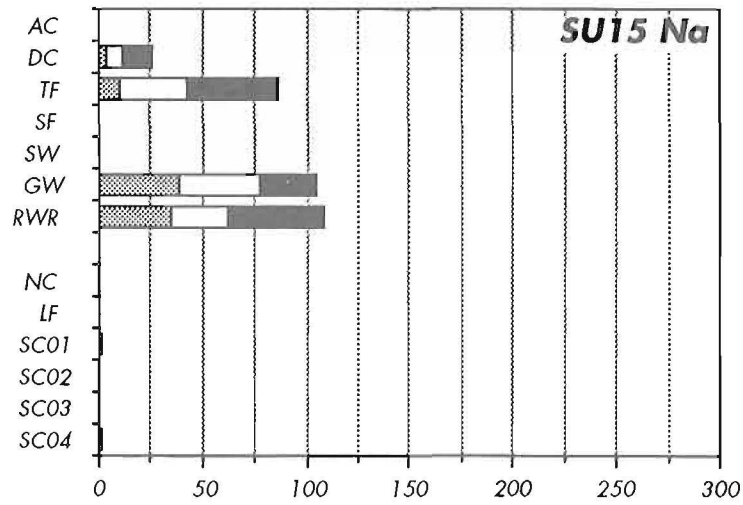

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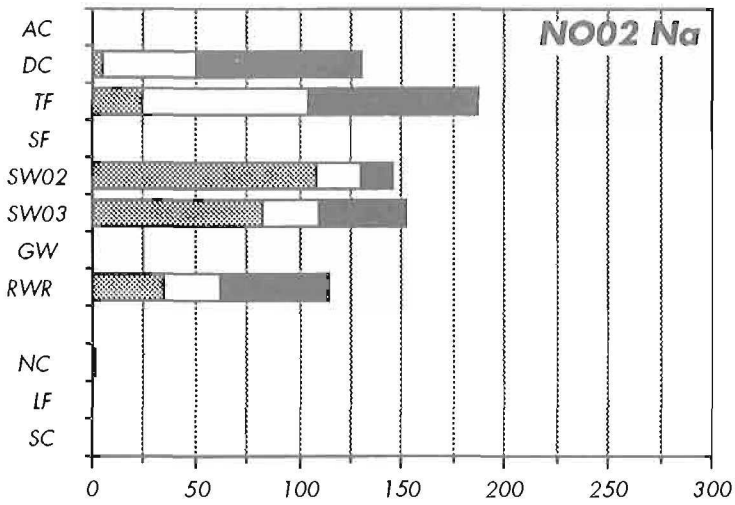
LF	0 0
SC01	01 01 9008 9008
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

The concentrations in precipitation and throughfall are highest close to the Atlantic coast (NO01) and decline towards east and north. They grow again closer to the Arctic Sea as shown by Vuoskojärvi (FI05) and Velikiy (SU16). Concentrations in soil water exceeds those of runoff water in all areas except for Hietajärvi (FI03) and Reivo (SE03). The soil concentrations are quite insignificant.



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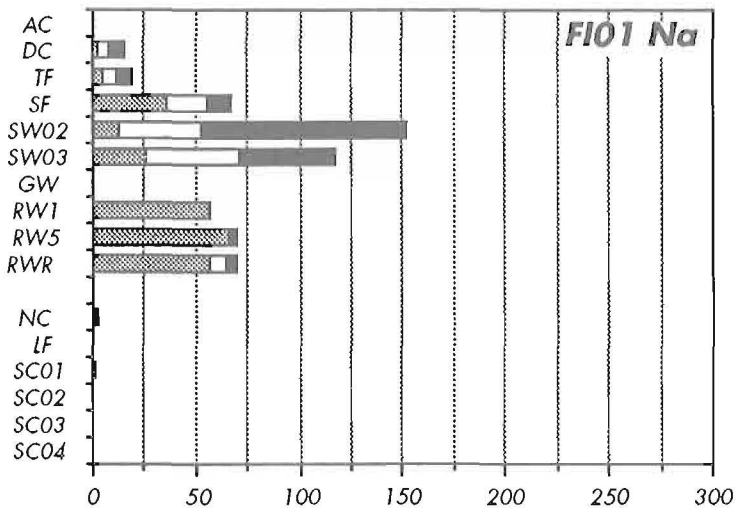

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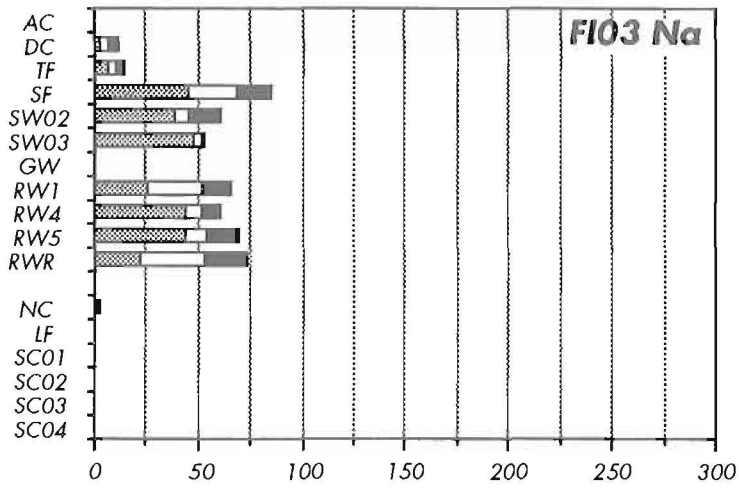

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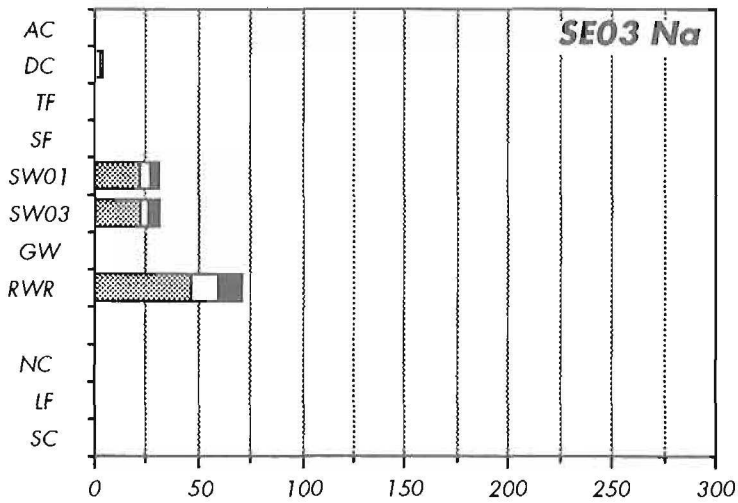

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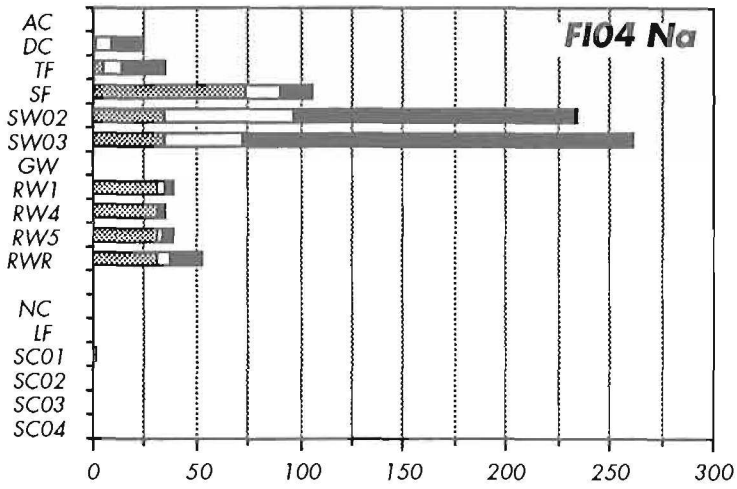

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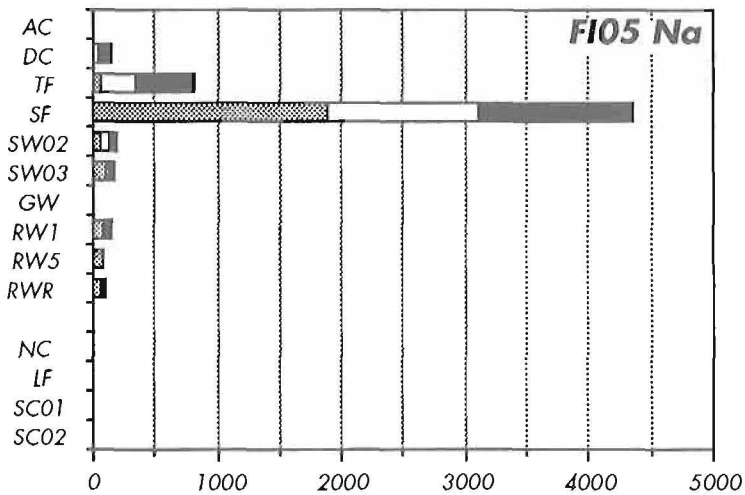

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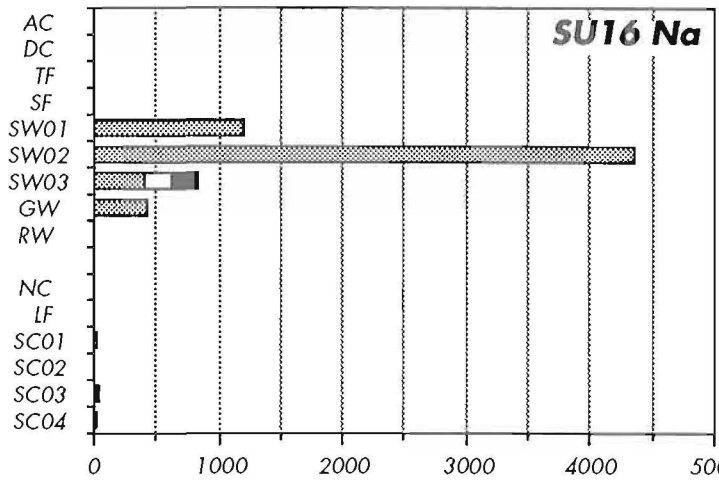

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GW	01	01	8908	8908
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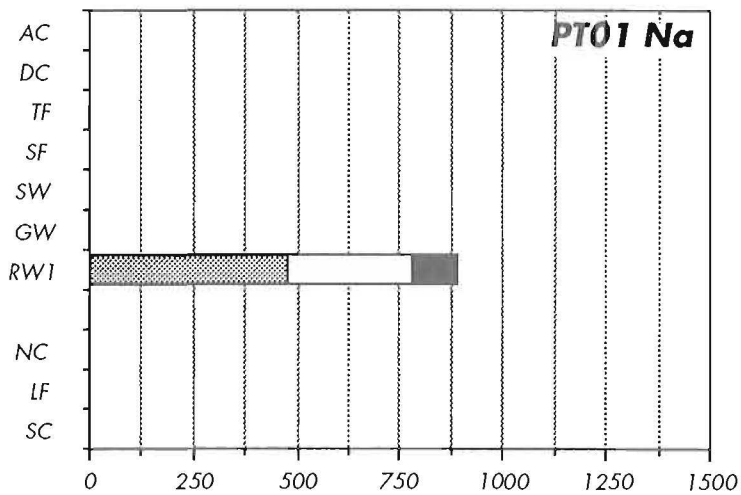
NC	0	0		
LF	0	0		
SC01	03	01	8908	8908
SC02	02	01	8908	8908
SC03	03	01	8908	8908
SC04	03	01	8908	8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

High concentrations predominate in lake surface water of Alentejo (PT01) and in precipitation, throughfall and stemflow of Komlosi (HU01).

Montaneous East (SU03,SU05)

Relatively high concentrations are recorded in the precipitation and throughfall of the Caucasian areas. Enrichment takes place towards groundwater and runoff water.



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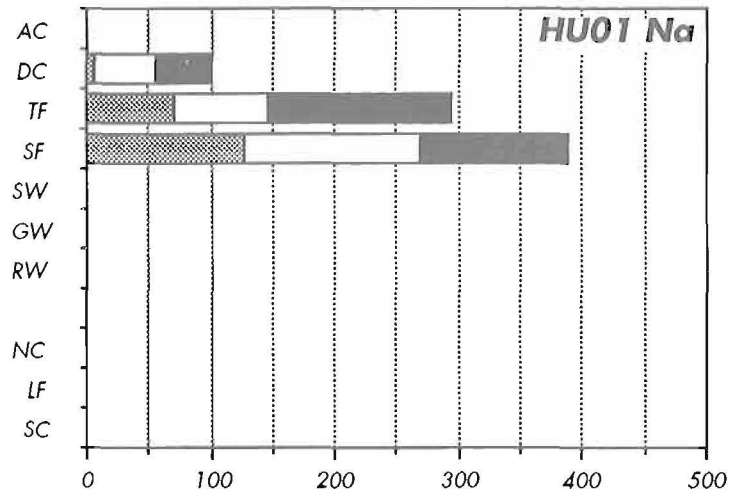

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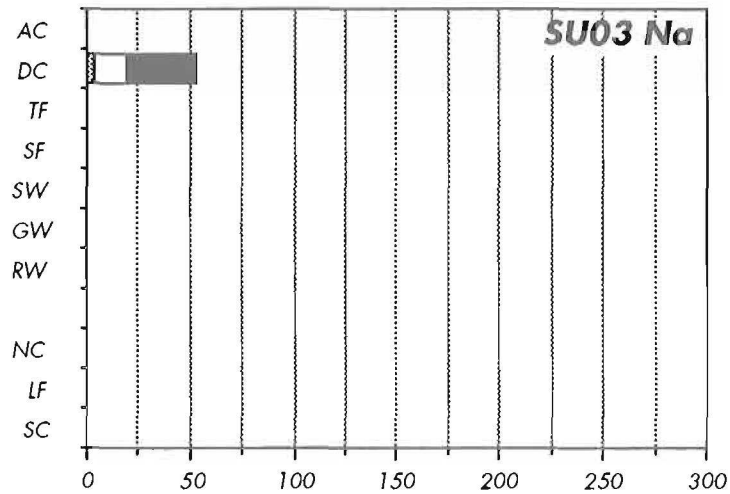

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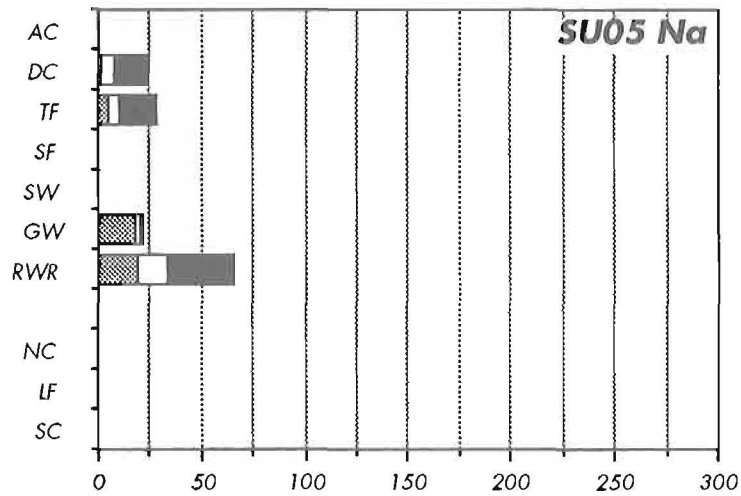

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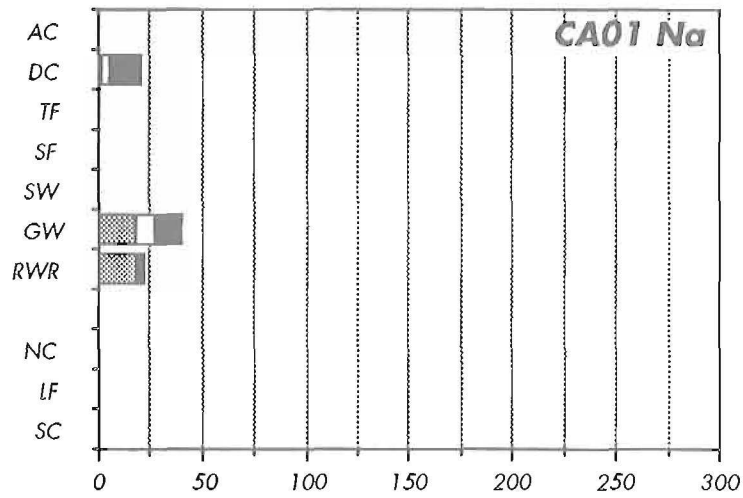
Nearctic Nemoral (CA01)

The Turkey Lakes (CA01) area show the lowermost concentrations of all areas encountered.



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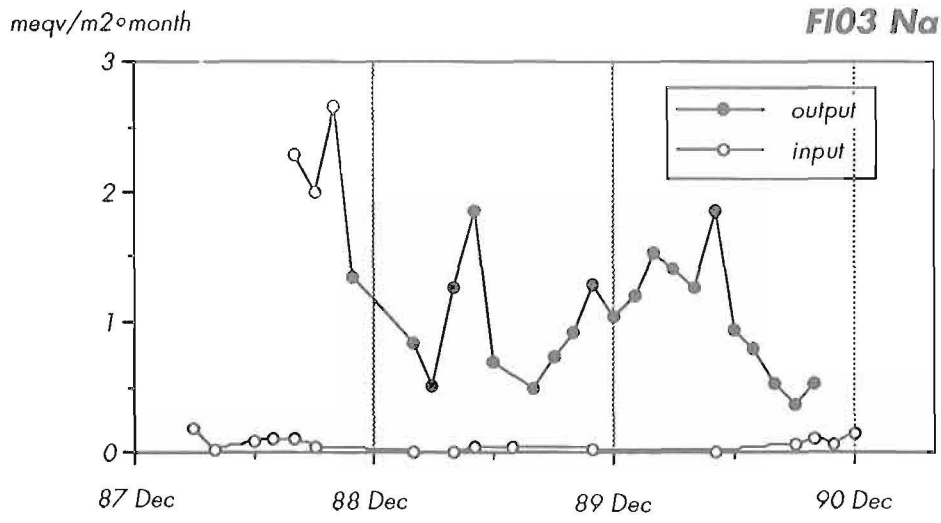
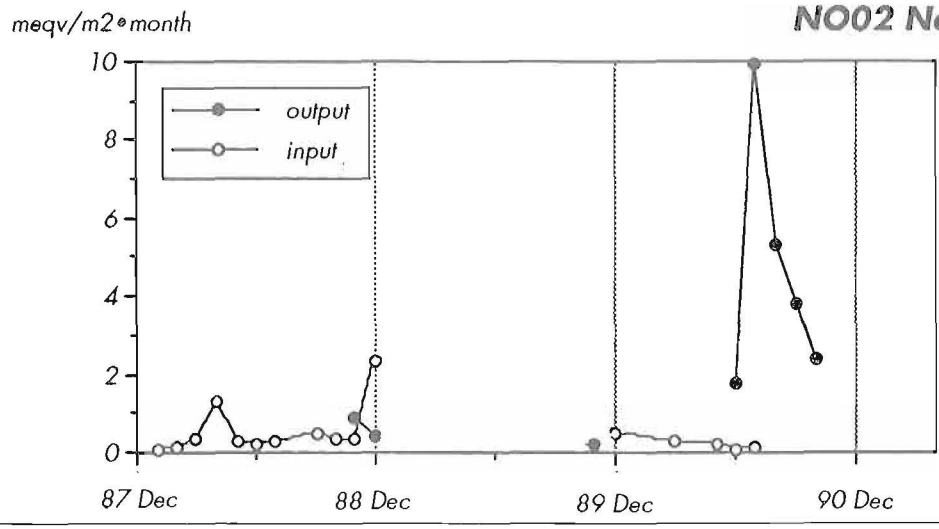
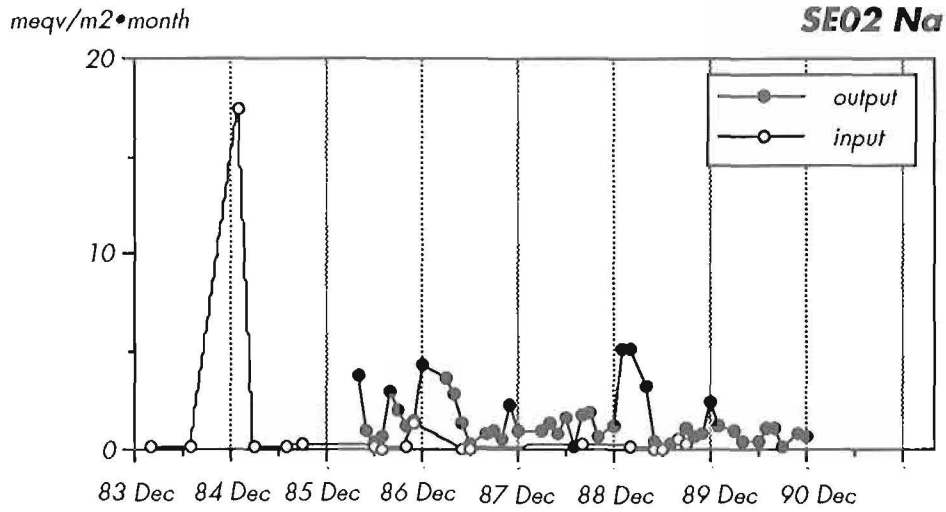
LF	0 0
SC	0 0

7.3 Long-term temporal variation

In this section, time series of monthly fluxes of natrium expressed as meqv/(m²◦month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02).



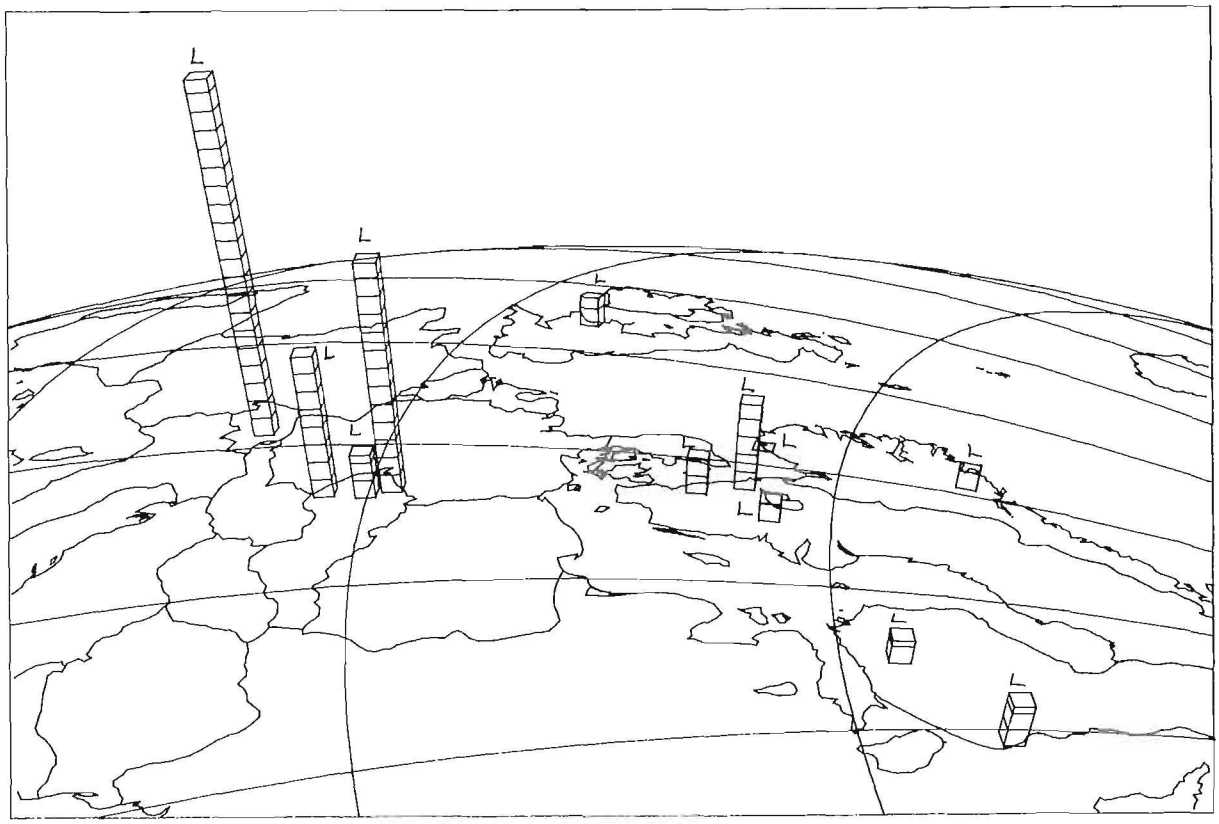




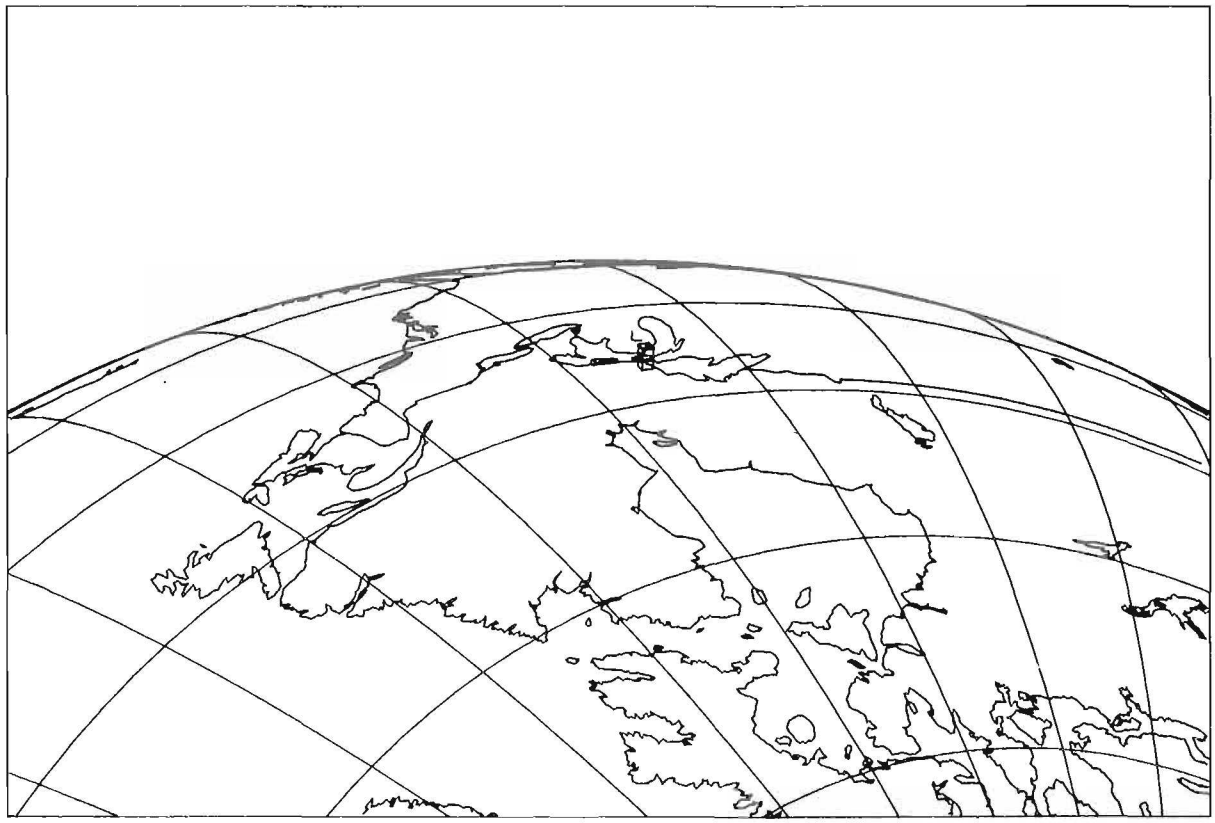
7.4 Mass balances

Sodium shows either retention or loss. Retention is associated with areas close to marine coasts and therefore associated with sea-salts. Leaching takes place in more continental areas as a result of weathering of the regolith. The leached amount is probably correlated with the relative percentage of Na-rich minerals in soil.

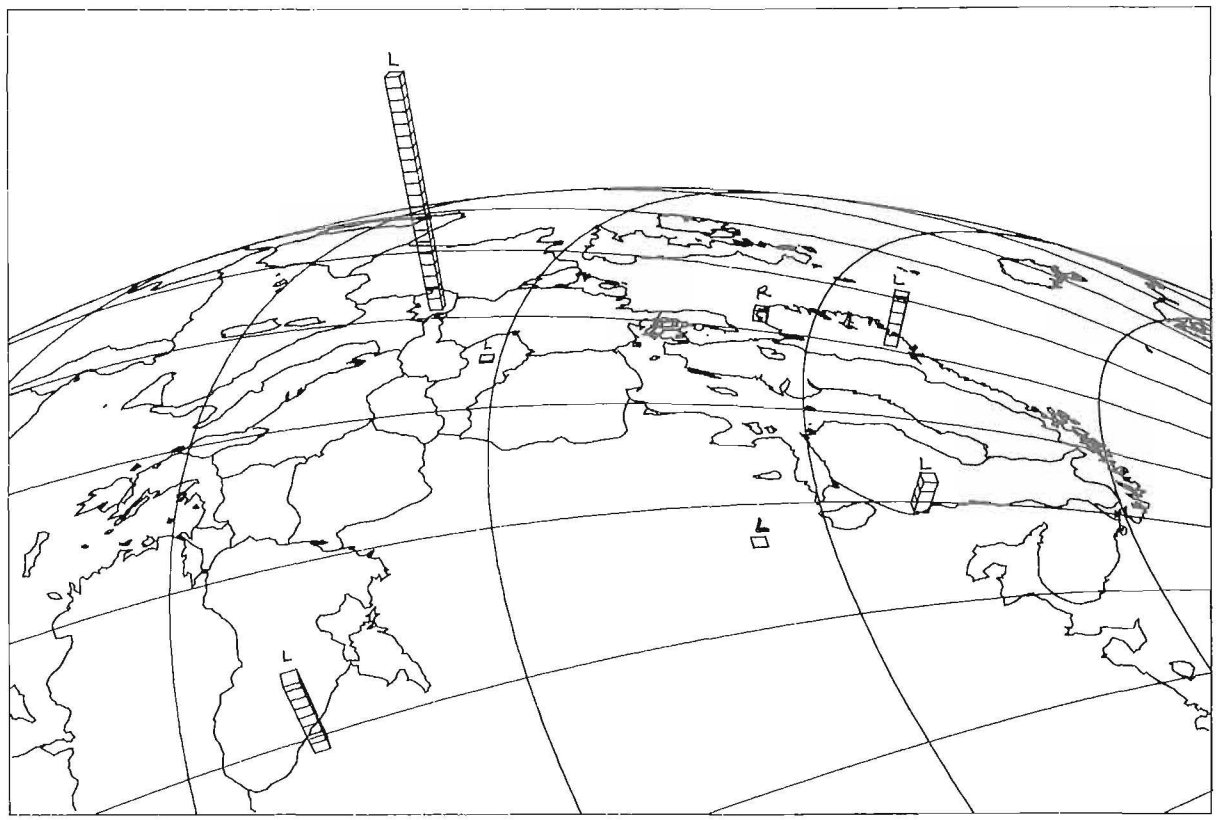
Na 1988-89, scale unit 100 mg/m²•a



Na 1988-89, scale unit 100 mg/m²•a



Na 1989-90, scale unit 100 mg/m²•a



CHAPTER 8

Potassium

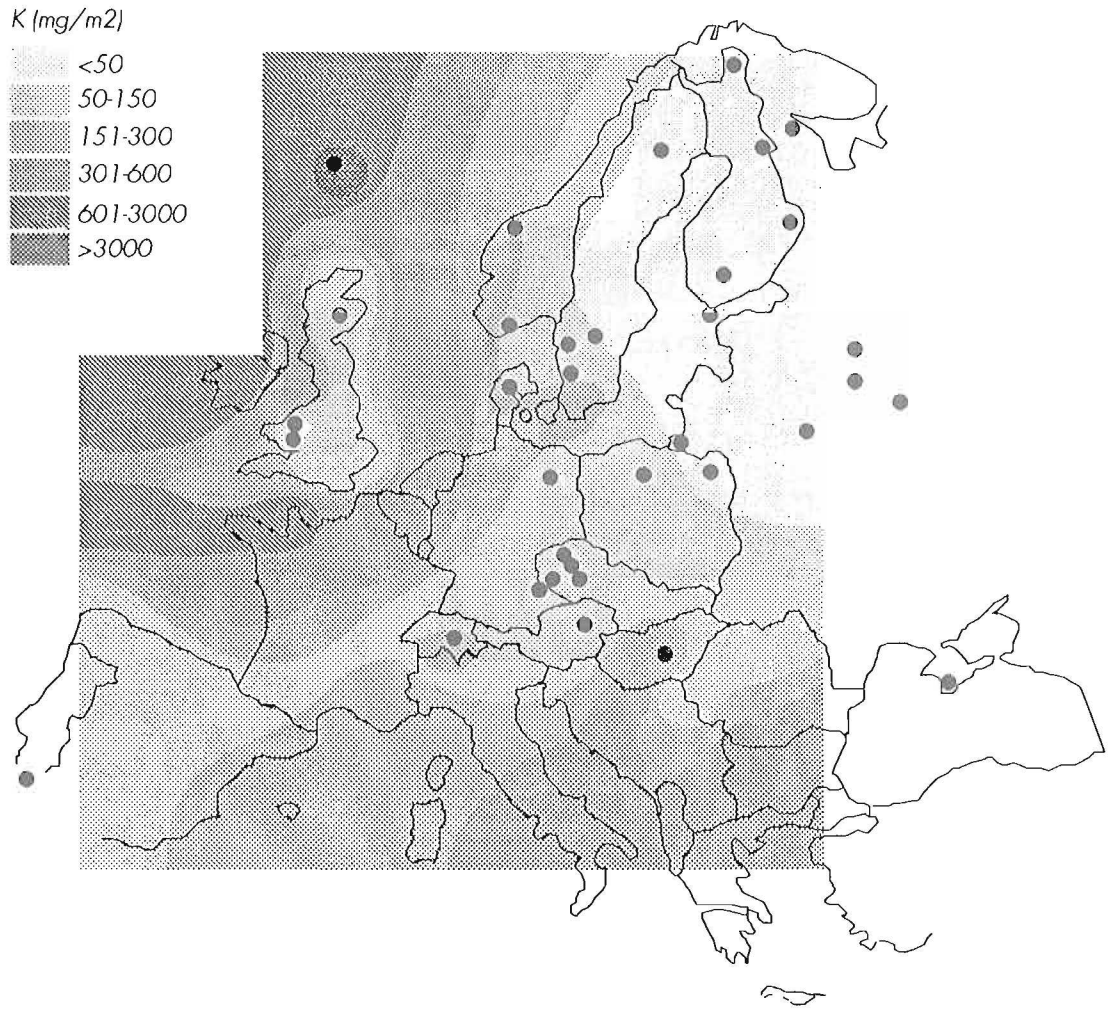
8.1 Fields of deposition

The main source is in the sea-spray and long-range dust from the African continent. The network mostly covers the low deposition class areas.

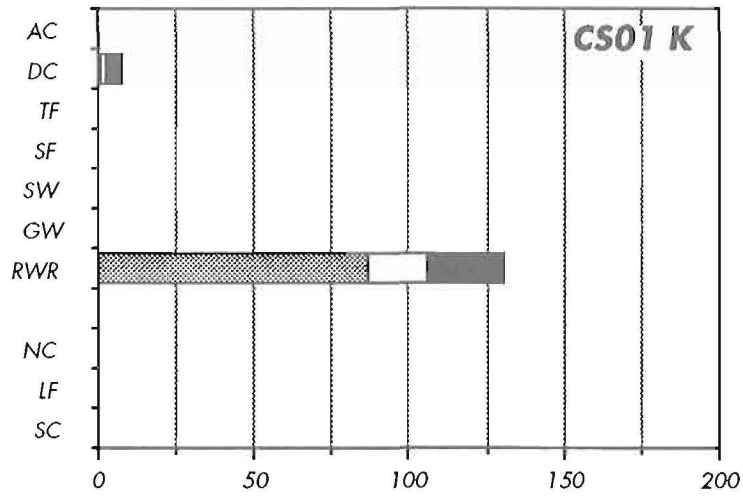
8.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,GB01,GB02)

Precipitation concentrations are low (but with high variation in Mlynaruv) whereas runoff concentrations are much higher (except for areas in United Kingdom). Concentrations in the argillitic topsoils of the Polish areas are also high, and needles in Stechlin (DD01) and Gardliczno (PL02) also show high values.



Field of deposition of K (mg/m²) in 1988 acc to EMEP (CCC 4190).



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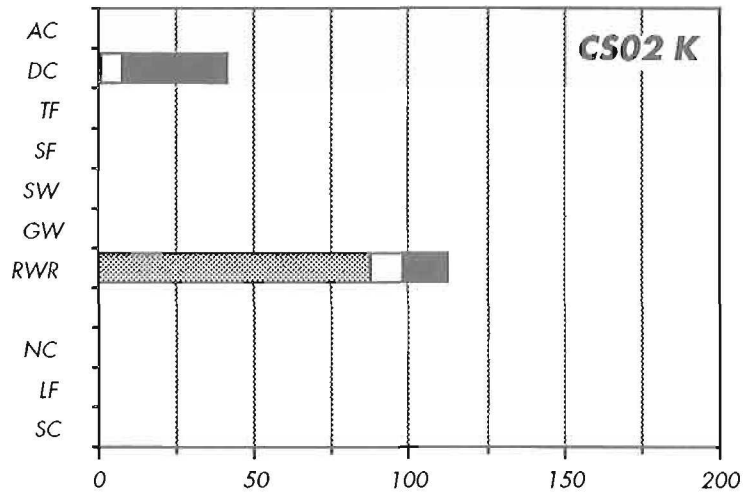

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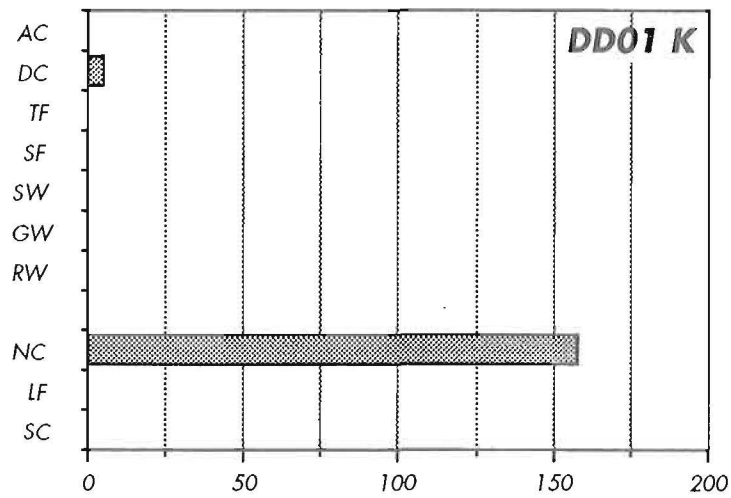

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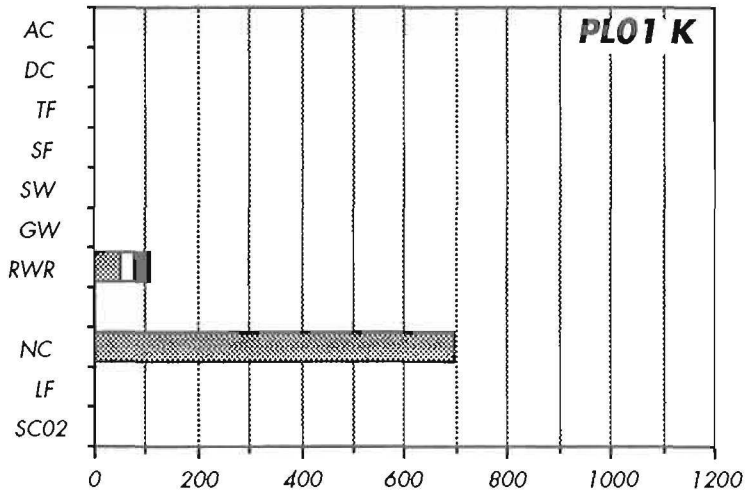

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RWR	05 01 9006 9006
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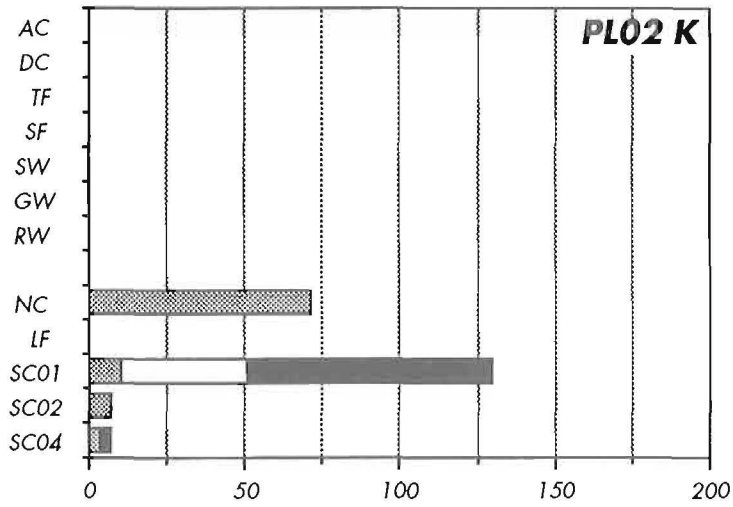

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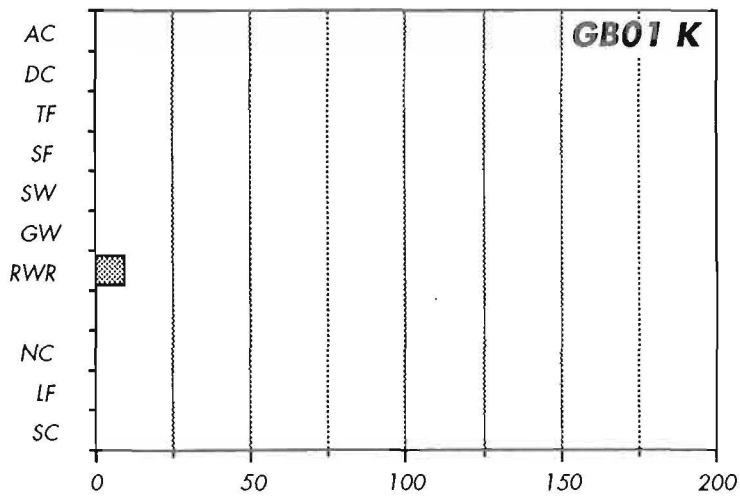
SC02	01 01 9006 9006
SC04	01 01 9006 9006



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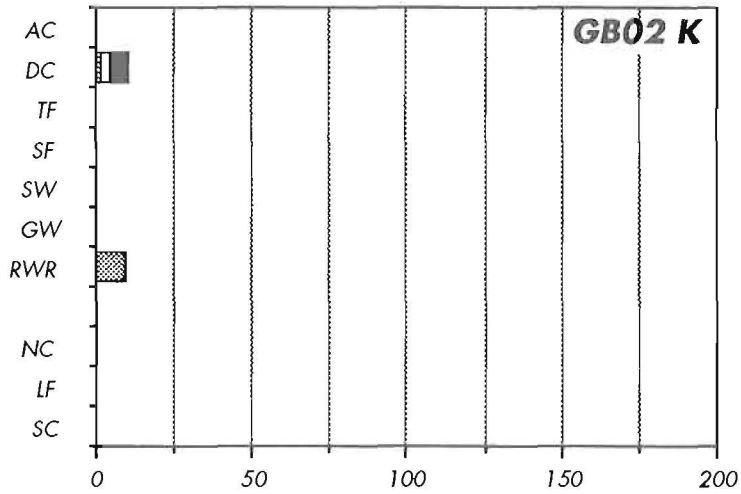

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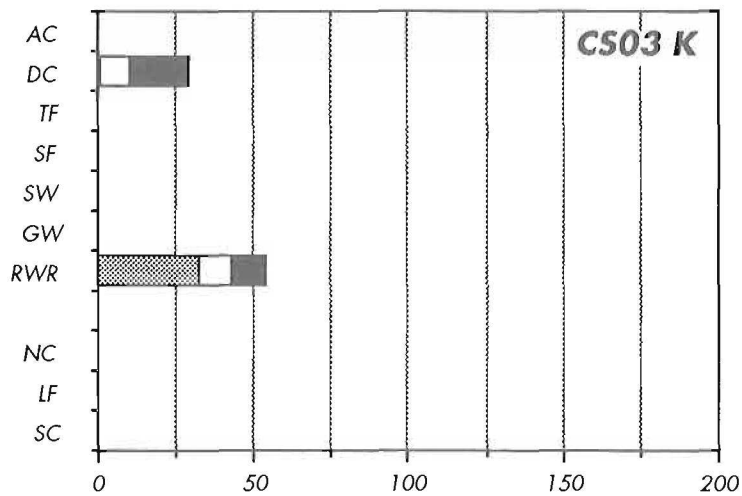
GW	0	0
RWR	01	11 8911 9009
NC	0	0
LF	0	0
SC	0	0

Montaneous Central (CS03,CS04,DE01,CH01)

The concentrations in precipitation is usually low, although exceeding 25 µeqv/l/month in Czech areas. Runoff concentrations are much higher. Recordings in Forellenbach indicates leaching from canopies (high throughfall values).



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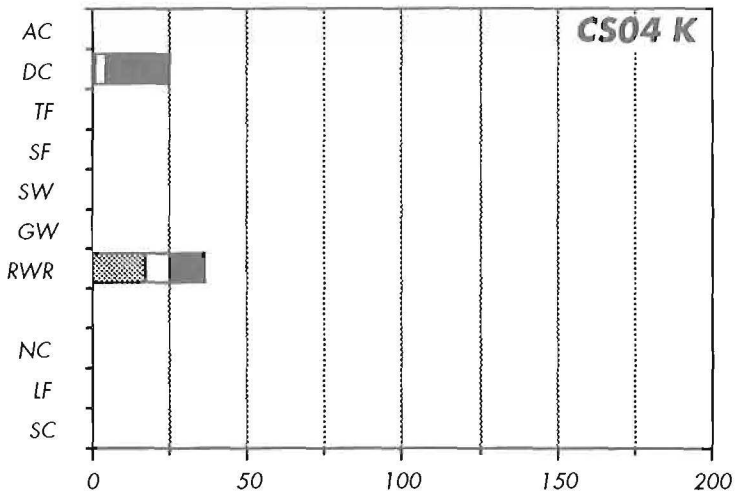

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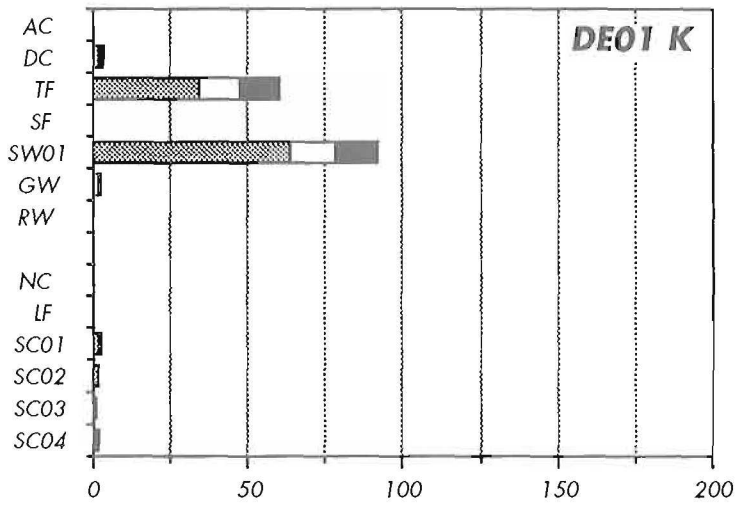

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SF	0 0
SW01	02 01 9010 9010
GW	03 05 8911 9007
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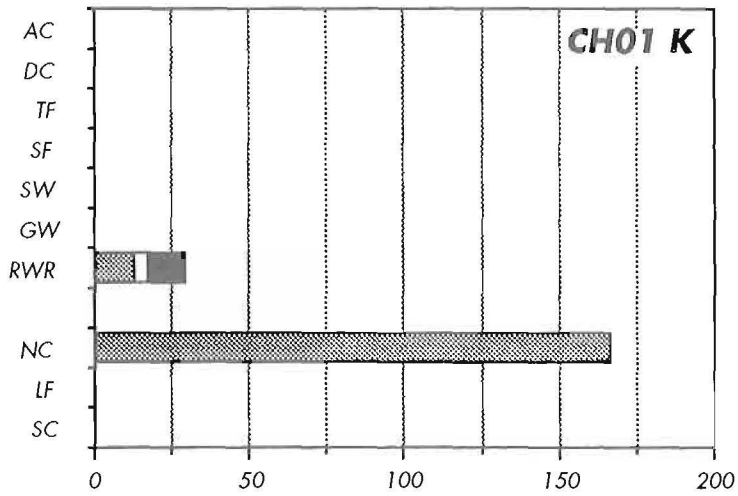
LF	0 0
SC01	03 01 9008 9008
SC02	01 01 9008 9008
SC03	02 01 9008 9008
SC04	03 01 9008 9008



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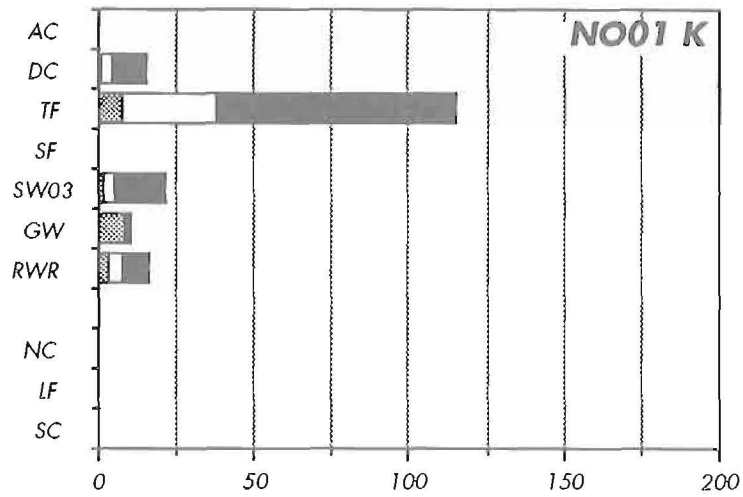
TF	0 0
SF	0 0
SW	0 0
GW	0 0
RWR	01 12 8911 9010
NC	01 01 8900 8900
LF	0 0
SC	0 0

In this region precipitation values are also low, but not considerably higher in soil water, groundwater and runoff water. The enrichment factor for throughfall ranges between 7 and 12. Exceptional is Valday (SU15) where potassium concentrations enrich by a factor close to 100 in throughfall.



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SF	0	0		
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RWR	01	12	8911	9010
NC	0	0		
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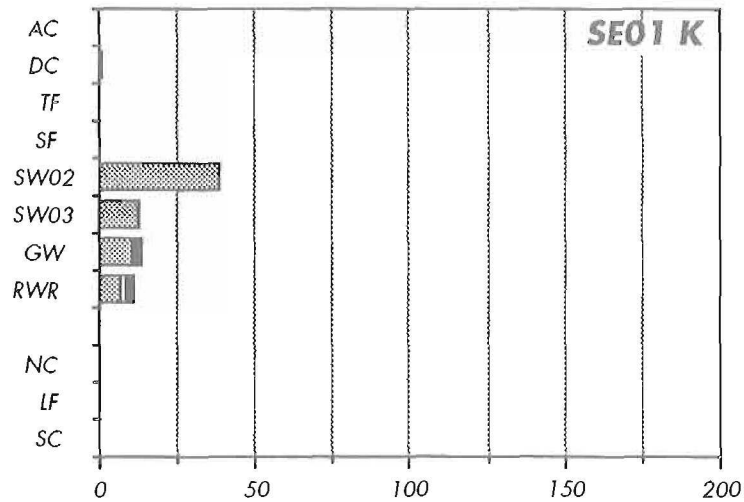

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SW03	01	01	8911	8911
GW	01	04	8911	9003
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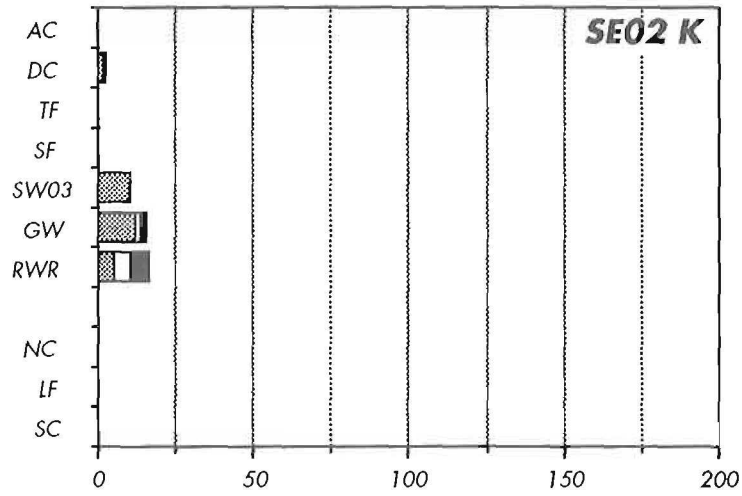
NC	0	0		
LF	0	0		
SC	0	0		



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RWR	02 02 8911 8912
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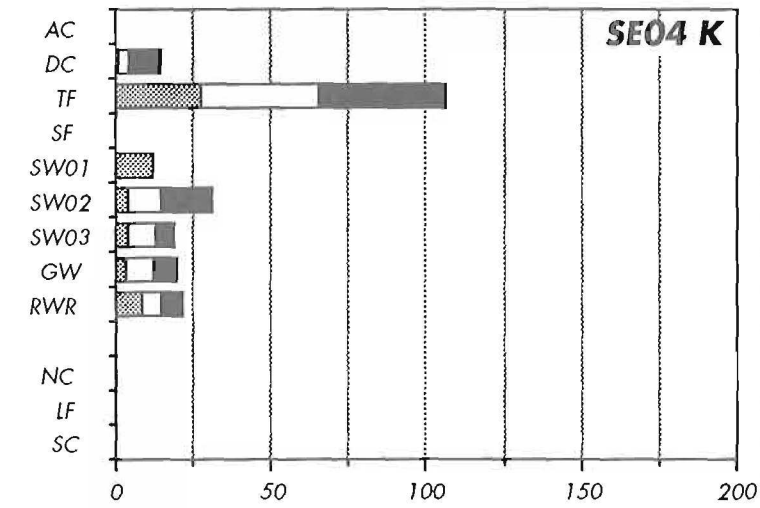
SC	0 0



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TF	01 12 8711 8810
SF	0 0
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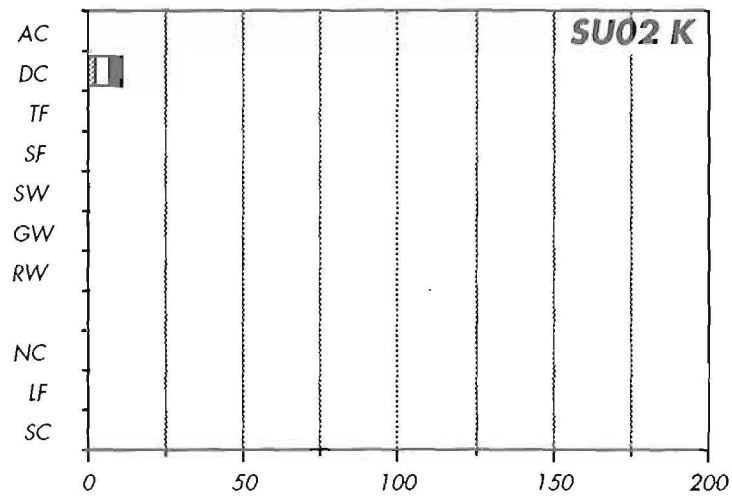
SW03	06 07 8711 8810
GW	05 07 8712 8810
RWR	01 12 8711 8810
NC	0 0
LF	0 0
SC	0 0



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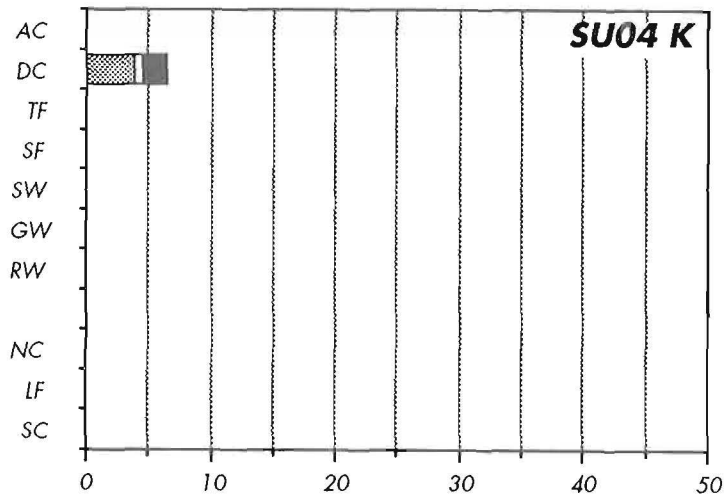
SC	0 0



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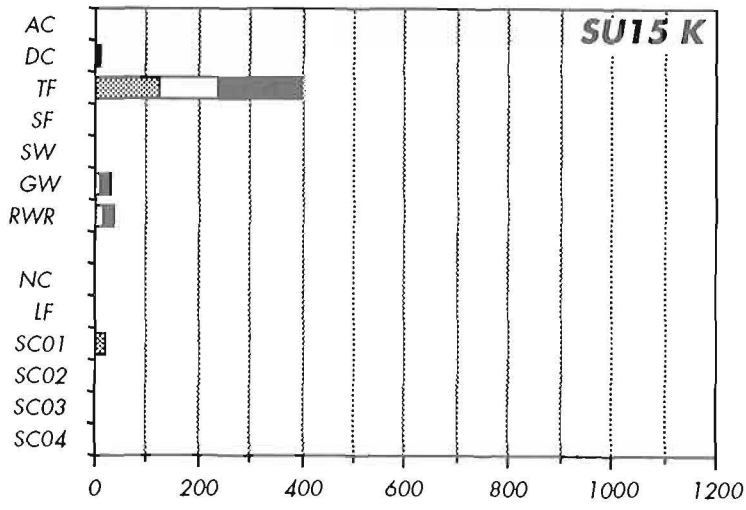

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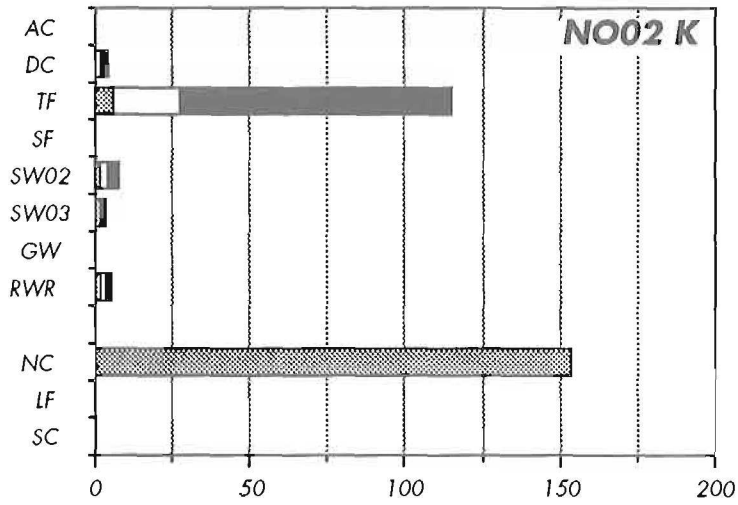
RWR	01 10 9001 9010
NC	0 0
LF	0 0
SC01	01 01 9008 9008
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

Concentrations in precipitation, soil water, runoff water and groundwater are low, most lowest in the west (NO02). The throughfall enrichment factor is ca 10, the stemflow enrichment factor, on the other hand, might exceed 100...200. Soil water concentrations are highest in Valkeakotinen (FI01), Hietajärvi (FI03) and Velikyi (SU16).



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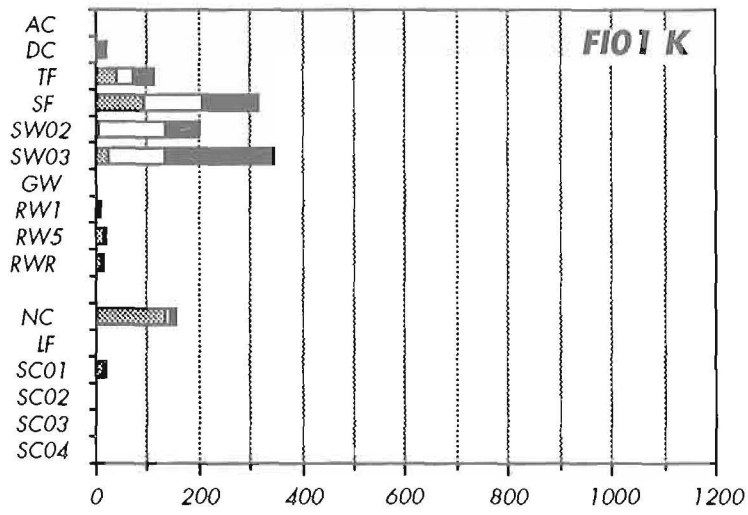
SC	0	0		



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SW03	02	04	8907	8910
GW	0	0		
RW1	01	02	9002	9008
RW5	01	02	9002	9008
RWR	01	03	9002	9008
NC	05	01	8800	8800
LF	0	0		
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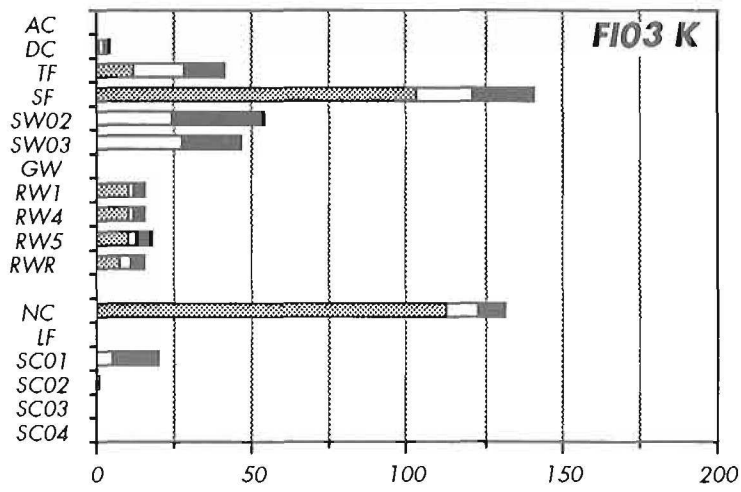

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RW4	02	11	8912	9010
RW5	02	11	8912	9010
RWR	03	12	8911	9010
NC	06	01	8800	8800
LF	0	0		
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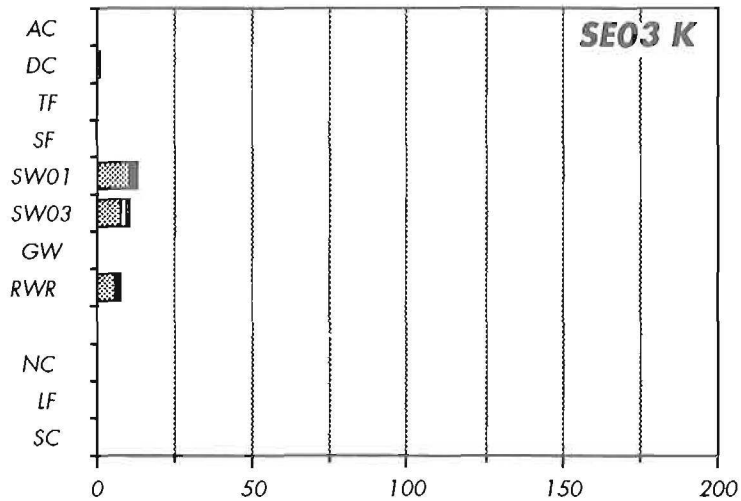

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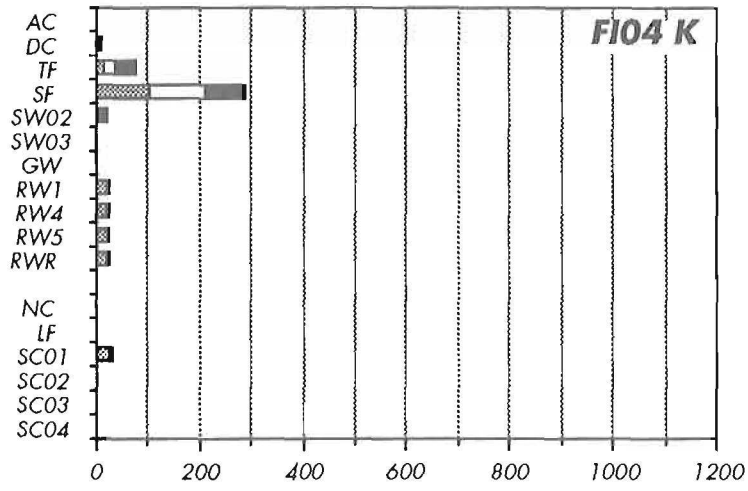

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NC	0	0		
LF	0	0		
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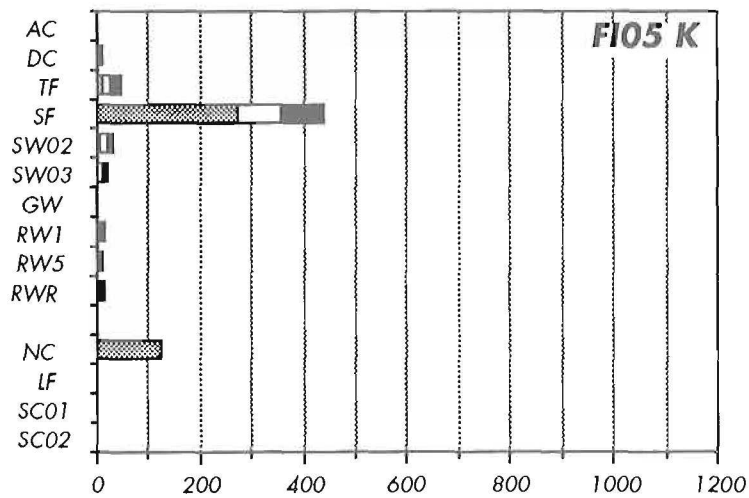

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RW1	01	04	8912	9004
RW5	01	04	8912	9004
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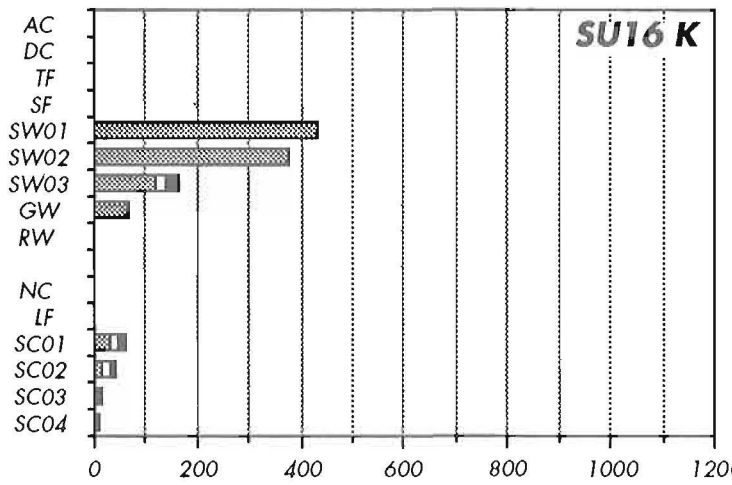

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GW 01 01 8908 8908
RW 0 0

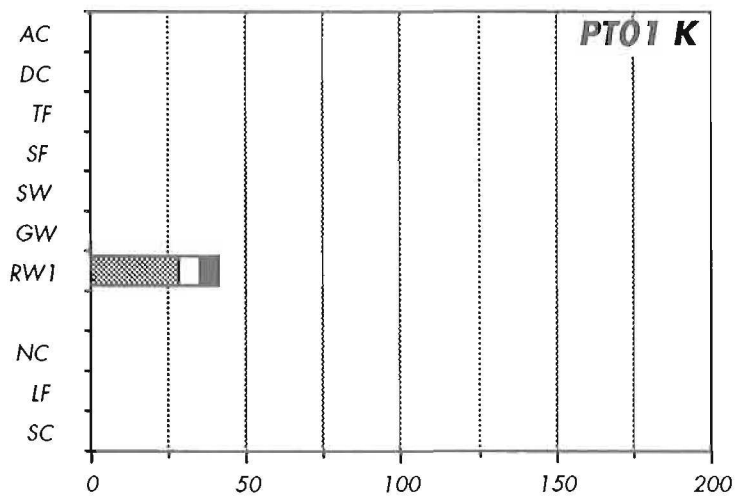
NC 0 0
LF 0 0
SC01 03 01 8908 8908
SC02 02 01 8908 8908
SC03 03 01 8908 8908
SC04 03 01 8908 8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

Concentrations grow from precipitation to throughfall and stemflow in Komlosi (HU01). The stemflow concentrations show a very high variation.

Montaneous East (SU03,SU05)

The concentrations in rainfall do not very much differ from those in groundwater and runoff water. The throughfall enrichment factor is ca 10.



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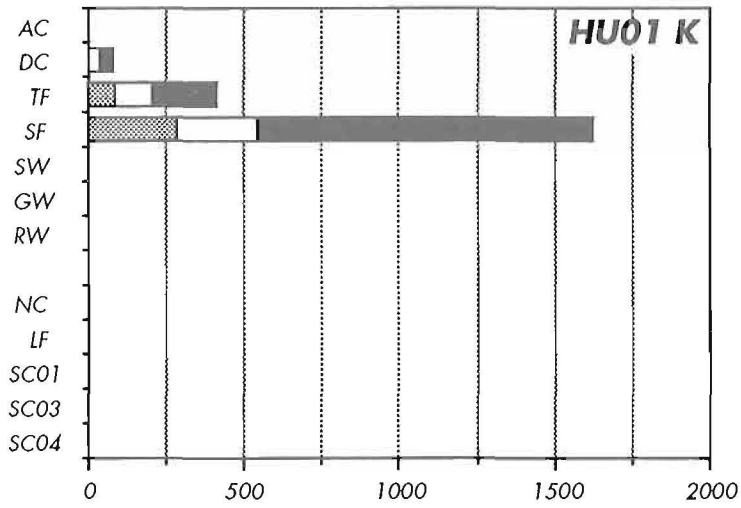

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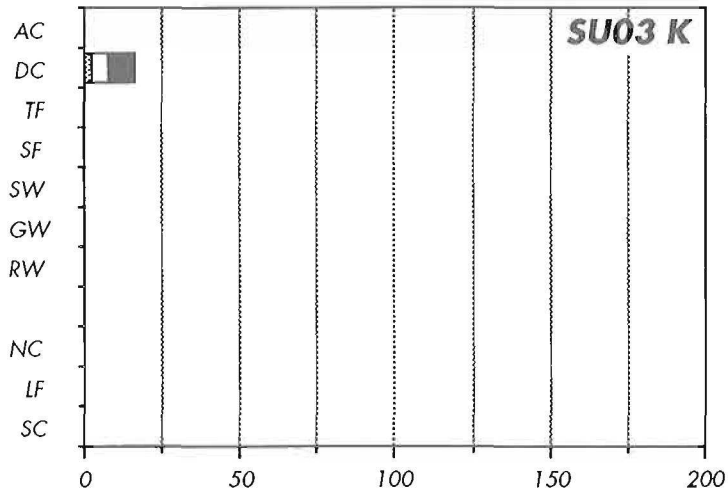

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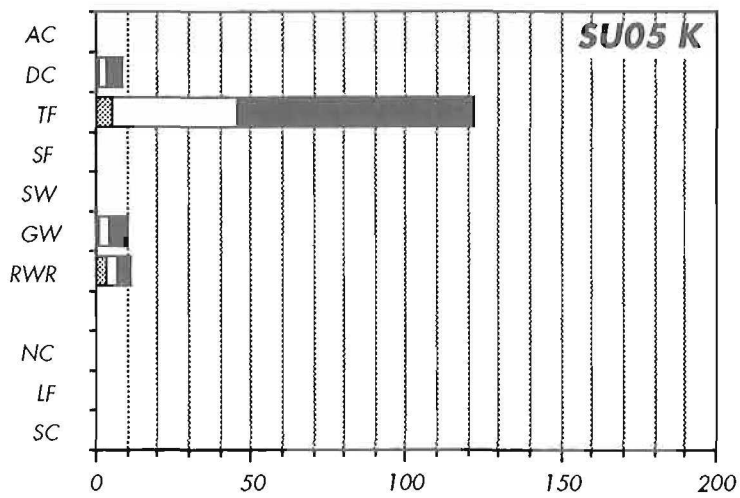

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RWR	01 13 8911 9010
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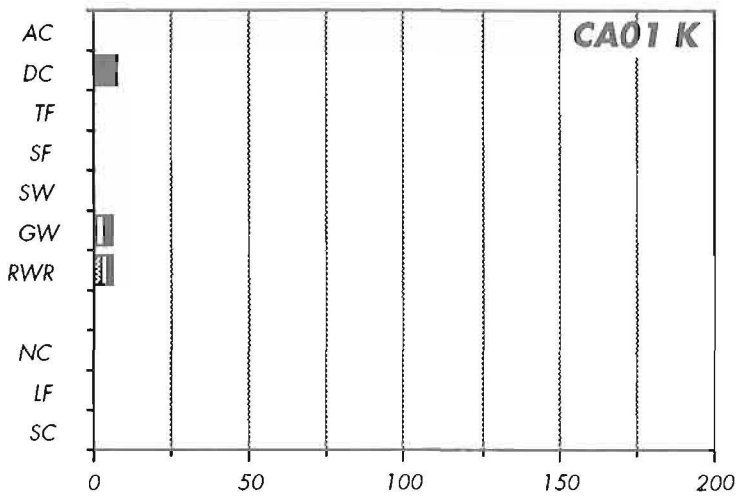
LF	0 0
SC	0 0

Nearctic Nemoral (CA01)

The Turkey Lakes area (CA01) does not stand out very different from the deciduous wood areas in Europe.



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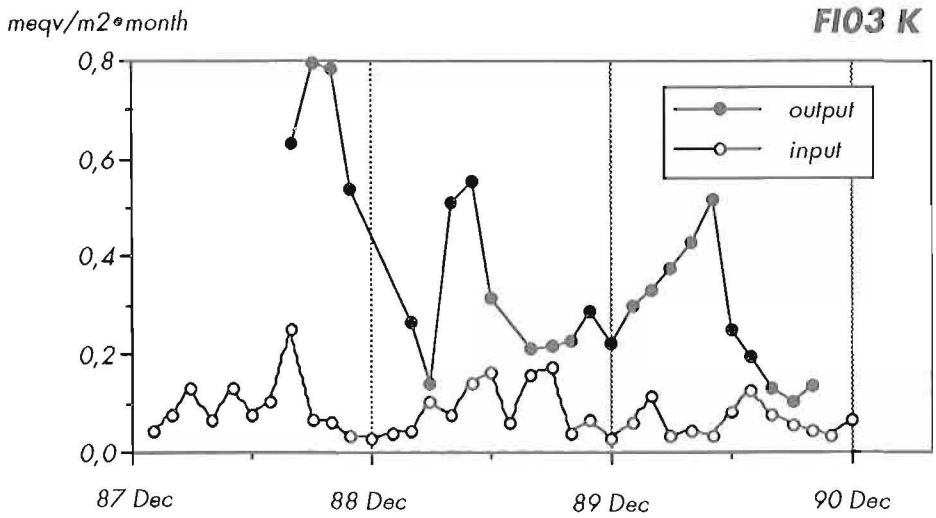
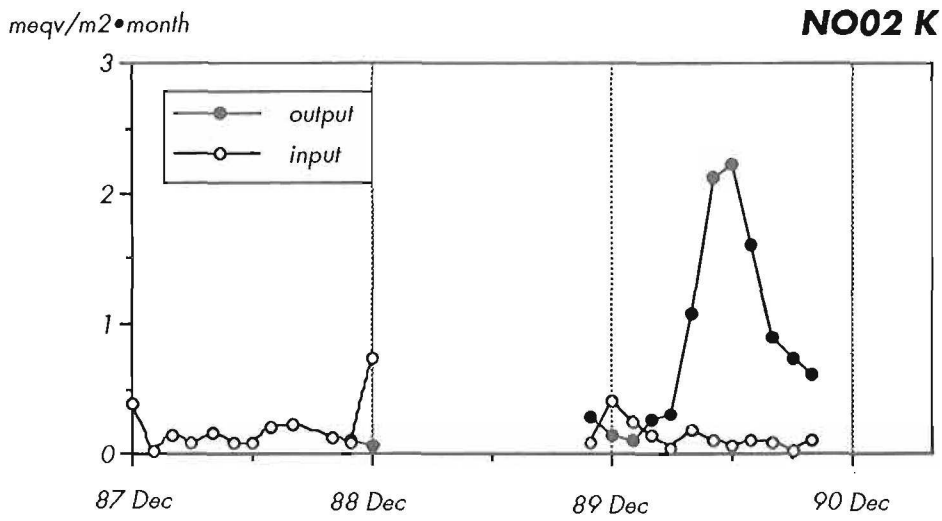
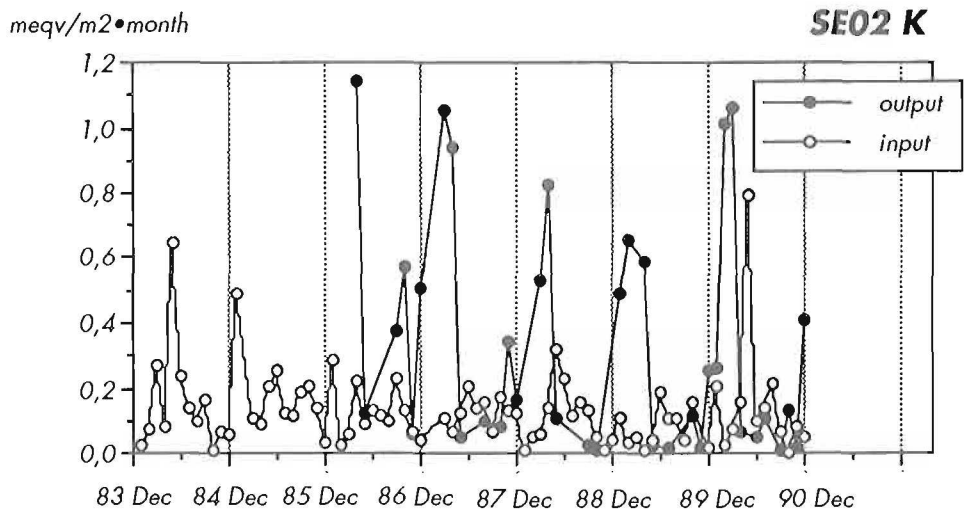
GW	01 08 8811 8906
RWR	01 11 8811 8909
NC	0 0
LF	0 0
SC	0 0

8.3 Long-term temporal variation

In this section, time series of monthly fluxes of potassium expressed as meqv/(m^2•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02). N.B. Not corrected for sea-salts.



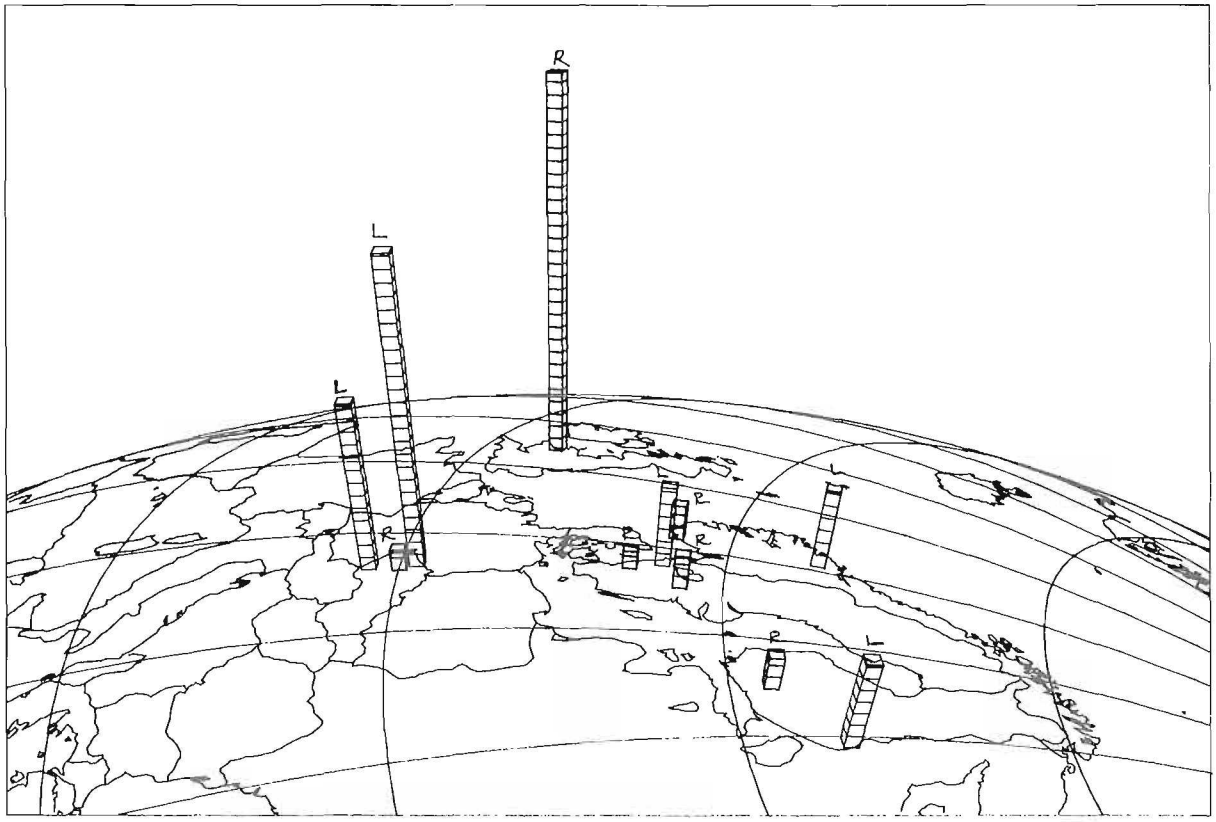




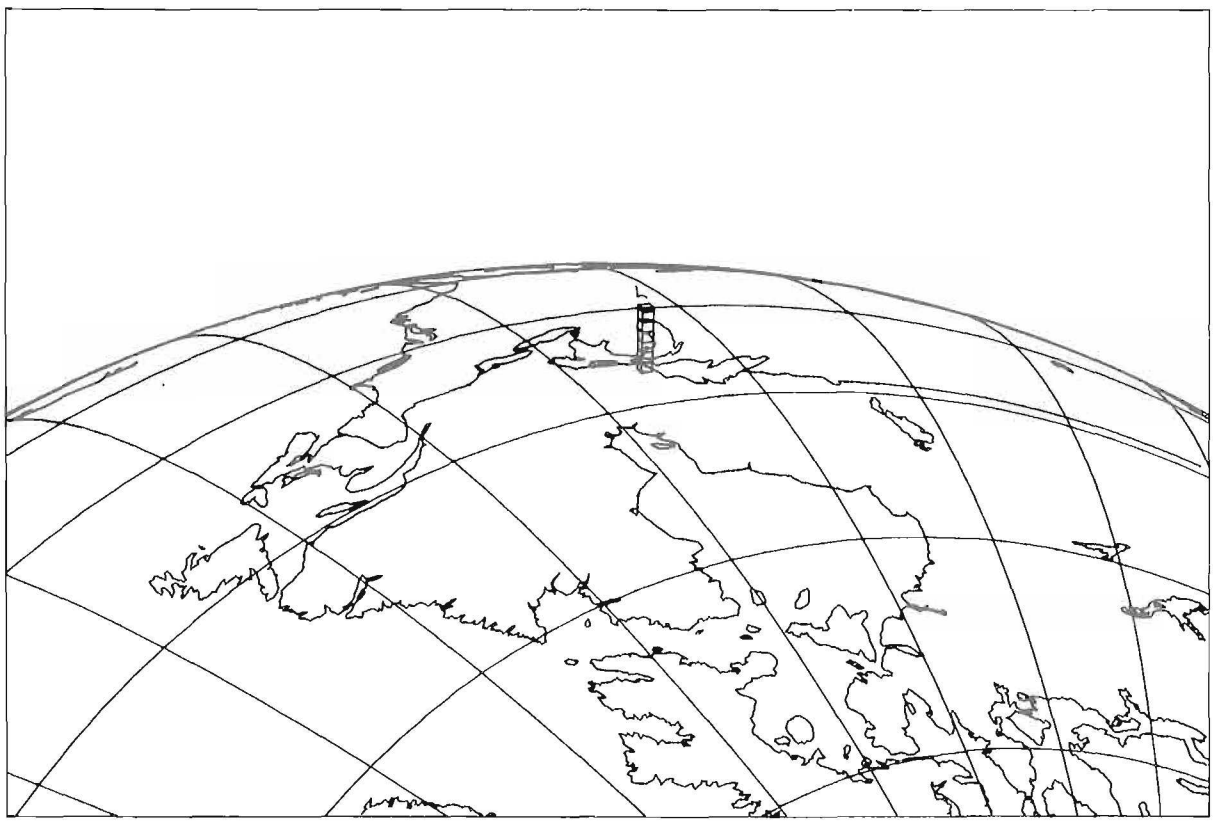
8.4 Mass balances

Potassium balances show both leaching and retention. To what extent leaching is correlated to the soil chemistry or type of foliage is not yet known.

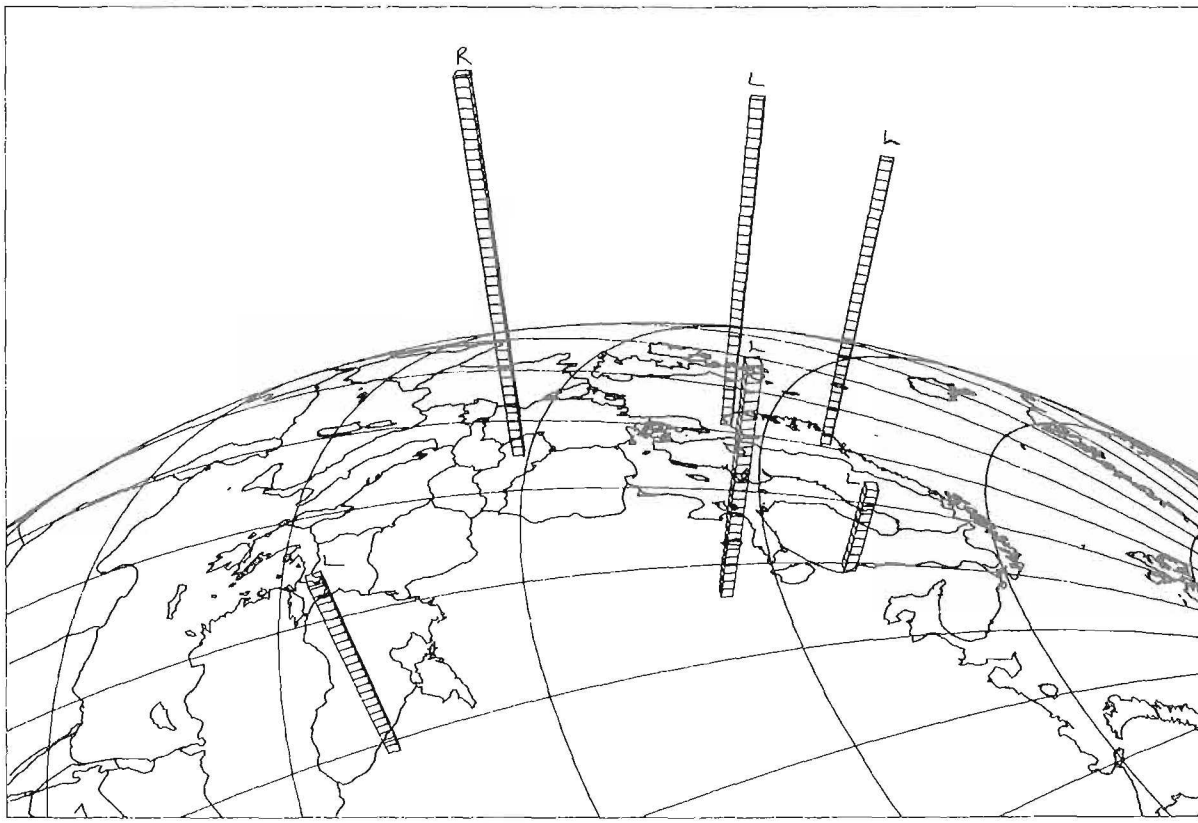
K 1988-89, scale unit 10 mg/m²•a



K 1988-89, scale unit 10 mg/m²•a



K 1989-90, scale unit 10 mg/m²•a



CHAPTER 9

Magnesium

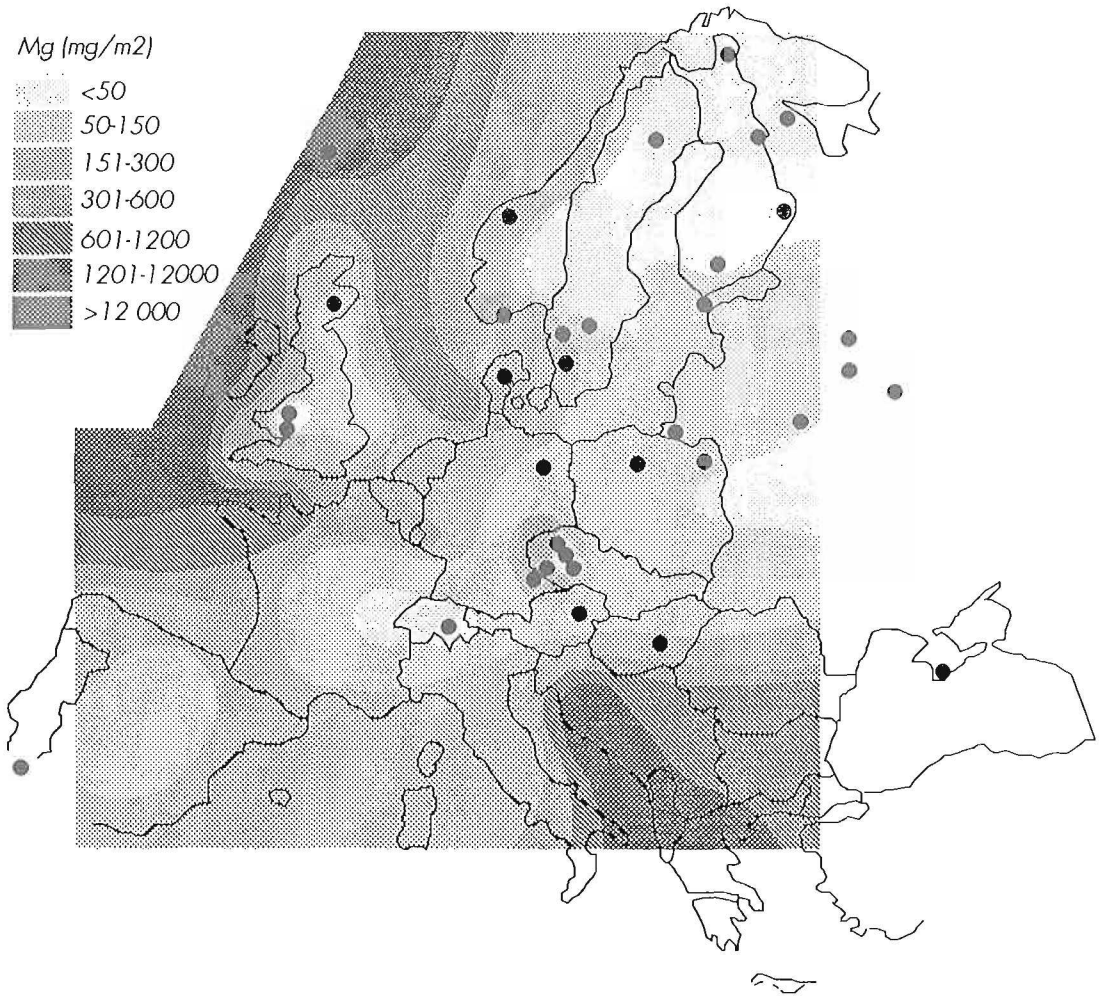
9.1 Fields of deposition

Sea-spray is the most important source. Few high deposition areas are covered by the network.

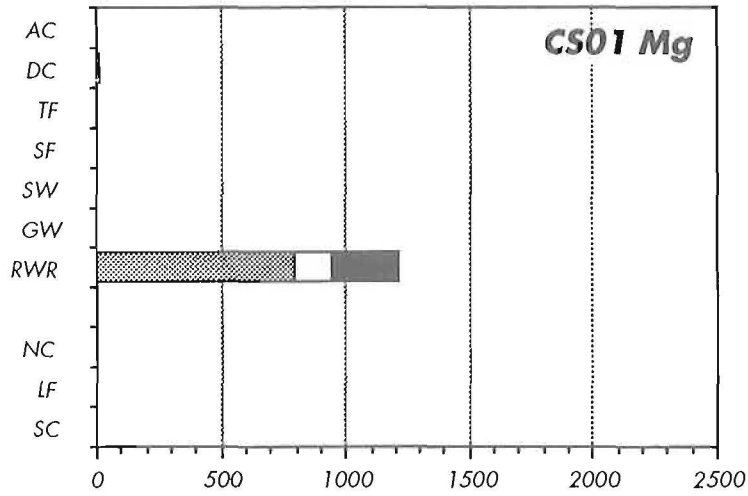
9.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,PL02,GB01,GB02)

Precipitation values are low but runoff water concentrations are high in some of the Czech and Polish areas. In the west at Afon Hafren (GB02) precipitation values show a higher variation and the runoff values are lower.



Field of deposition of Mg (mg/m²) in 1988 acc to EMEP (CCC 4190).



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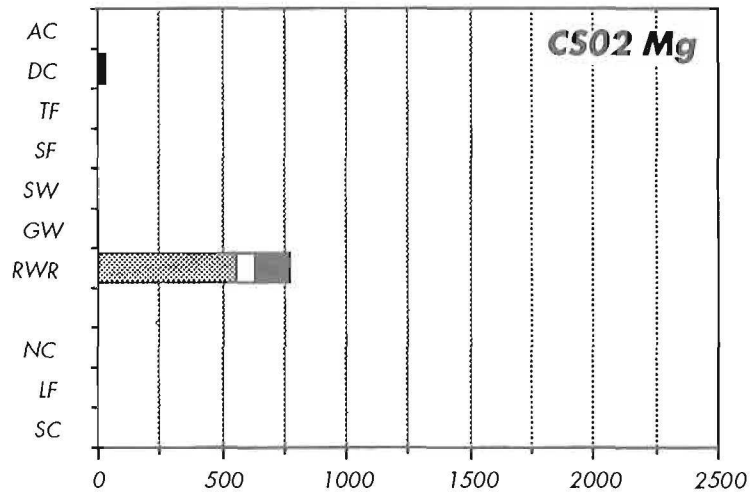

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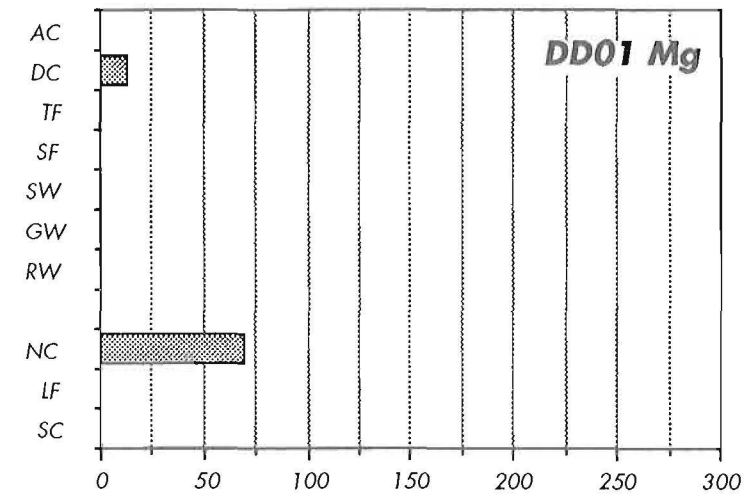

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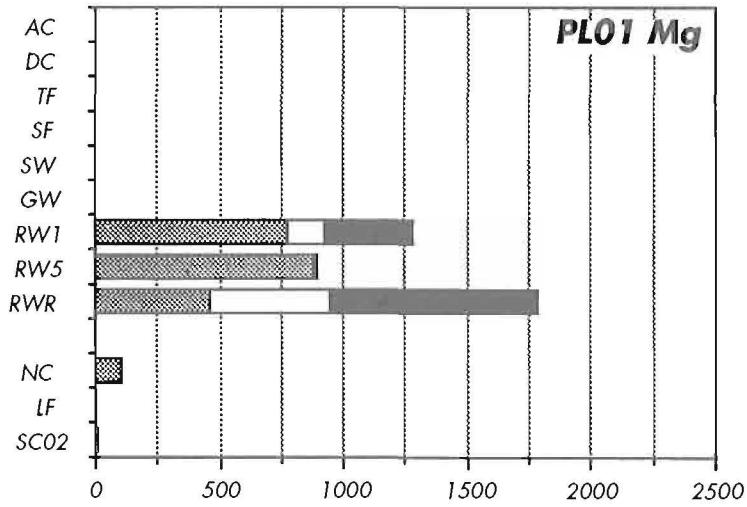

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RWR	06 03 9004 9007
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LF	0 0
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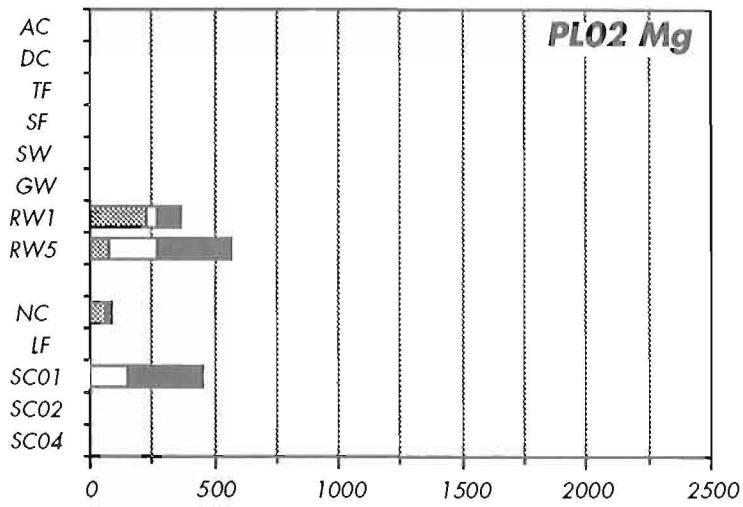

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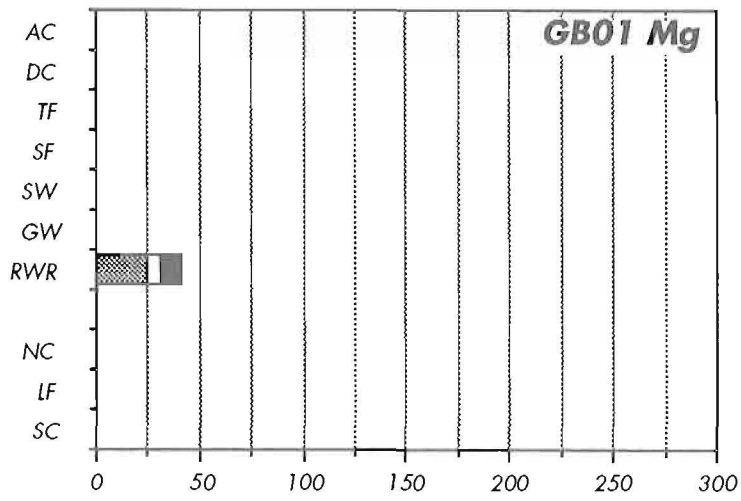
SC04	01 01 9006 9006



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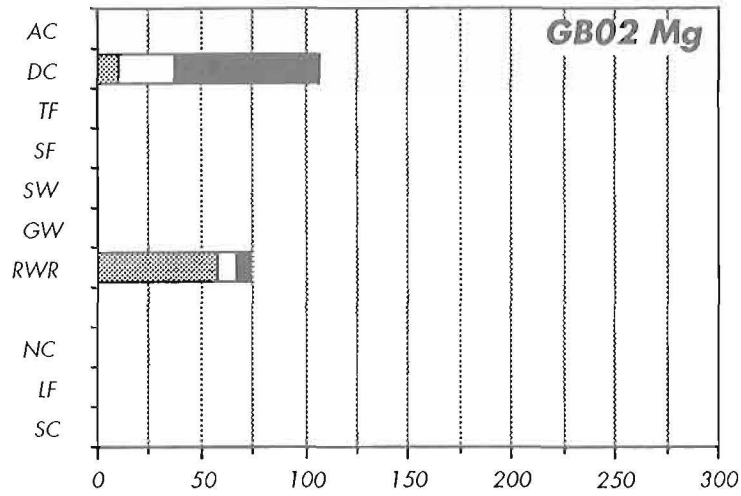

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GW	0 0
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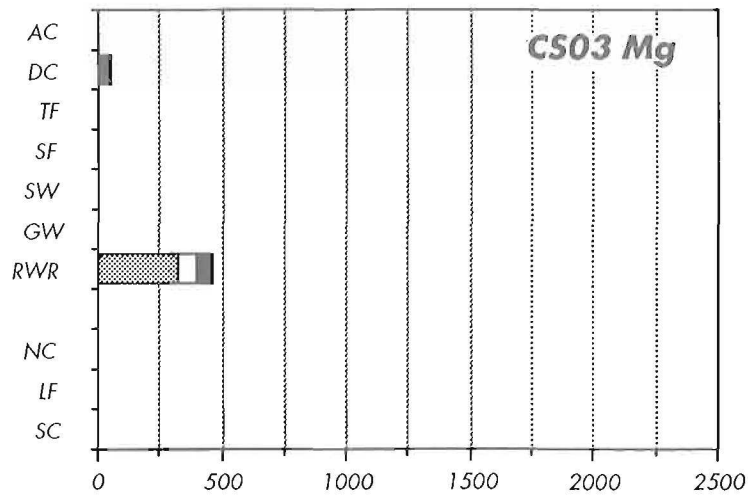
LF	0 0
SC	0 0

Montaneous Central (CS03,CS04,DE01,CH01)

Jezeri (CS03) has outstanding high values although not very different from the nemoral areas. Recordings in Forellenbach (DE01) show enrichment with gravitional flow.



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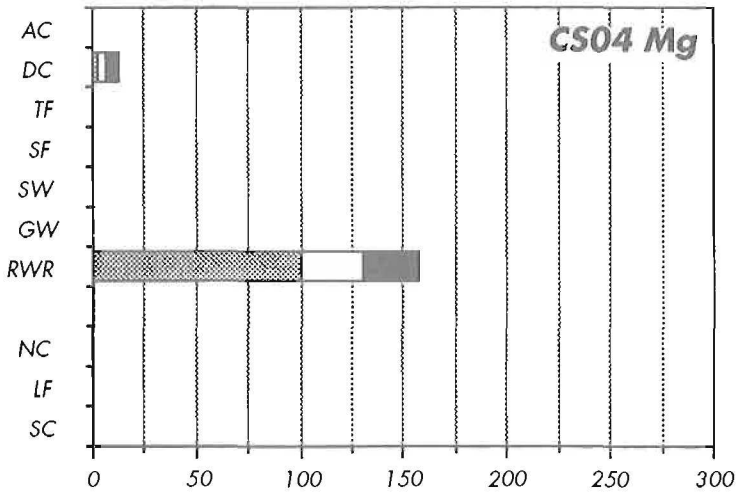

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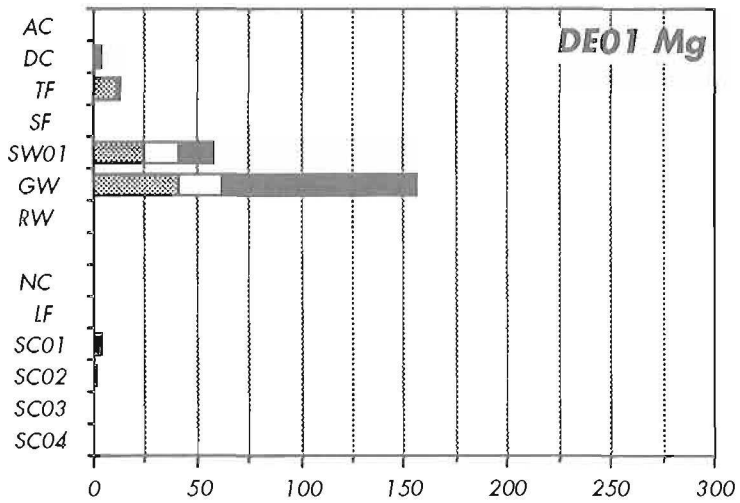

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GW	03 05 8911 9007
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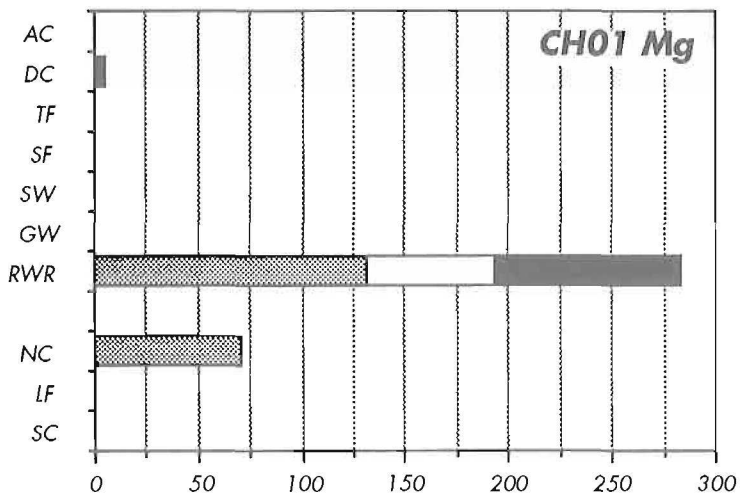
SC02	01 01 9008 9008
SC03	02 01 9008 9008
SC04	03 01 9008 9008



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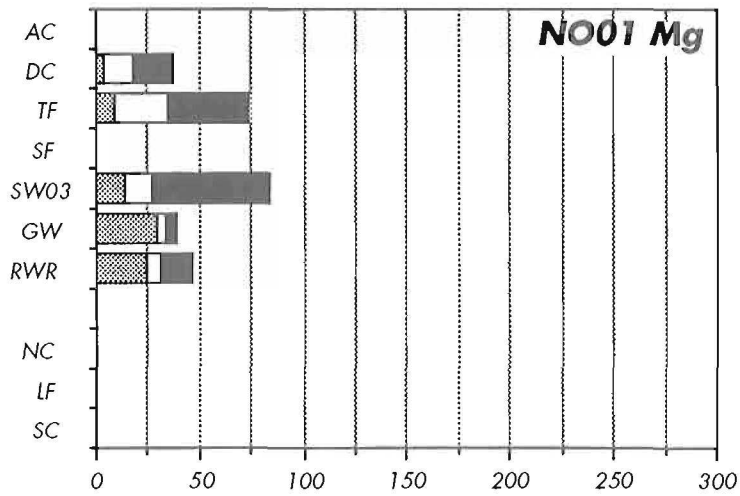
SW	0 0
GW	0 0
RWR	01 12 8911 9010
NC	01 01 8900 8900
LF	0 0
SC	0 0

Boreonemoral Ecotone (NO01,SE01,SE02,SE04,SU02,SU04,SU15)

In the areas of this region enrichment of the element concentrations takes place with gravitional flow. In Birkenes (NO01) and Tiveden (SE01) the enrichment factors are however very small.



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GW	01 11 8711 8810
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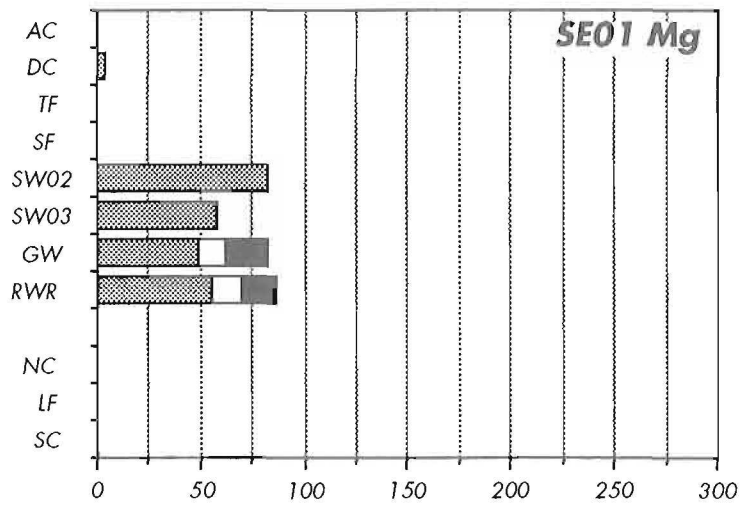

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SW03	01 01 8911 8911
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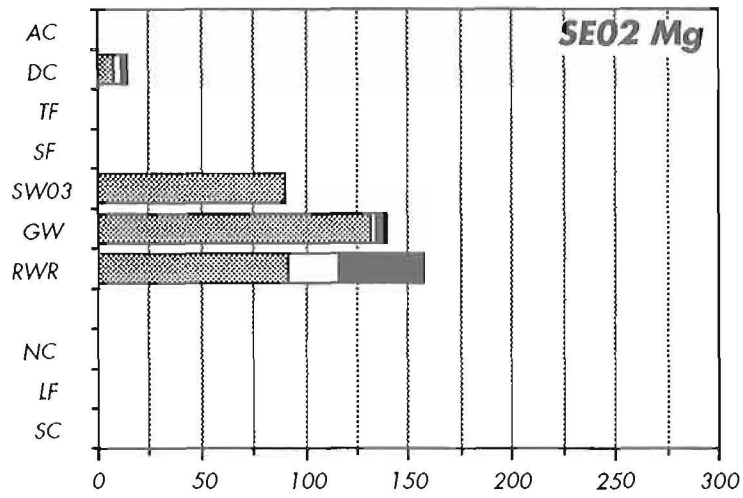

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TF	0 0
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SW03	01 01 8911 8911
GW	01 03 8904 8910
RWR	02 02 8911 8912
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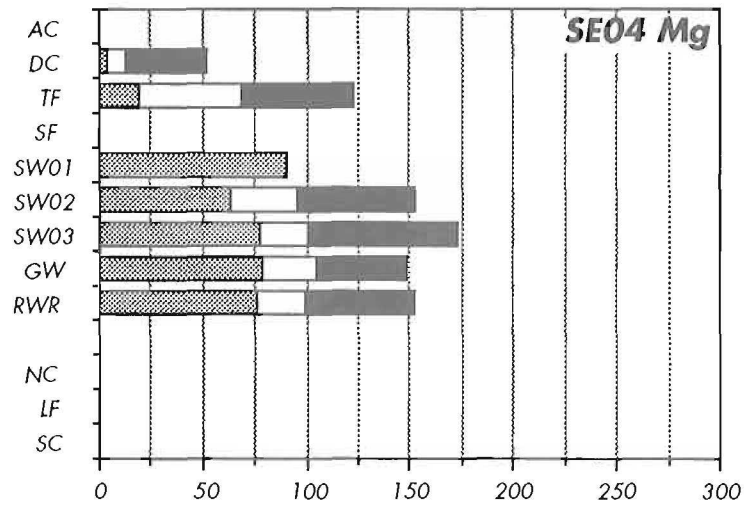
LF	0 0
SC	0 0



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SW03	06 07 8711 8810
GW	05 07 8712 8810
RWR	01 12 8711 8810
NC	0 0
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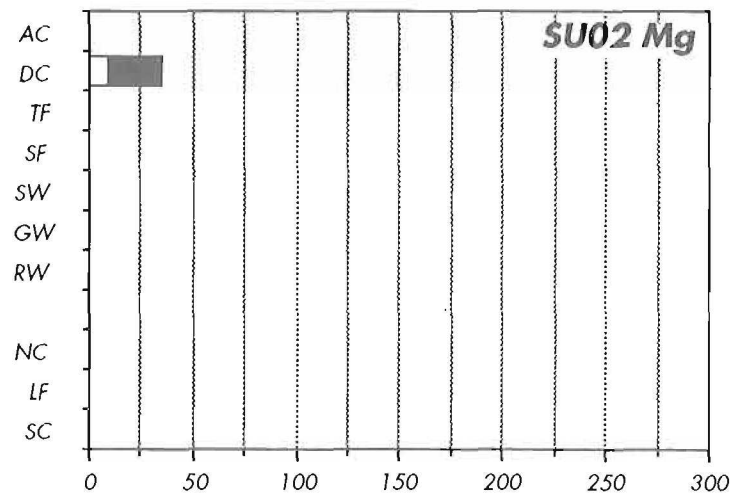
SC	0 0



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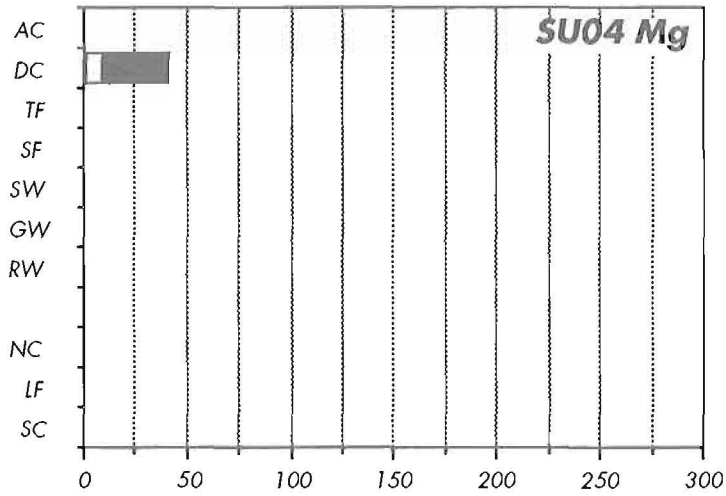

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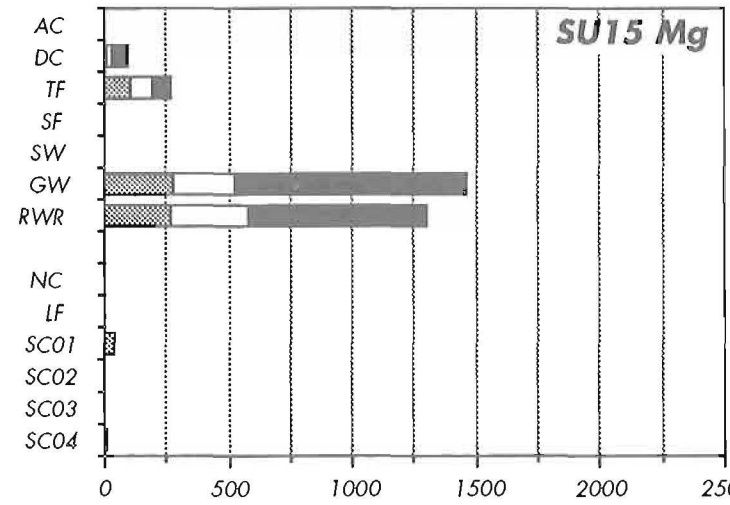

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SW	0 0
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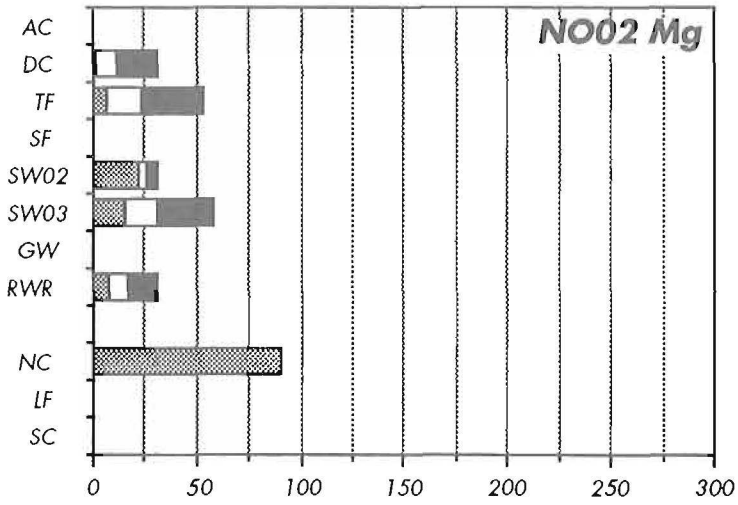
RWR	01 10 9001 9010
NC	0 0
LF	0 0
SC01	01 01 9008 9008
SC02	01 01 9008 9008
SC03	01 01 9008 9008
SC04	01 01 9008 9008

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

The enrichment of concentrations differs slightly from the above mentioned region. Maximum concentrations are found in very different media: in soil water (Kårvatn; Valkeakotinen, at 10-20 cm depth; Velikiy, at 0-10 cm depth), in runoff water (Pesosjärvi, influenced by dolomitic regolith) and in stemflow (Hietajärvi and Vuoskojärvi).



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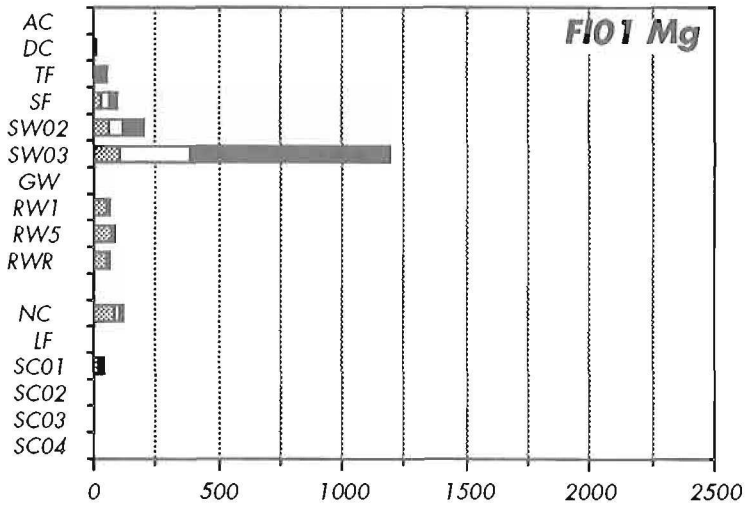
SW03	01 06 9005 9010
GW	0 0
RWR	01 12 8911 9010
NC	01 01 8909 8909
LF	0 0
SC	0 0



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SW03	02 04 8907 8910
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RW1	01 02 9002 9008
RW5	01 02 9002 9008
RWR	01 03 9002 9008
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SC02	05 01 8900 8900
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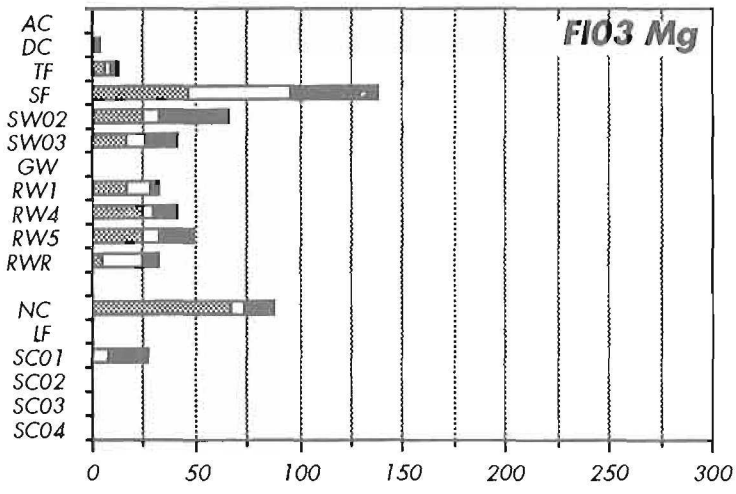

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SW03	02 03 8908 8910
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RW1	02 11 8912 9010
RW4	02 11 8912 9010
RW5	02 11 8912 9010
RWR	03 12 8911 9010
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LF	0 0
SC01	04 01 8800 8800
SC02	04 01 8800 8800
SC03	01 01 8800 8800
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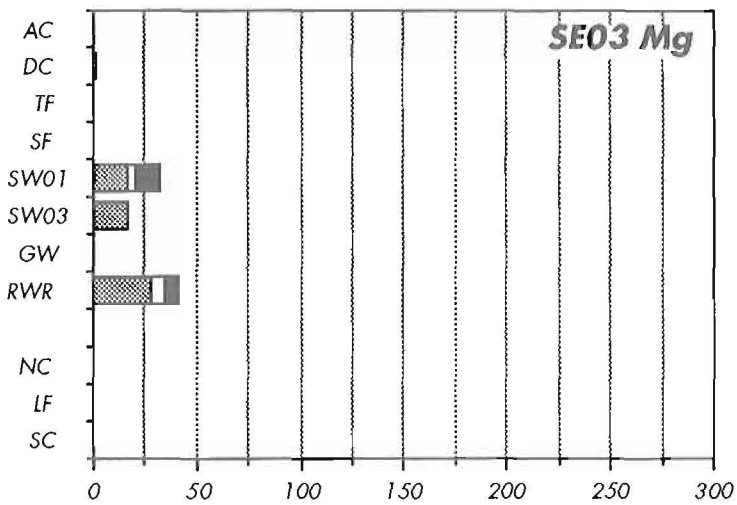

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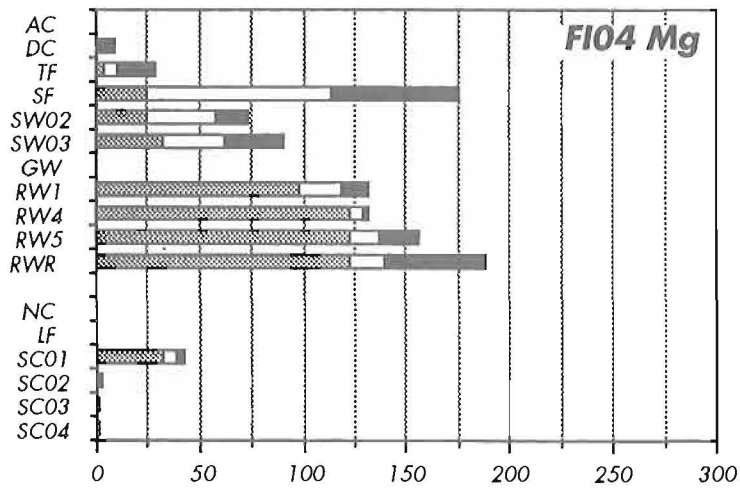

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RW4	01 03 9004 9009
RW5	01 03 9004 9009
RWR	04 12 8911 9010
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SC03	05 01 8900 8900
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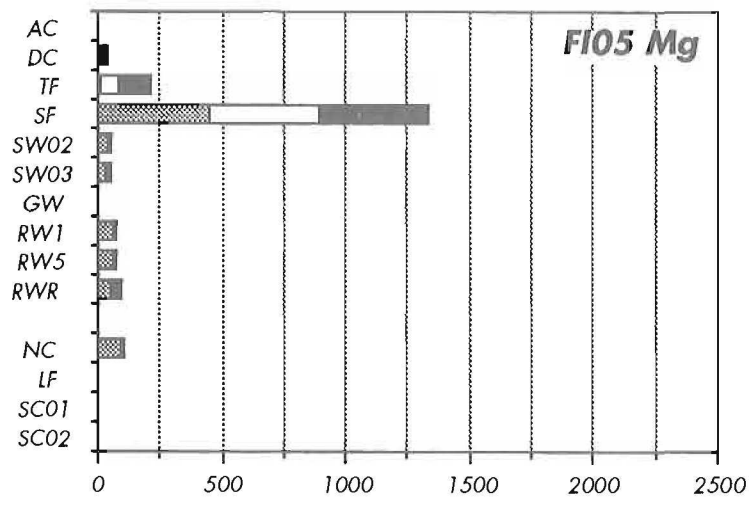

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SW03	02 03 8908 8910
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LF	0 0
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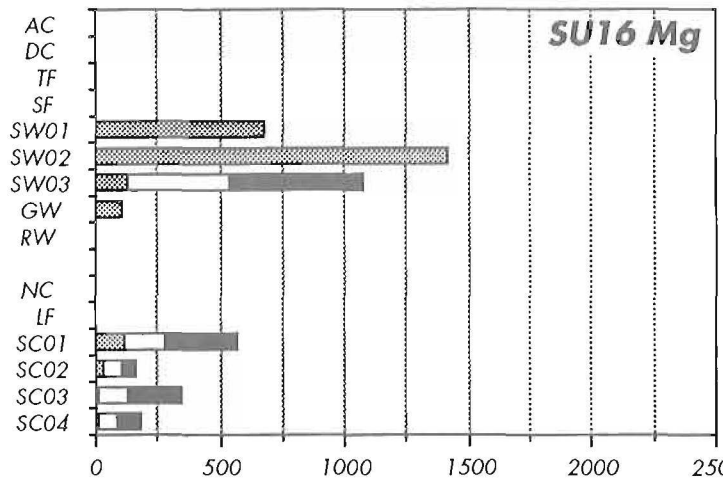

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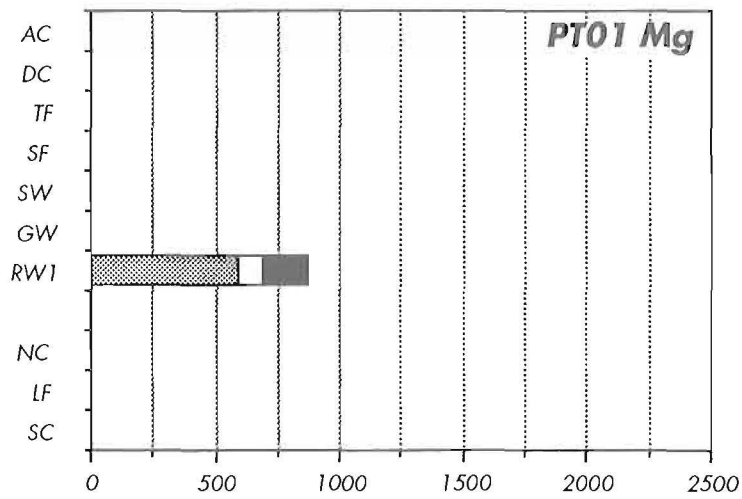
SW02	01	01	8908	8908
SW03	02	01	8908	8908
GW	01	01	8908	8908
RW	0	0		
NC	0	0		
LF	0	0		
SC01	03	01	8908	8908
SC02	02	01	8908	8908
SC03	03	01	8908	8908
SC04	03	01	8908	8908

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

High concentration in lake surface water are found in Alentejo (PT01). In Komlosi (HU01) enrichment occurs with passing of canopy (maximum 1200 µeqv/l/month in stemflow).



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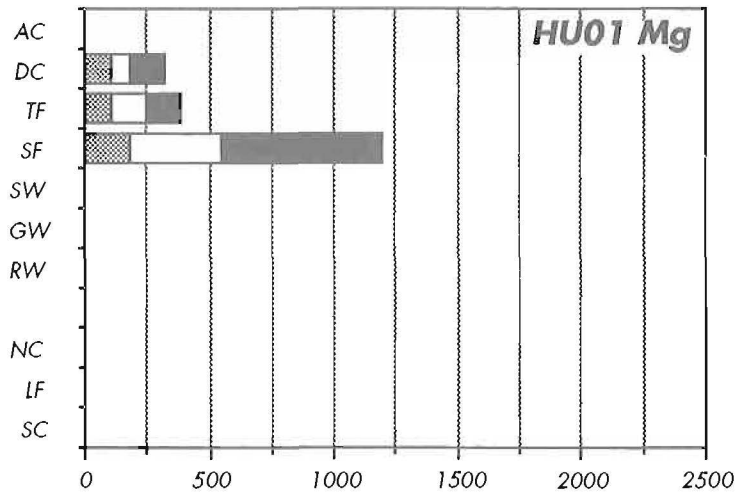

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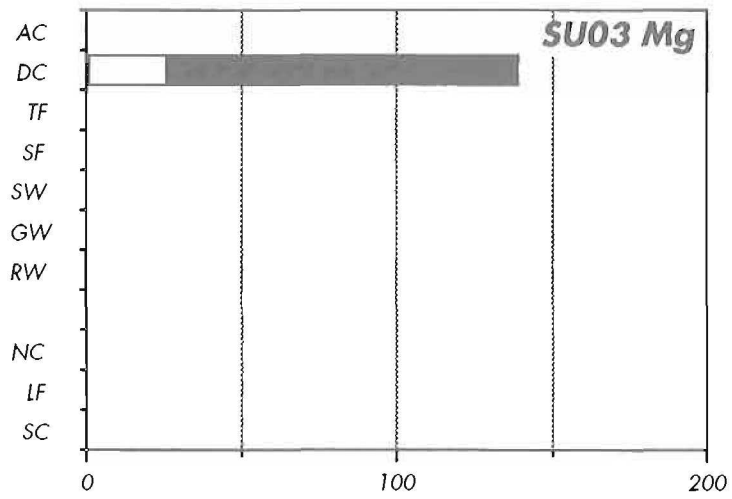
LF	0 0
SC	0 0

Montaneous East (SU03,SU05)

In Caucasus BR (SU03) notable is the high variation in the concentrations of precipitation. In the Juga Massif (SU05) enrichment towards groundwater and runoff water is evident.

Nearctic Nemoral (CA01)

The highest concentrations are found in the groundwaters of Turkey Lakes (CA01).



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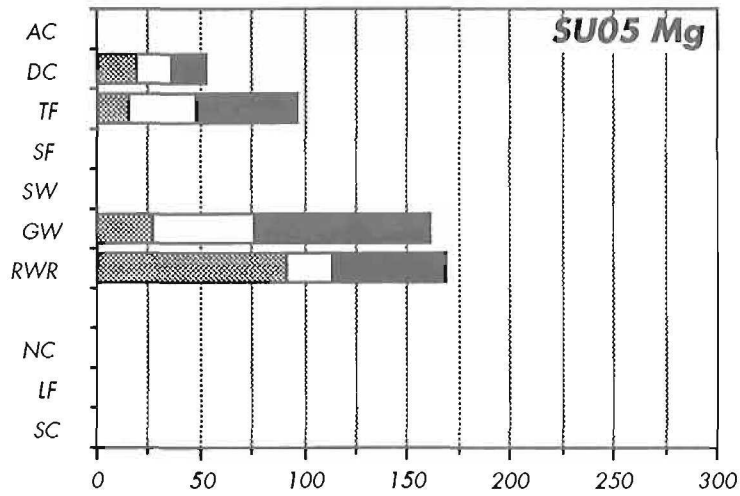

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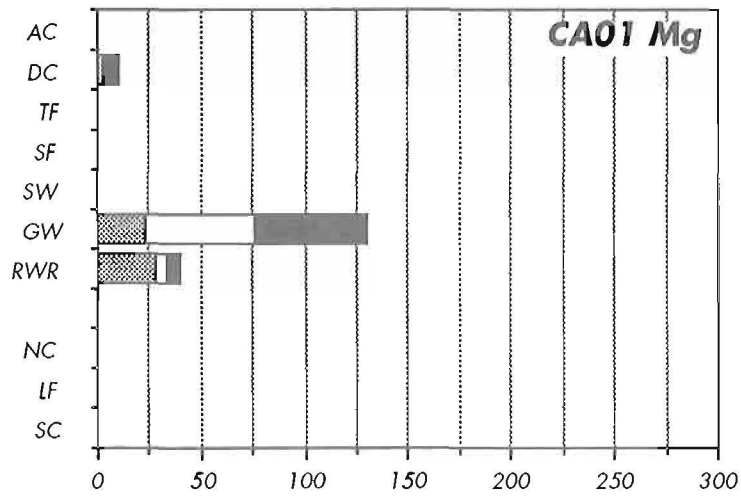

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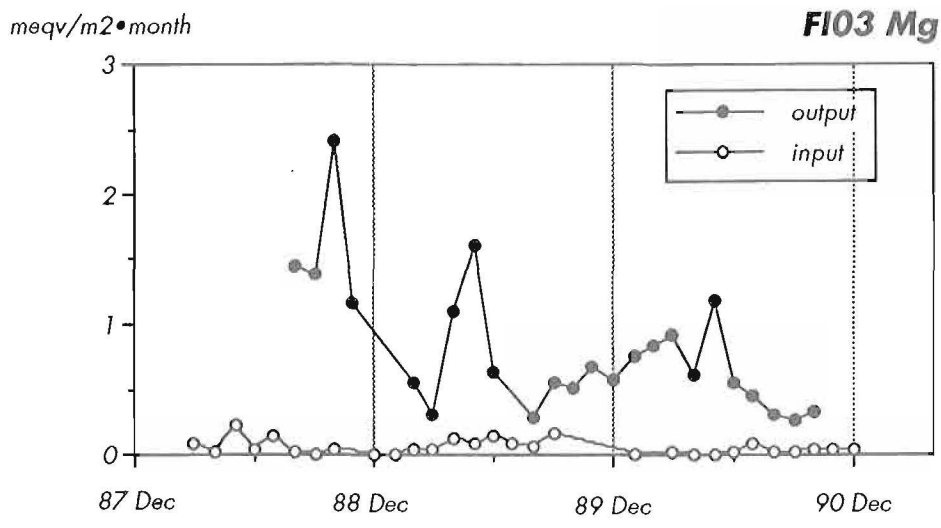
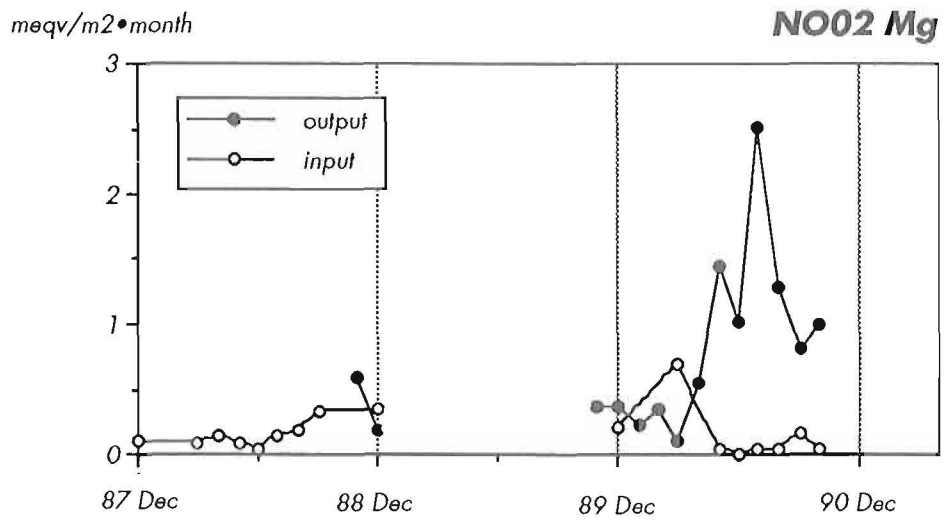
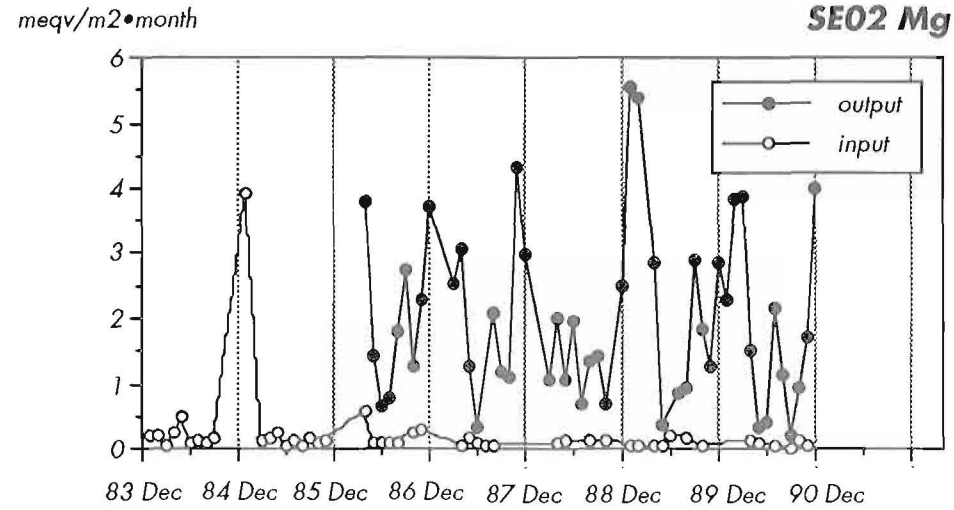
RWR	01 11 8811 8909
NC	0 0
LF	0 0
SC	0 0

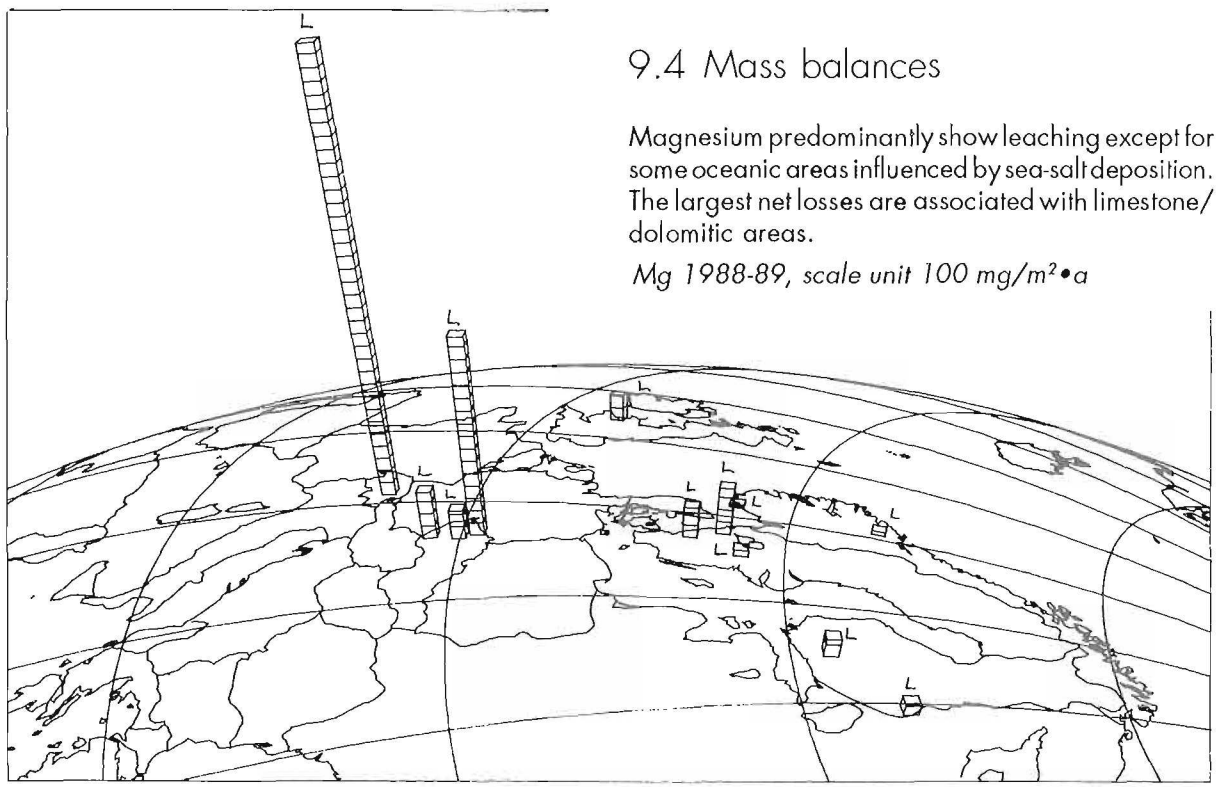
9.3 Long-term temporal variation

In this section, time series of monthly fluxes of magnesium expressed as m eqv/(m²•month) are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02). N.B. Not corrected for sea-salts.







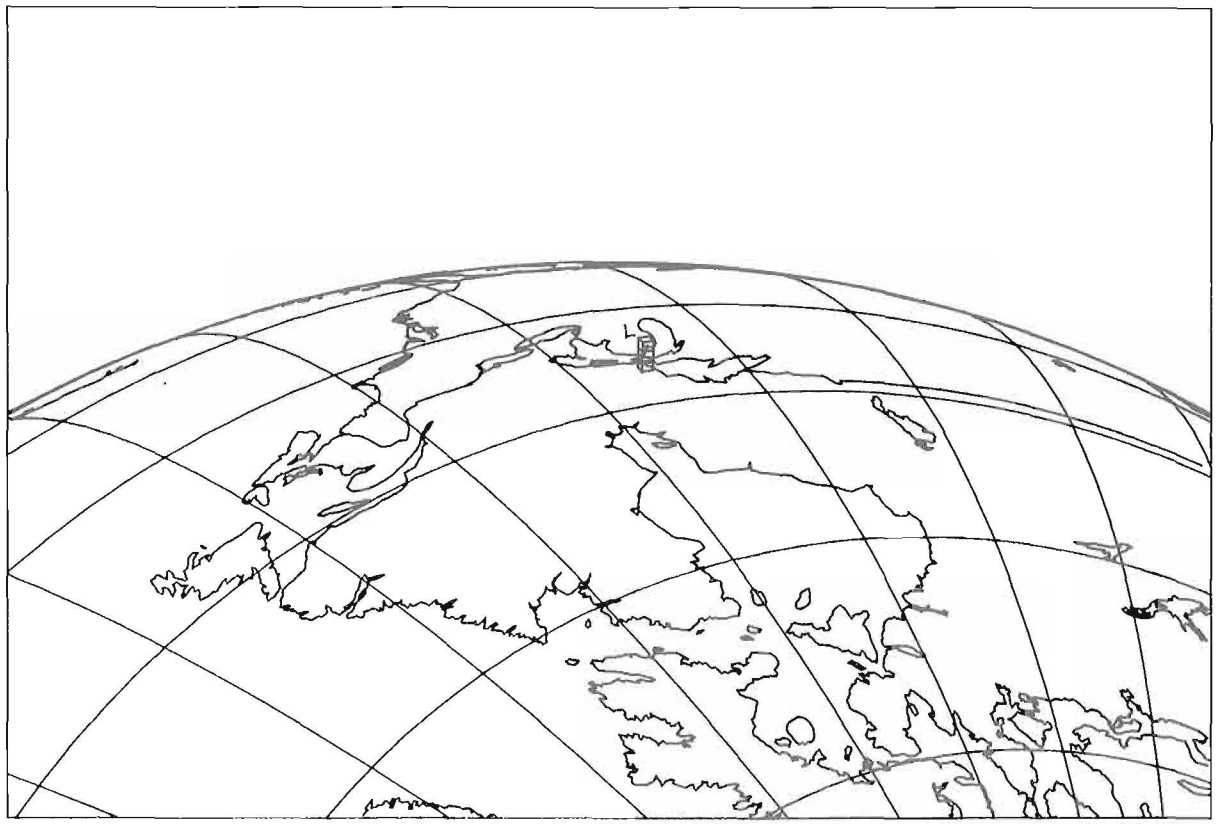


9.4 Mass balances

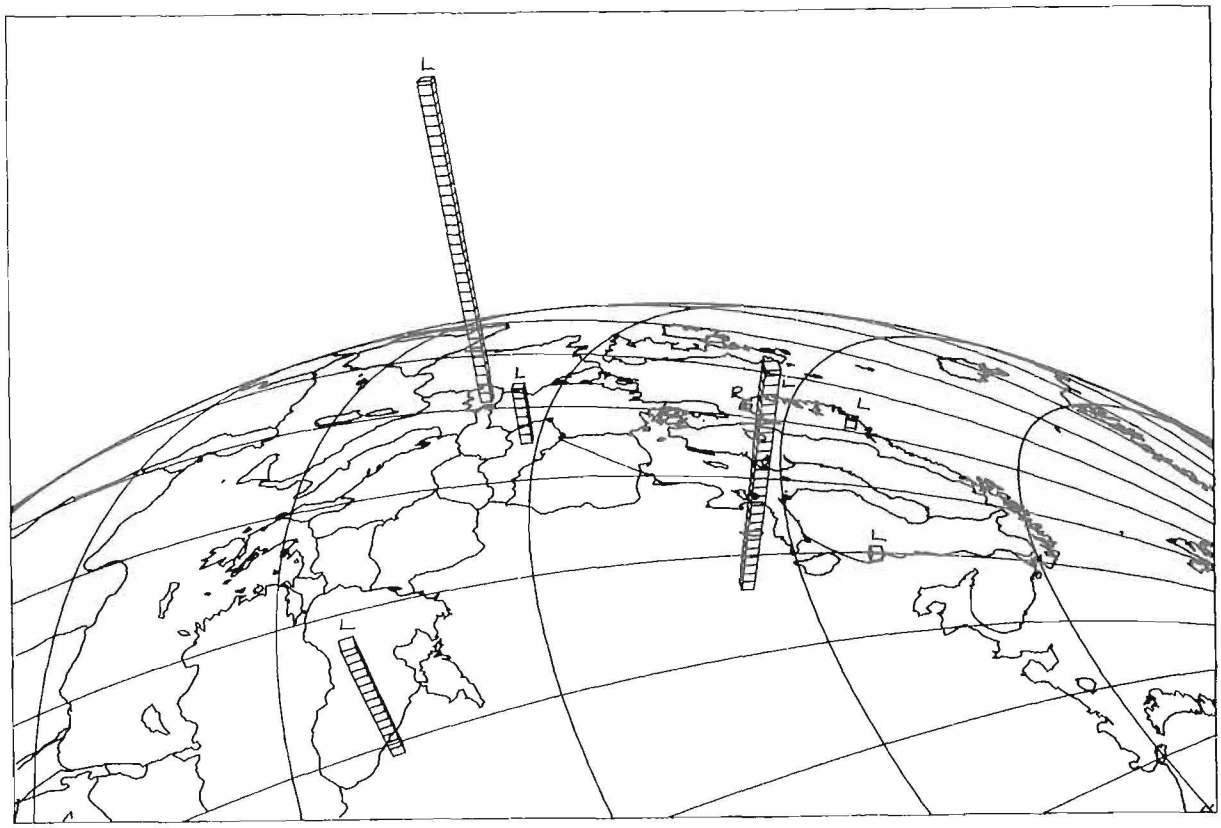
Magnesium predominantly show leaching except for some oceanic areas influenced by sea-salt deposition. The largest net losses are associated with limestone/ dolomitic areas.

Mg 1988-89, scale unit 100 mg/m²•a

Mg 1988-89, scale unit 100 mg/m²•a



Mg 1989-90, scale unit 100 mg/m²•a



CHAPTER 10

Chloride

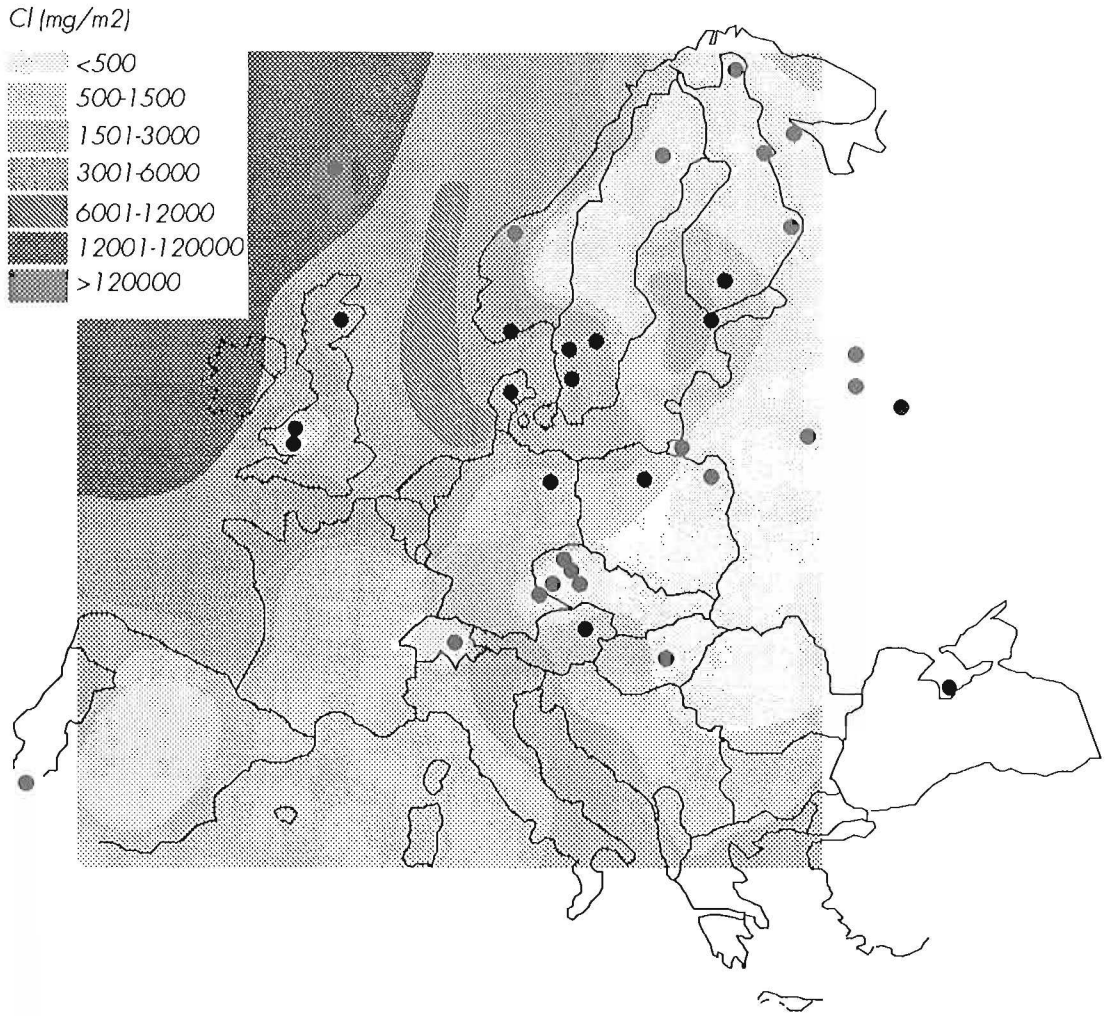
10.1 Fields of deposition

The source of this conservative element is in the sea-spray. As poorly reactive salt-bindings it normally passes quite fast through the ecosystem and is often used as a tracer and mass budget balancer (sc. Cl-corrections when output/input ratio is greater than 1).

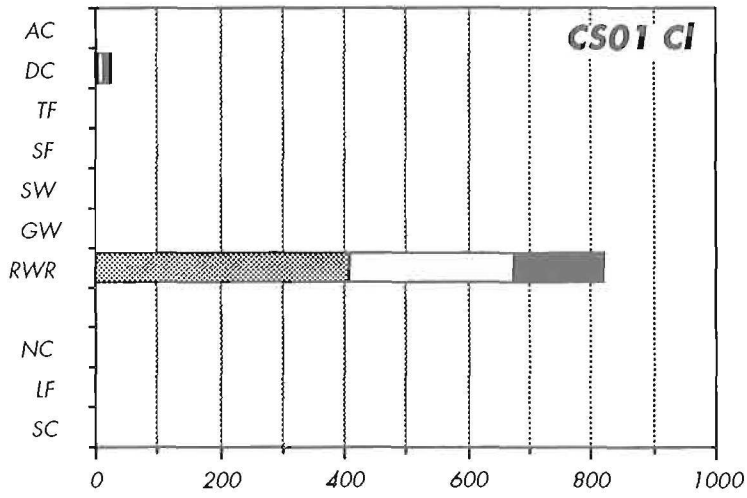
10.2 Short-term temporal variation

Nemoral Region (CS01,CS02,DD01,PL01,SU11,GB01,GB02)

Distance from sea causes low concentrations in precipitation, whereas runoff water concentrations are higher in some areas - observe e.g Anenske (CS01) with maximum > 800 µeqv/l/month - due to internal sources. More towards the coast chloride concentrations in precipitation, reflecting sea-spray, increase and exceed those of runoff waters. In Afon Hafren (GB02) precipitation concentrations already exceeds 700 µeqv/l/month temporarily.



Field of deposition of Cl (mg/m²) in 1988 acc to EMEP (CCC 4190).



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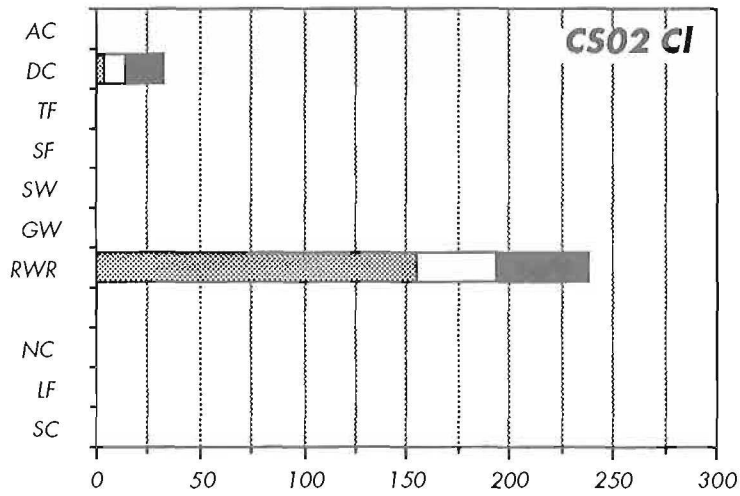

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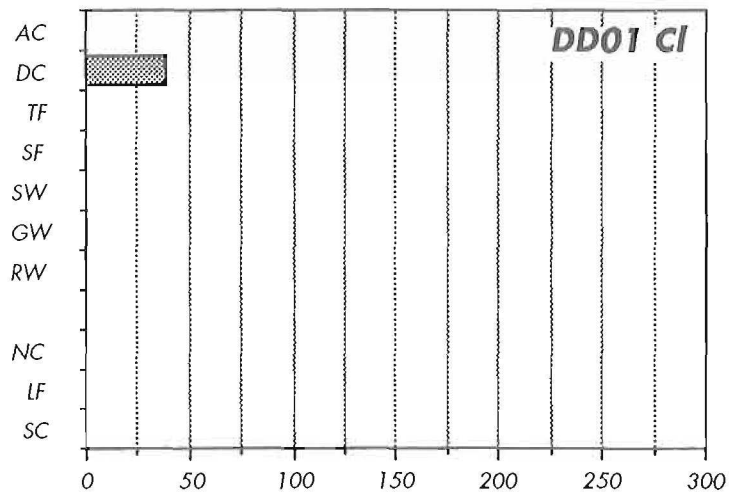

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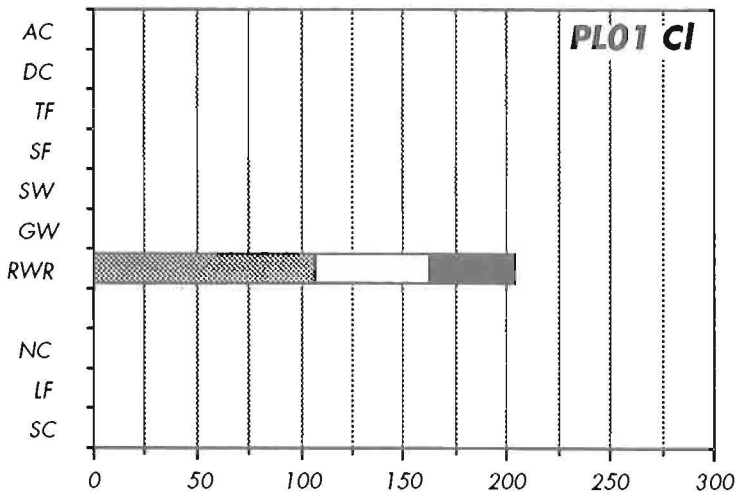

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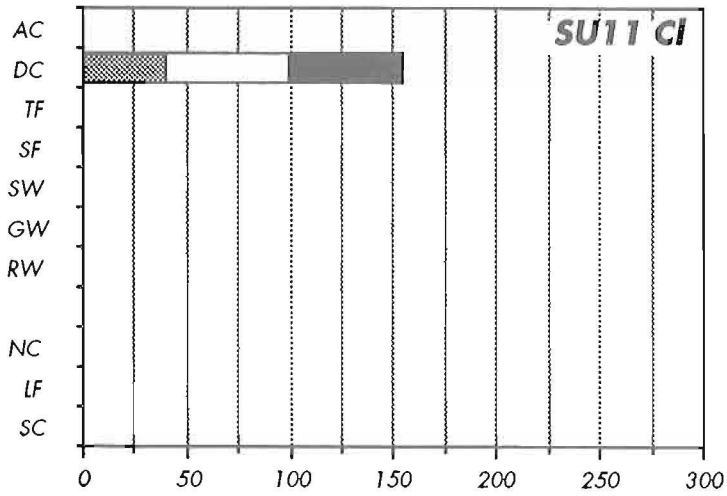

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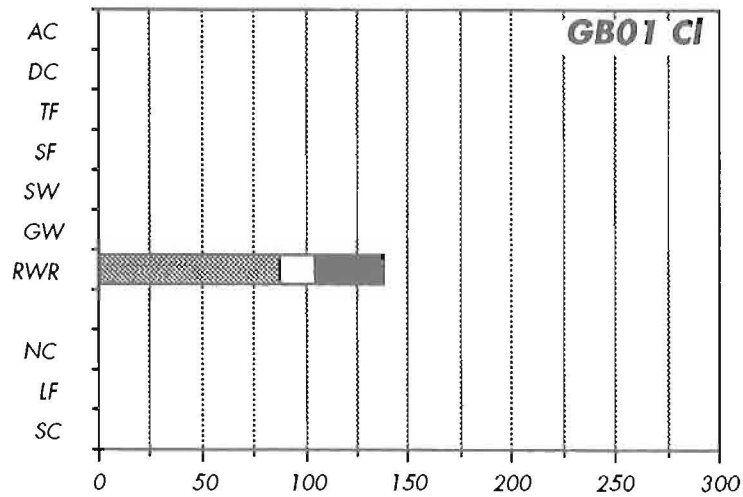

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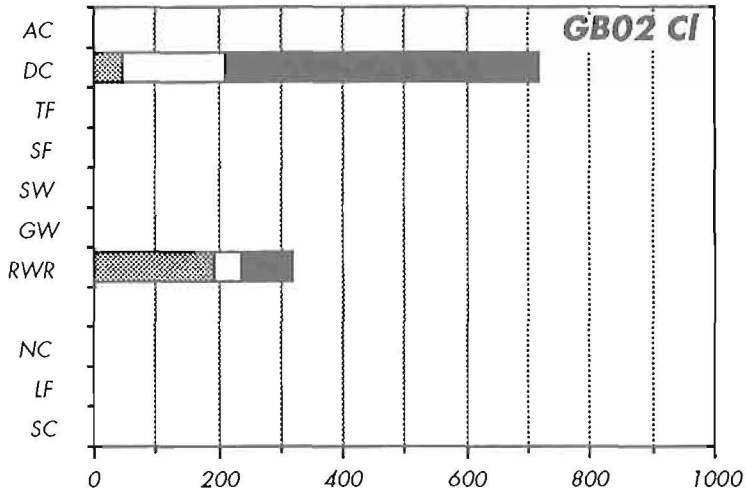

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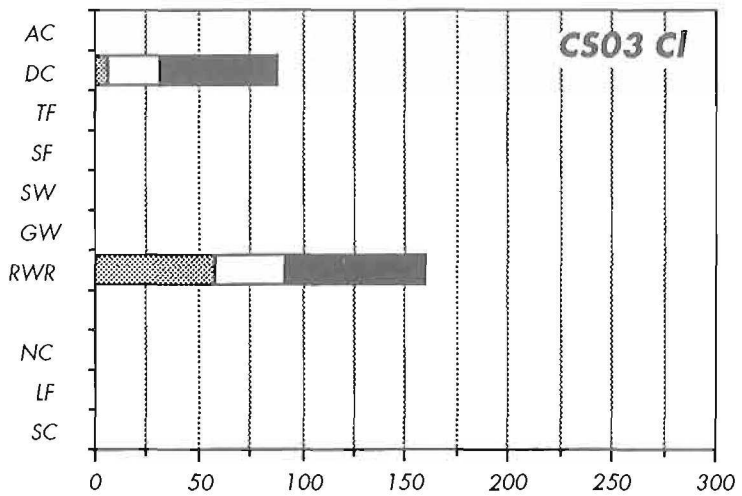
Montaneous Central (CS03,CS04,DE01,CH01)

In the mountains the concentrations in precipitation are lower than in soil water, groundwater and runoff water, in the latter with maxima in Jezeri (CS03), > 150 µeqv/l/month. In Forellenbach the enrichment factor for throughfall is approximately 2.5.



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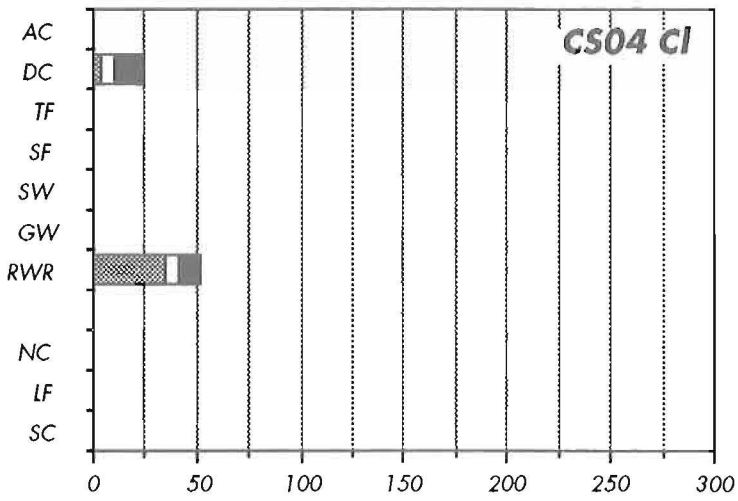

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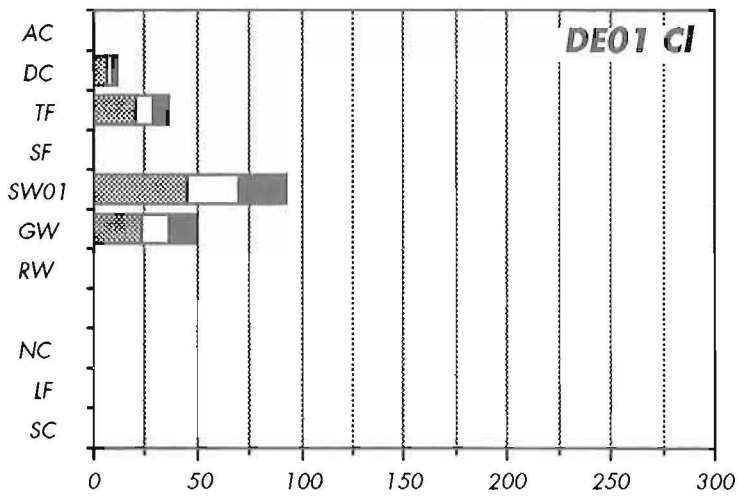

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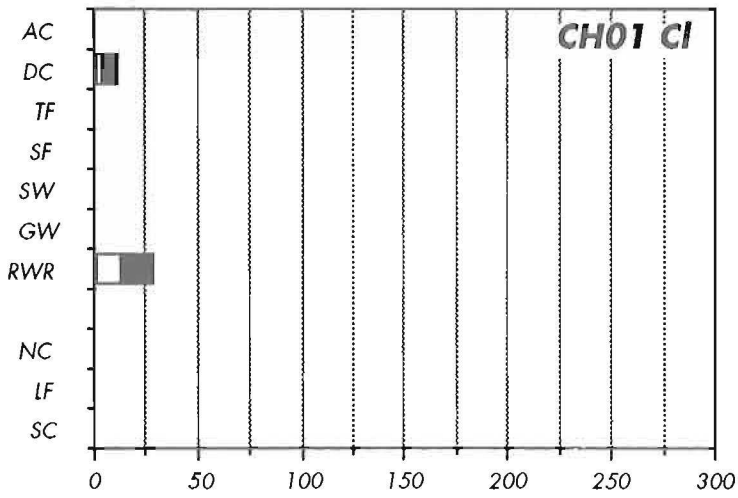

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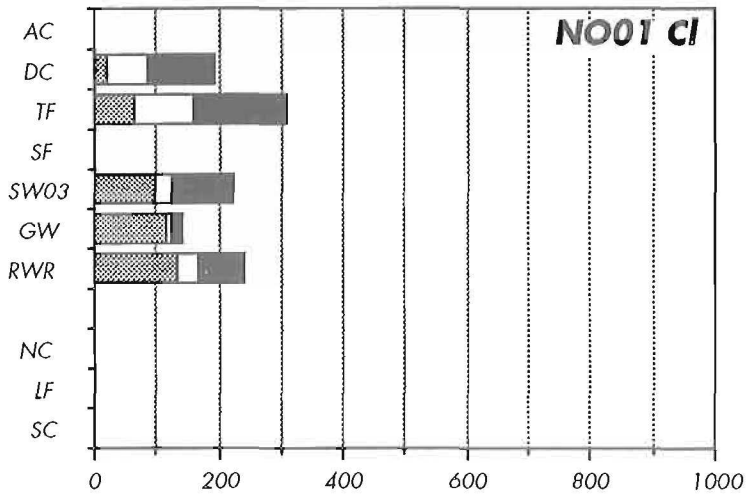
SC	0 0

In continental areas concentrations in precipitation stay below those in soil water, groundwater and runoff water Closer to the coast precipitation concentrations increase, like in Birkenes (NO01) and, quite astonishingly also in Valday (SU15). The enrichment factor for throughfall varies: being ca 1.5 at Birkenes and Valday but already 4 at Gårdsjön (SE04). In Tiveden (SE01) soil water concentrations are very high, probably due to leaching of marine Yoldia-sediments.



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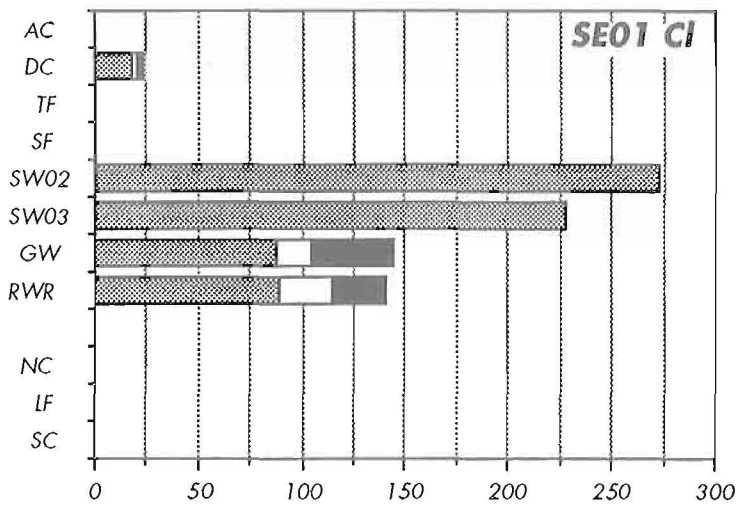

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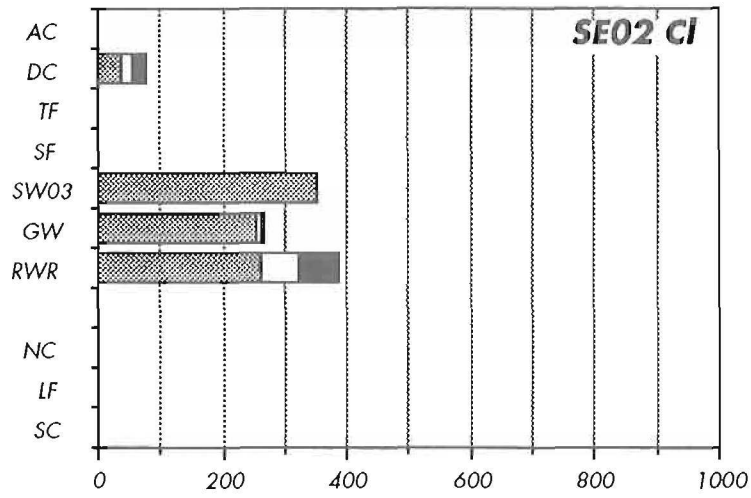

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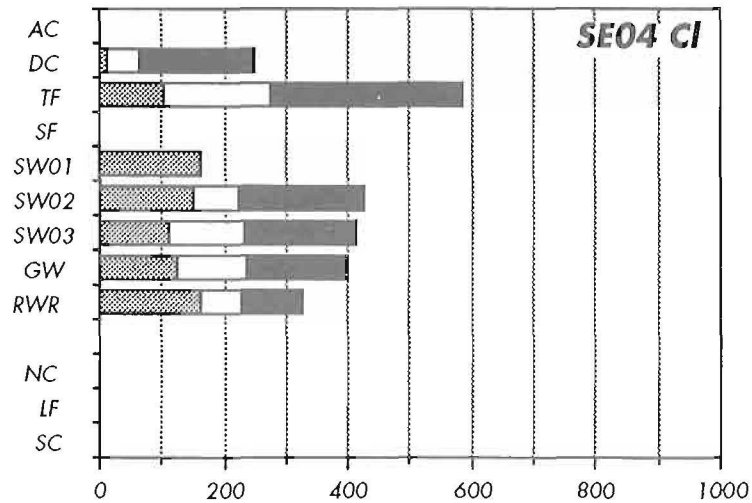

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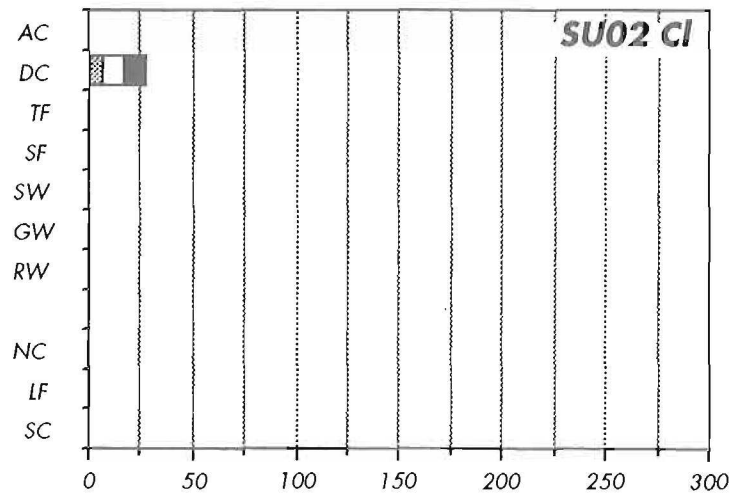

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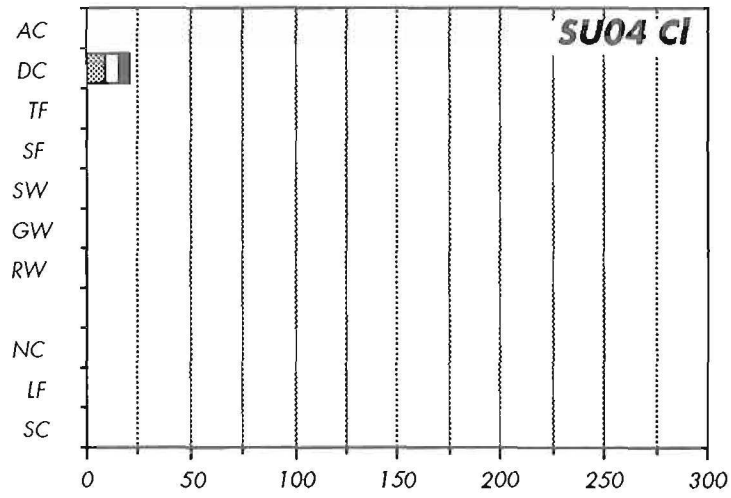

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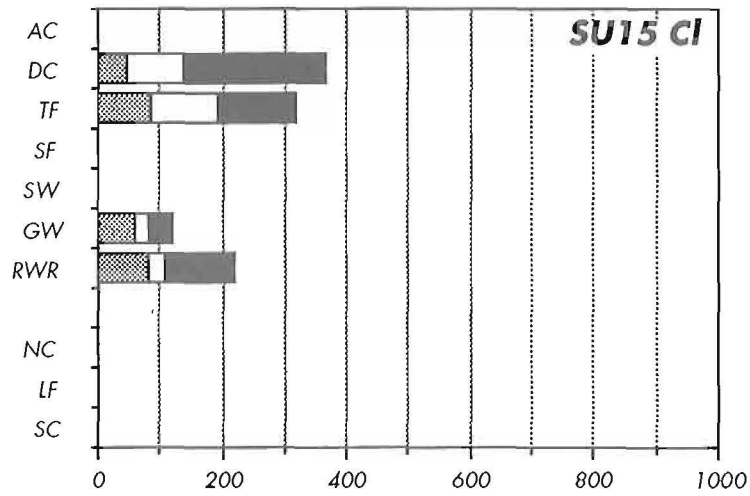

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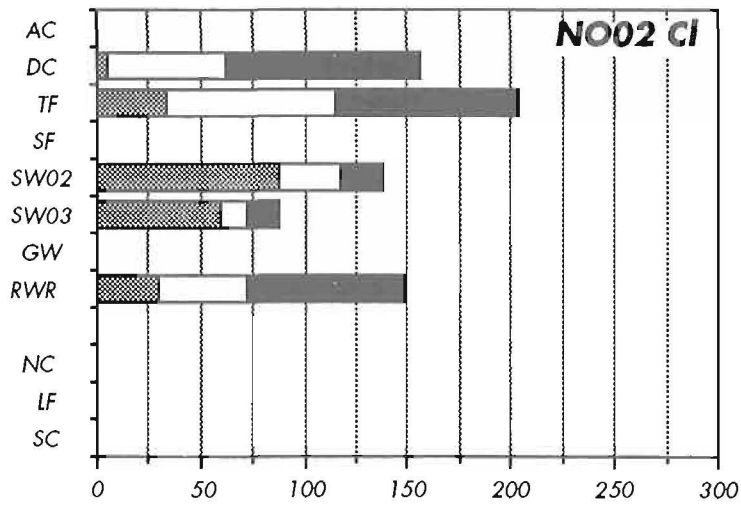
Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05)

Concentrations in soil water commonly exceeds those of running water and precipitation, except within the sphere of influece of the Arctic Sea (Velikiy, SU16). Throughfall enrichment factors range between 2 and 4 and stemflow enrichments from 5 to 35. Extreme enrichment factors (> 5000) are displayed by data from the Velikiy Island (SU16).



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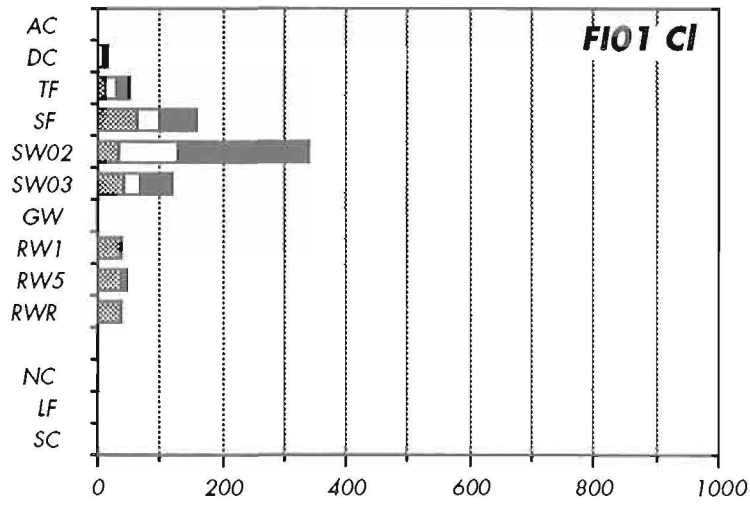

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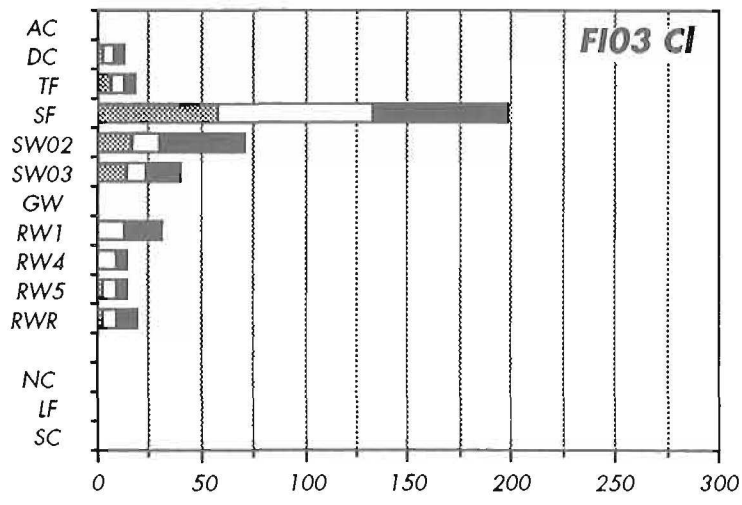

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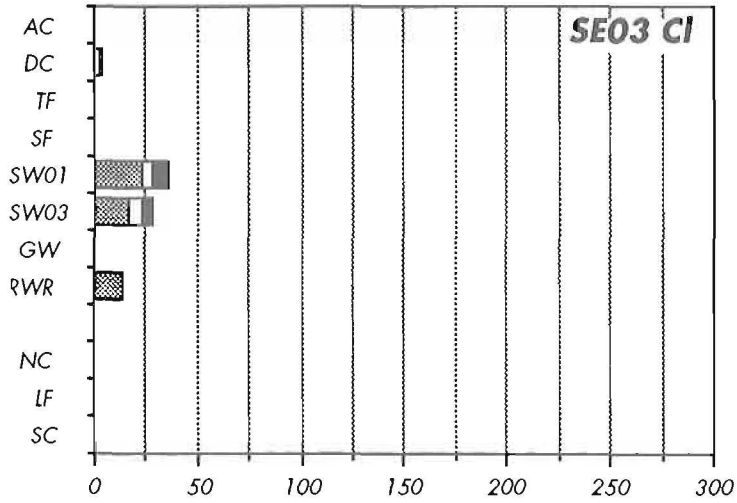

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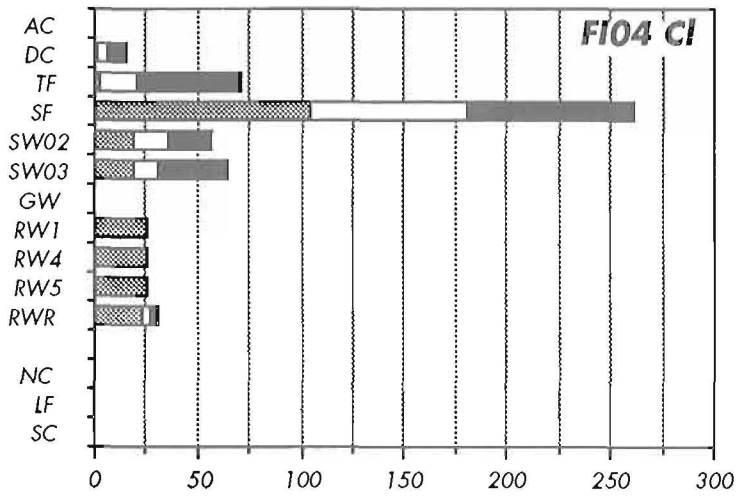

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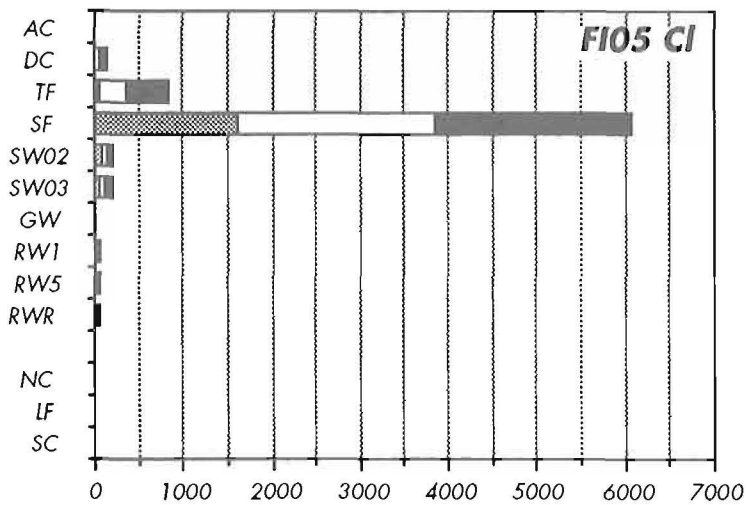

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LF	0 0
SC	0 0

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

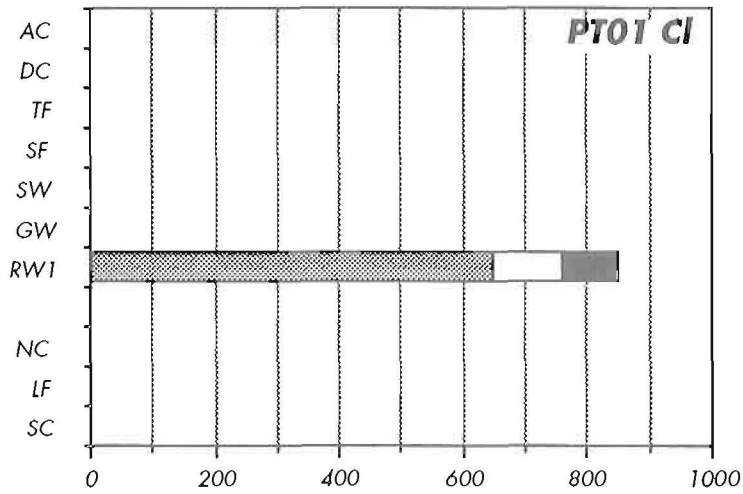
Chloride contents of lake surface waters in Alentejo (PT01) is high. In Komlosi (HU01) throughfall enrichment has a factor of 1.5 and stemflow a factor of 3...3.5.

Montaneous East (SU03,SU05)

Low concentrations characterize the Juga Massif area (SU05). The throughfall enrichment factor is ca 4.

Nearctic Nemoral (CA01)

All concentration values are very low indicating high continentality.



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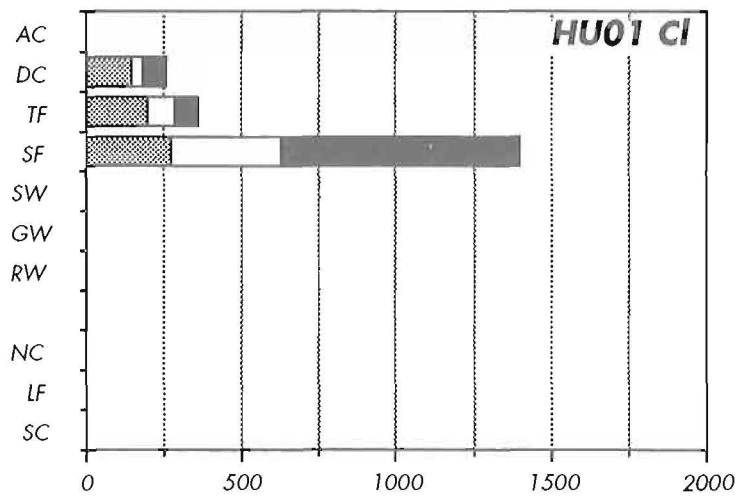

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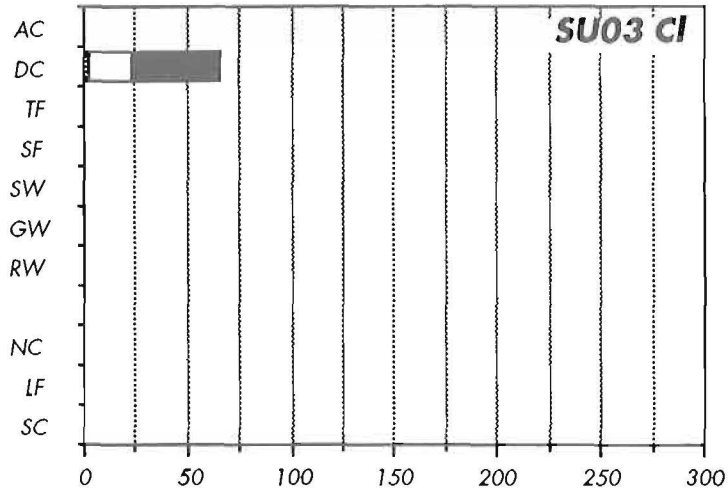

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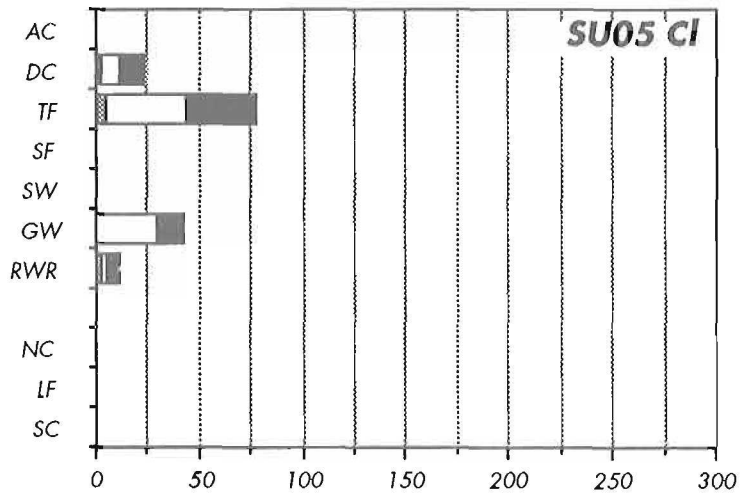

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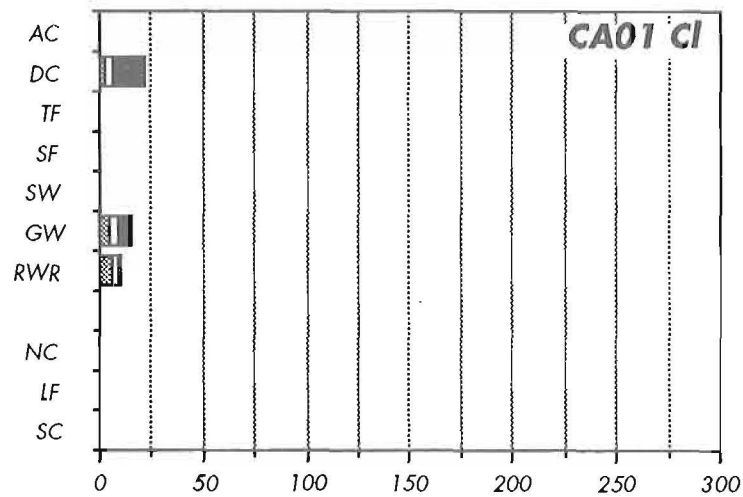

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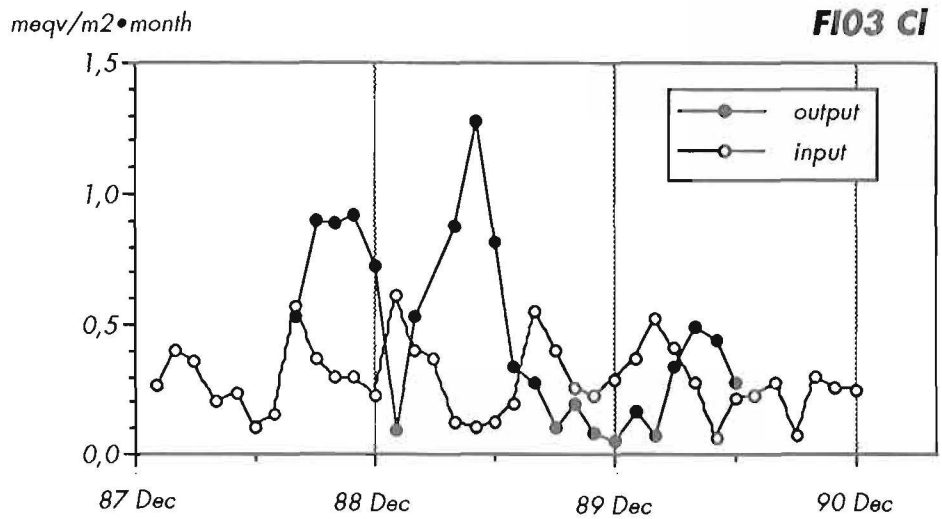
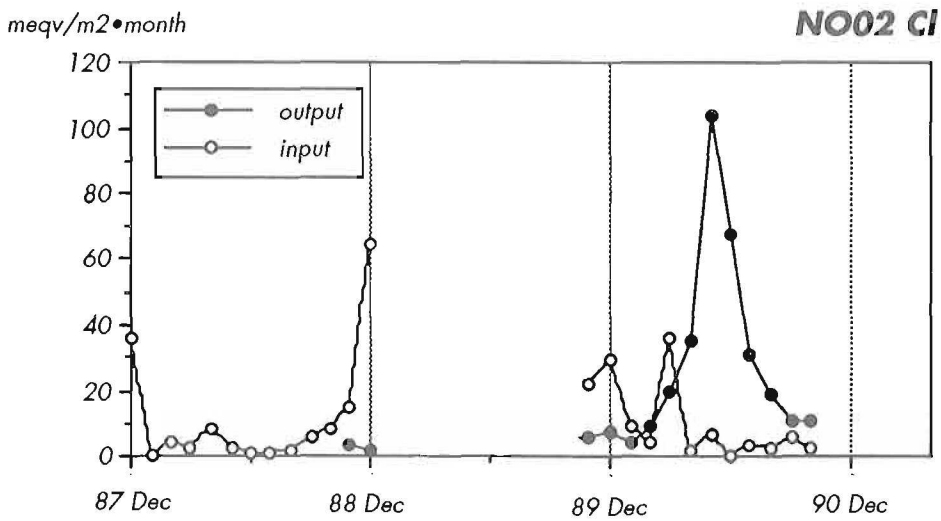
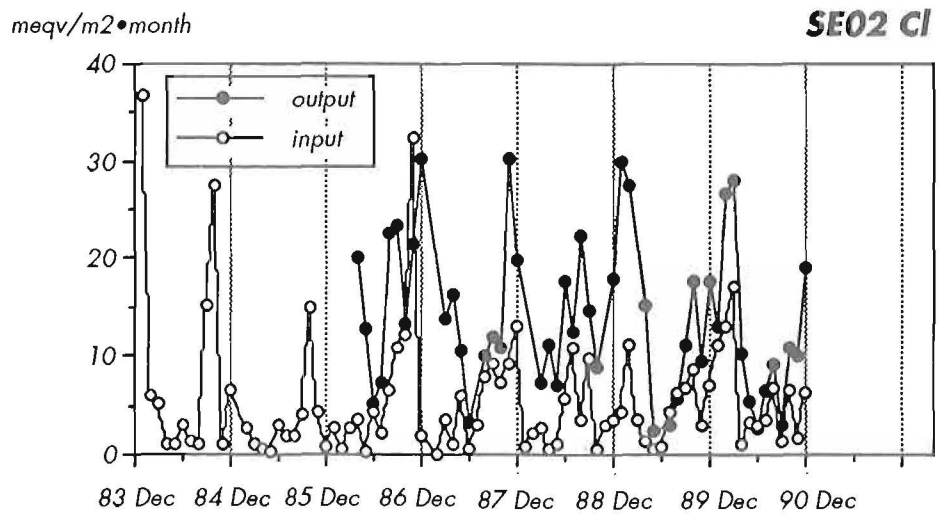
10.3 Long-term temporal variation

In this section, time series of monthly fluxes of chloride expressed as meqv/(m²•month are shown for the IM areas Hietajärvi (FI03), Kårvatn (NO02) and Berg (SE02).





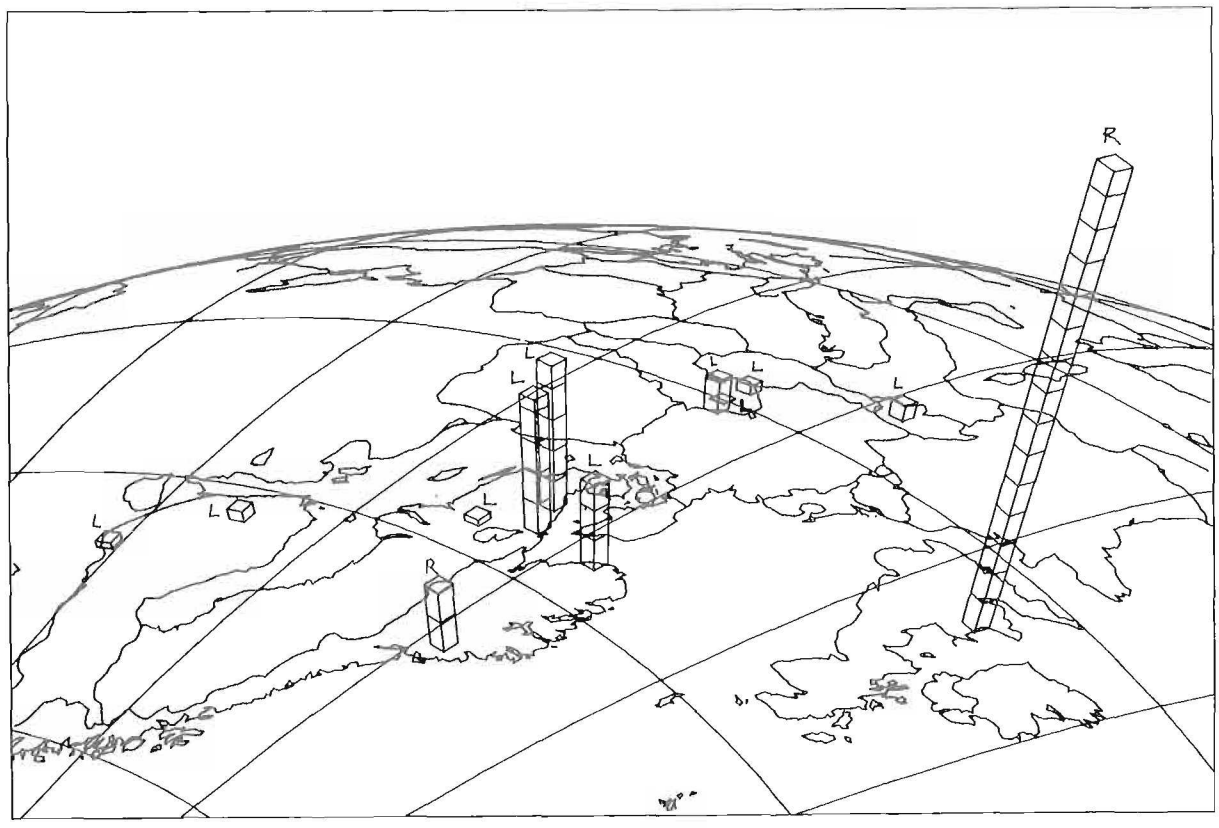


10.4 Mass balances

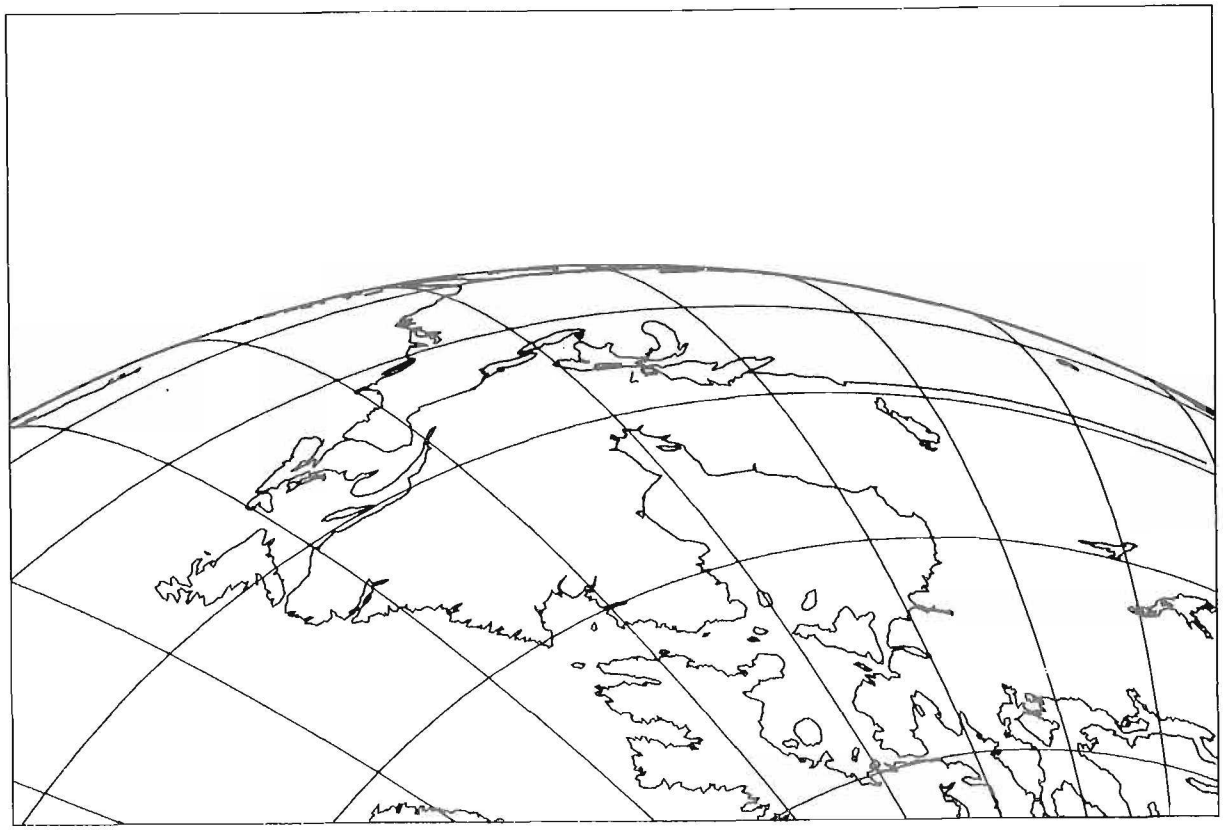
As a mobile anion chloride should (at least not in a longer perspective) show retentions or losses. For most areas the output > input (measured as bulk deposition) and the difference is accounted for as dry deposition. In some areas the input (measured as bulk deposition) > output which makes balance calculations more complicated. Such areas are influenced by sea-salt transport from adjacent seas of high salinity, eg. Kårvatn (NO02) and Afon Hafren (GB02) close to the Atlantic. The Soviet areas (SU05, SU15) also show higher inputs than outputs, which probably is due to artificial reasons. The list below gives some O/I ratios:

CA01	Turkey Lakes	1988/89	1.14
CH01	Erlentobel	1988/89	1.58
CH01	Erlentobel	1989/90	1.62
CS01	Anenske	1989/90	15.2
CS02	Mlynaruv	1988/89	1.05
CS03	Jezeri	1988/89	1.82
CS04	Liz Sumava	1988/89	1.55
FI01	Valkeakotinen	1988/89	1.91
FI03	Hietajärvi	1988/89	1.76
GB02	Afon Hafren	1988/89	0.41
NO01	Birkenes	1988/89	1.58
NO01	Birkenes	1989/90	3.39
NO02	Kårvatn	1988/89	0.86
NO02	Kårvatn	1989/90	2.86
SE01	Tiveden	1988/89	1.24
SE02	Berg	1988/89	2.14
SE04	Gårdsjön	1987/88	2.33
SU05	Juga Massif	1989/90	0.60
SU15	Valday	1989/90	0.43

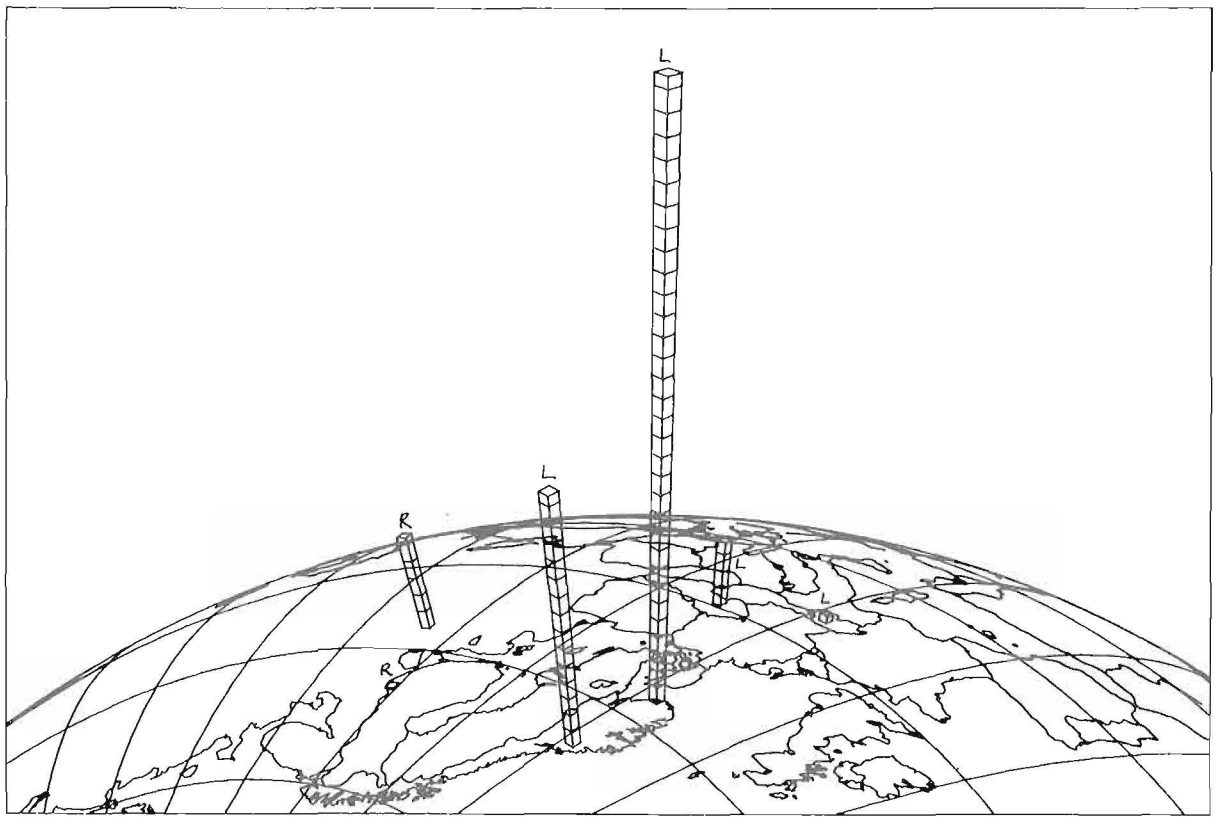
Cl1988-89, scale unit 500 mg/m²•a



Cl 1988-89, scale unit 100 mg/m²•a



Cl 1989-90, scale unit 500 mg/m²•a



CHAPTER 11

Aluminium

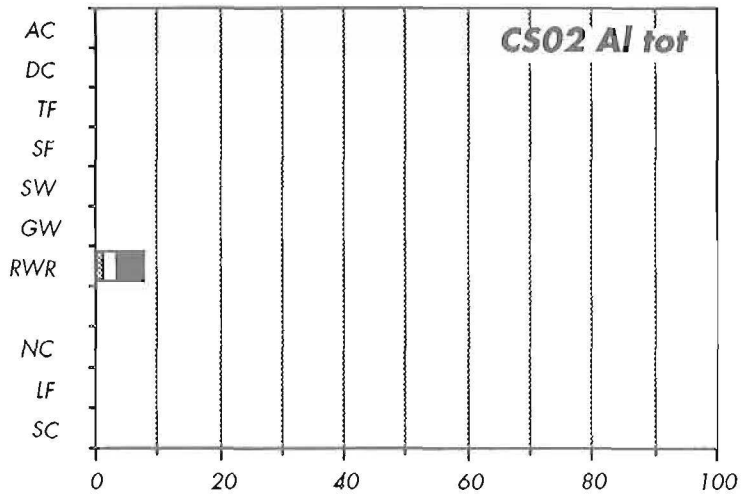
Most aluminium is found in soil dust. The depositional fields of the element are not known for Europe.

11.1 Short-term temporal variation

Very few aluminium measurements have been made yet and most refer to total aluminium in waters. Aluminium concentrations in precipitation has in several studies shown to be almost insignificant, often below analytical detection.

Nemoral Region (CS02,GB01,GB02)

In Mlynaruv (CS02) and Allt-a-Mharcaidh (GB01) runoff water concentrations are below 10 µeqv/l/month, in the latter area the labile fraction is almost 100%. In Afon Hafren runoff concentrations range between 5-30 µeqv/l/month of which the labile portion is only 33%.



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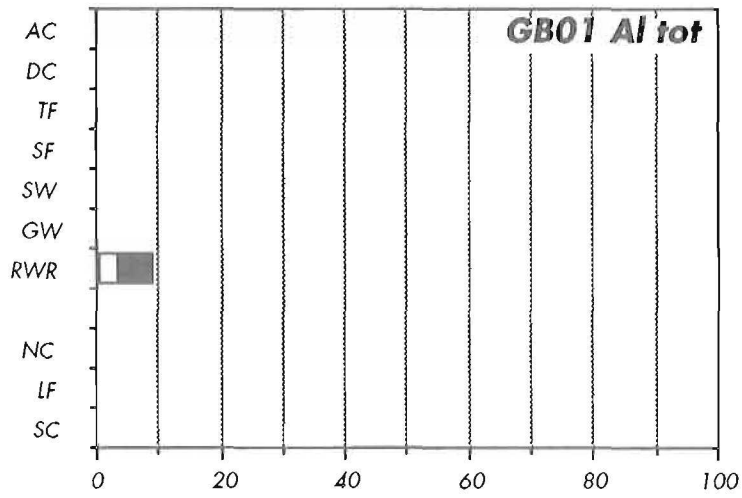

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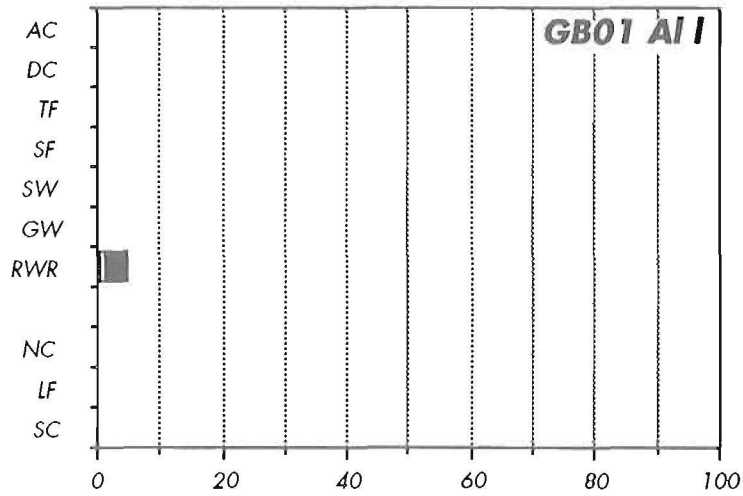

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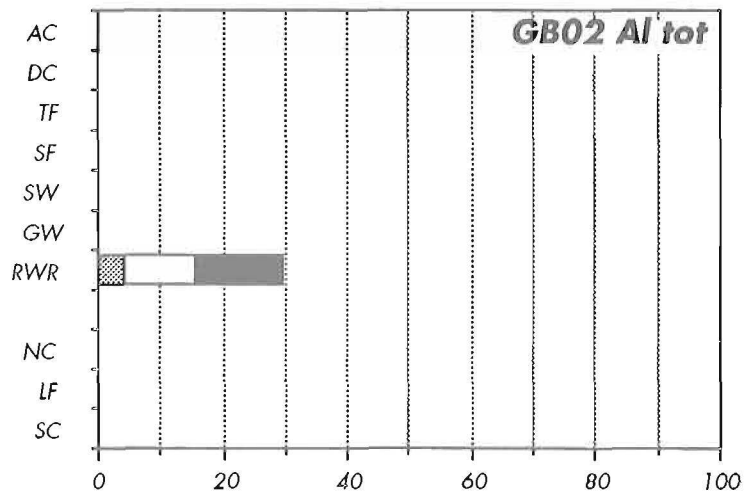

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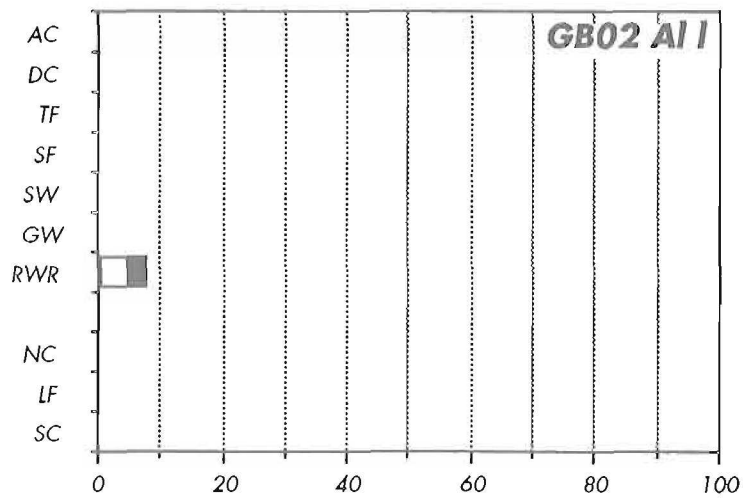

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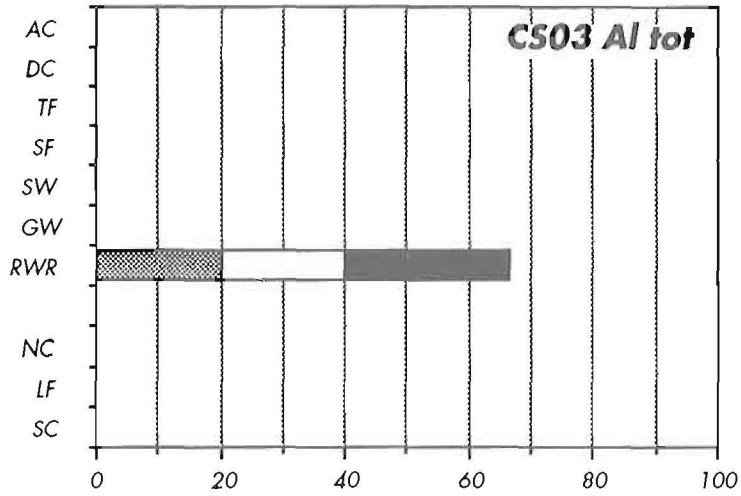
SC	0	0

Montaneous Central (CS03,CS04,DE01,CH01)

Runoff concentrations range between 5-37 µeqv/l/month except for Jezeri (CS03) where the range is 20-65. In Forellenbach (DE01) soilwater concentrations are close to 50 and groundwater concentrations between 0-8 µeqv/l/month.



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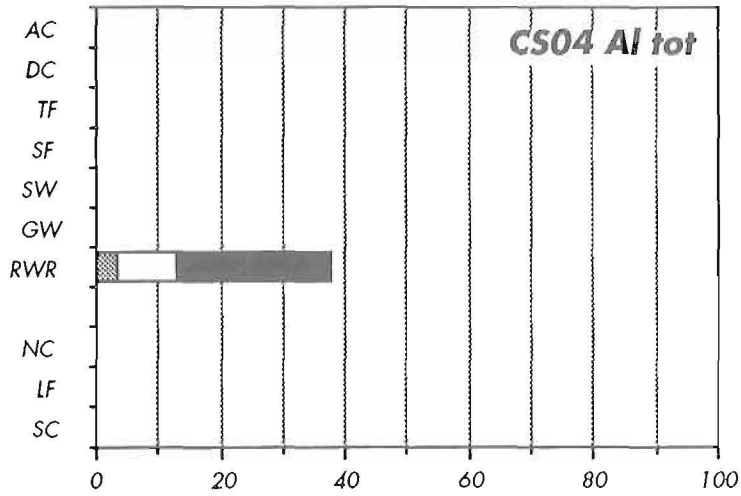

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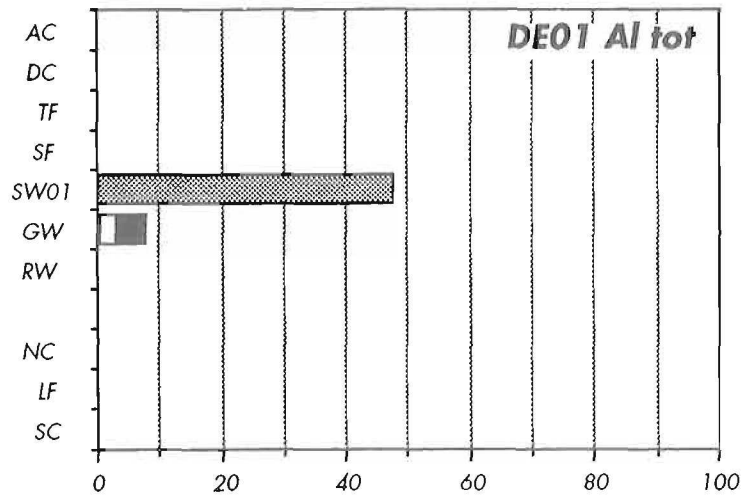

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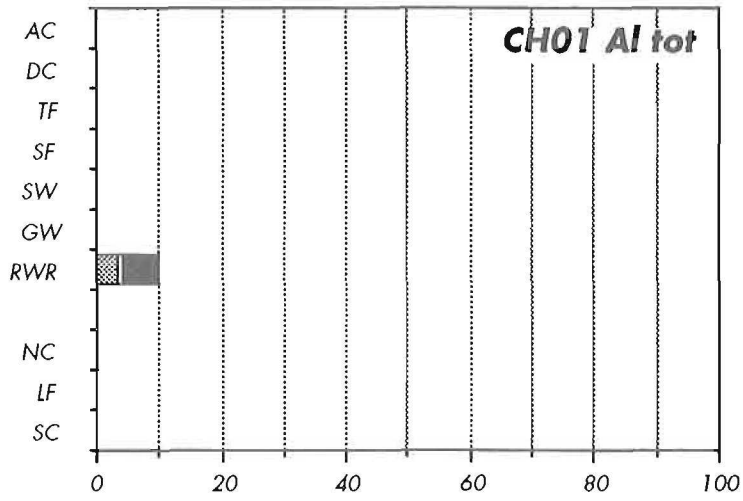

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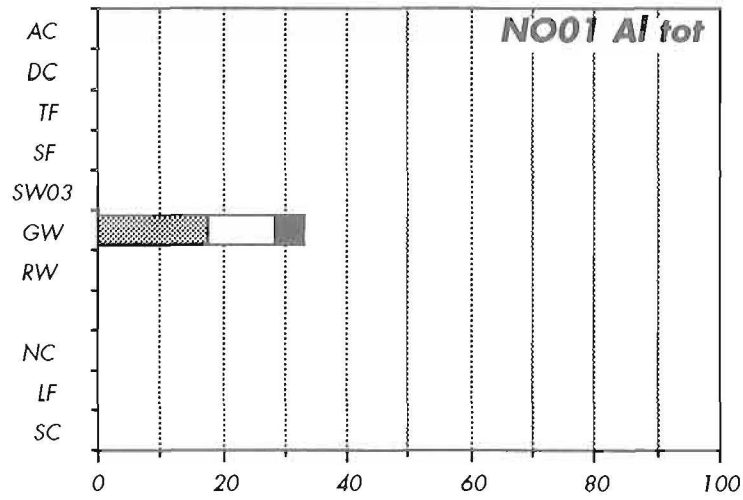
SC	0	0

Boreonemoral Ecotone (NO01,SE01,SE02,SE04)

In Birkenes the range is 17-33 µeqv/l/month nearly all of which is represented by the labile fraction. In the Swedish areas soil water, groundwater and runoff water concentrations are commonly > 50 µeqv/l/month (in Reivo only ca 3 µeqv/l/month). Maximum values range between 150-300 µeqv/l/month in deeper (> 20 cm) soilwater. Fractioning at Gårdsjön implies that the labile component of groundwater is some 50% and of runoff water some 40%.



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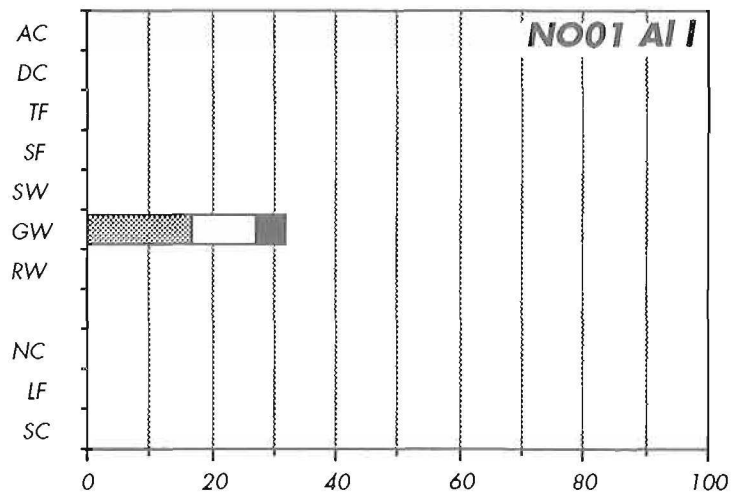

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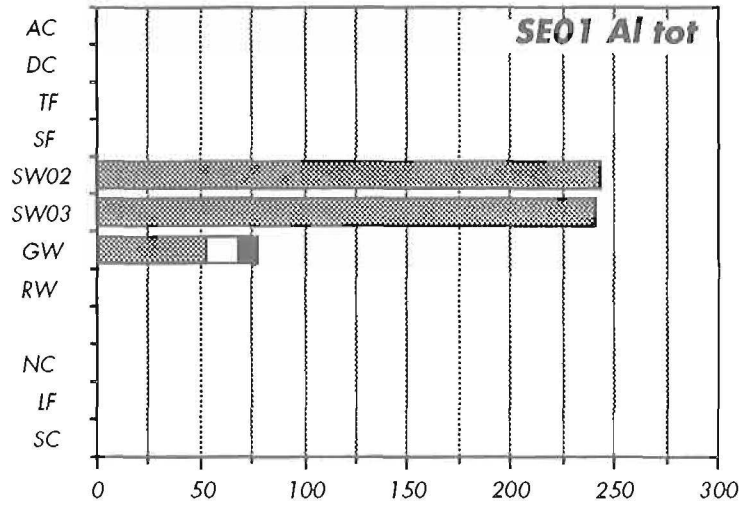

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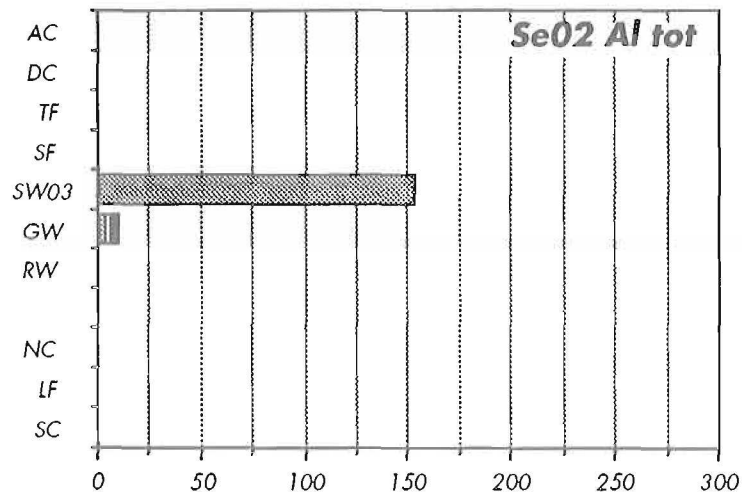

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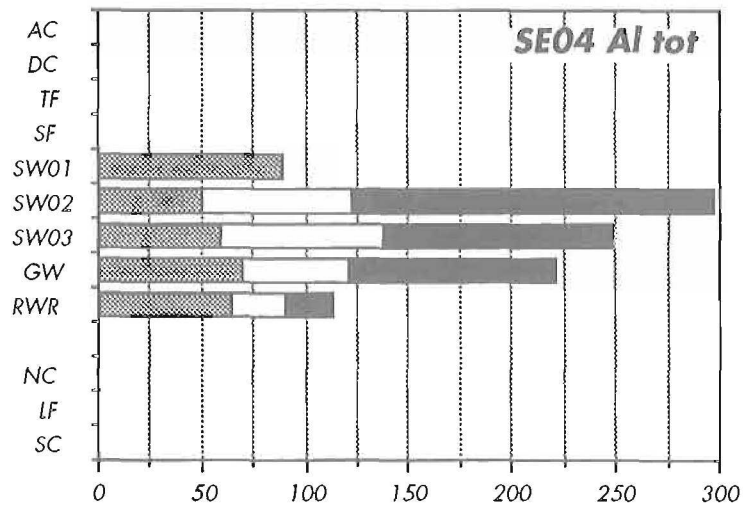

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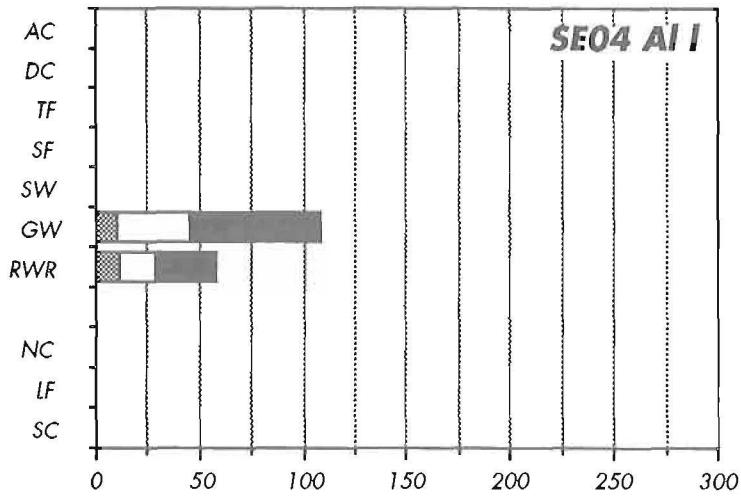

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RWR	01 12 8711	8810
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LF	0	0
SC	0	0

Boreal Region (NO02,FI01,FI03,SE03,FI04,FI05,SU16)

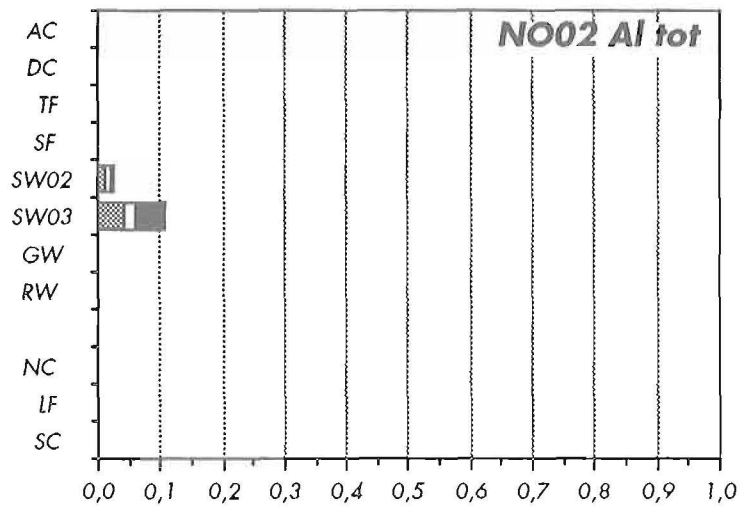
Concentrations in runoff water are often low, not exceeding 25 µeqv/l/month. Soil water concentrations in Hietajärvi (FI03) are higher, between 15-33, and in Velikiy (SU16) they exceed 100 µeqv/l/month. Here also the values of groundwater is about 50µeqv/l/month.

Forest Steppe - Submediterranean Ecotone (PT01,HU01)

No data exist on aluminium measurements.

Montaneous East (SU03,SU05)

No data exist on aluminium measurements.



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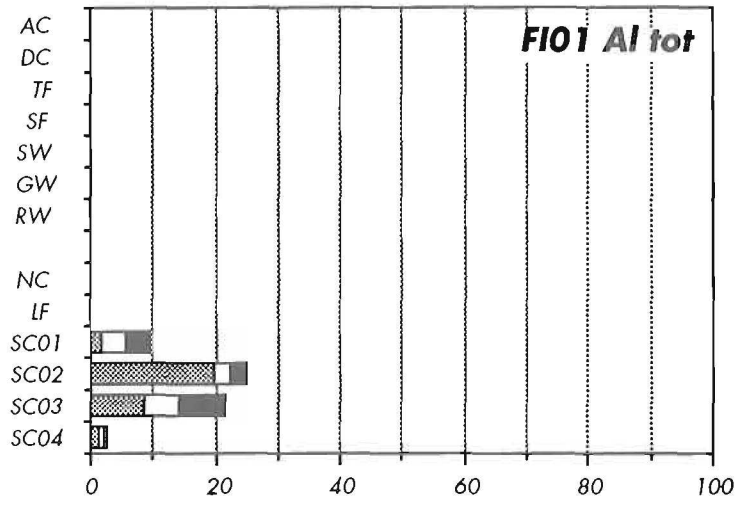

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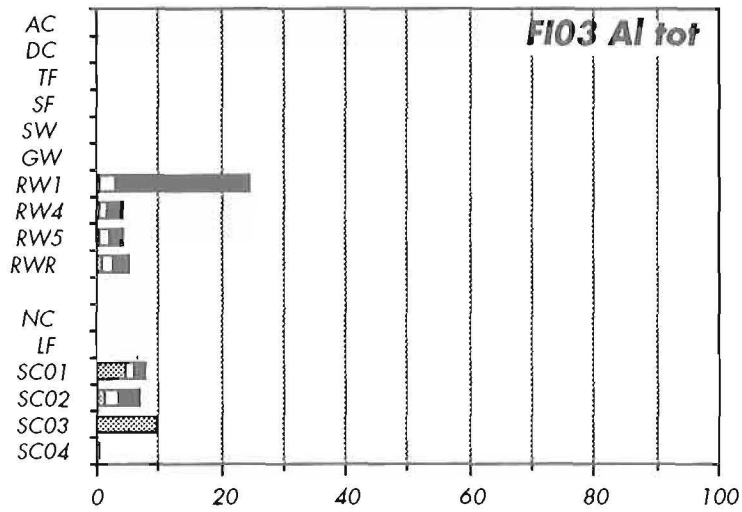

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RW5	02 08 8912 9010
RWR	02 10 8911 9010
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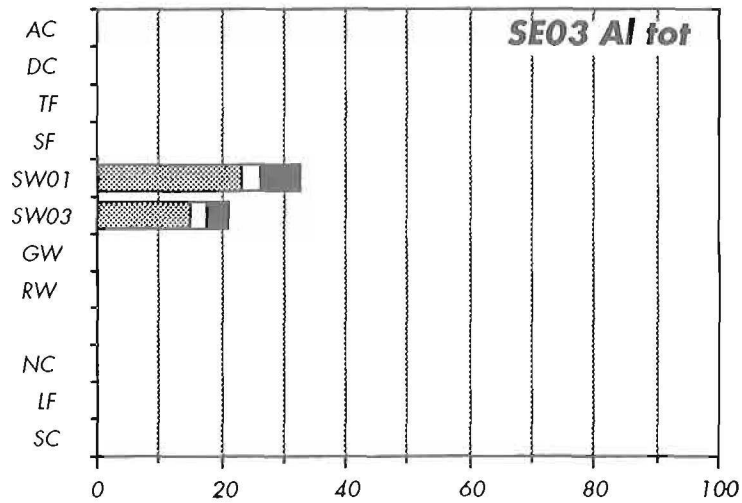
SC03	01 01 8800 8800
SC04	03 01 8800 8800



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SW03	01 05 8905 8909
GW	0 0
RW	0 0
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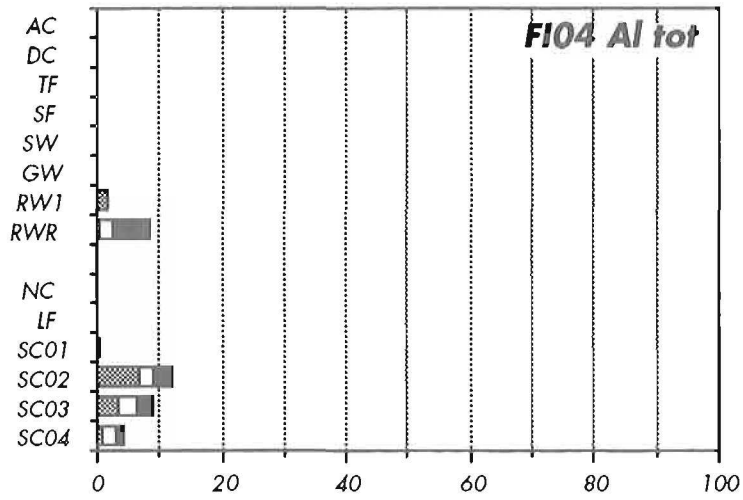

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SC03	05 01 8900 8900
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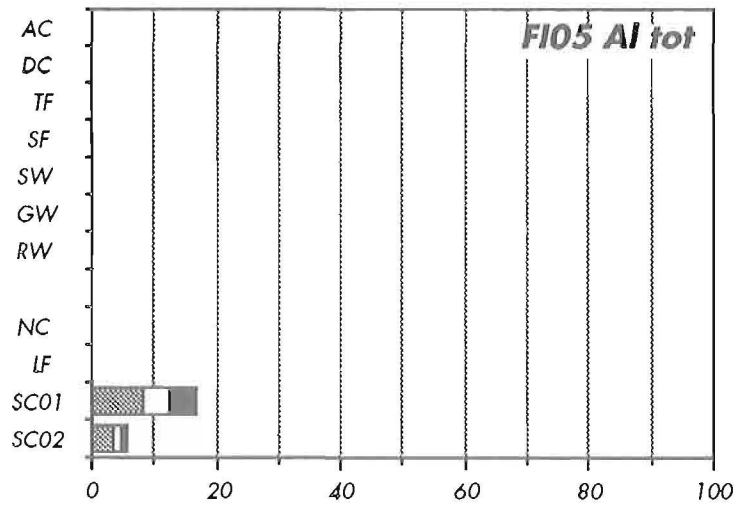

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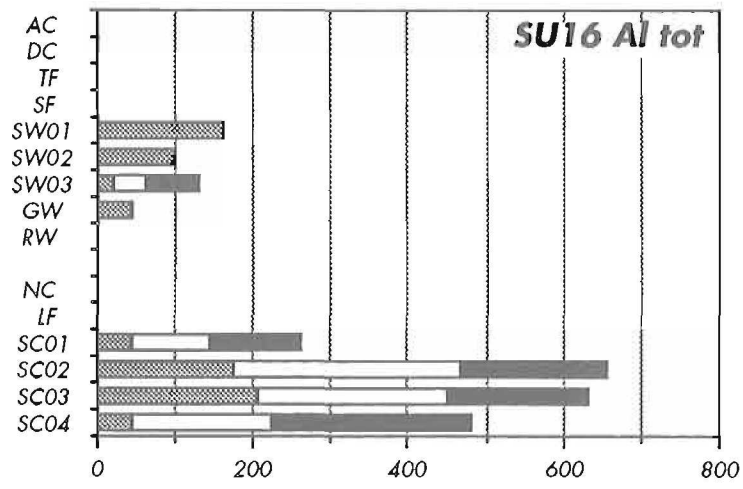

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RW	0 0
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LF	0 0
SC01	03 01 8908 8908
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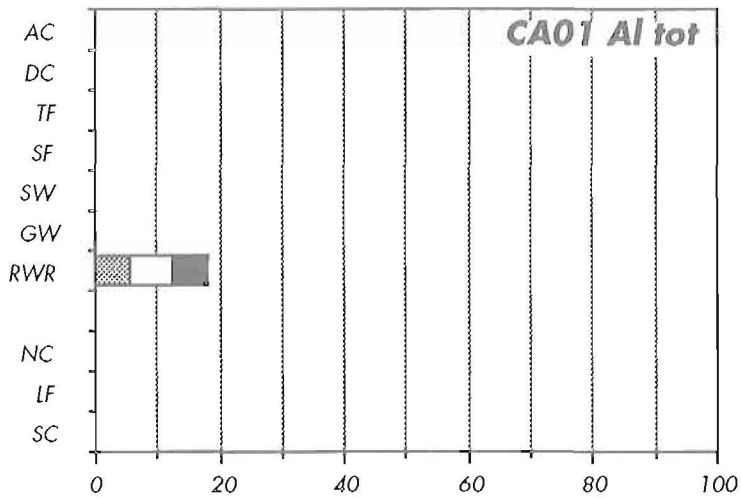
SC03	03 01 8908 8908
SC04	03 01 8908 8908

Runoff water concentrations in Turkey Lakes (CA01) range between 5-20 µeqv/l/month.



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RWR	01 11 8811 8909
NC	0 0
LF	0 0
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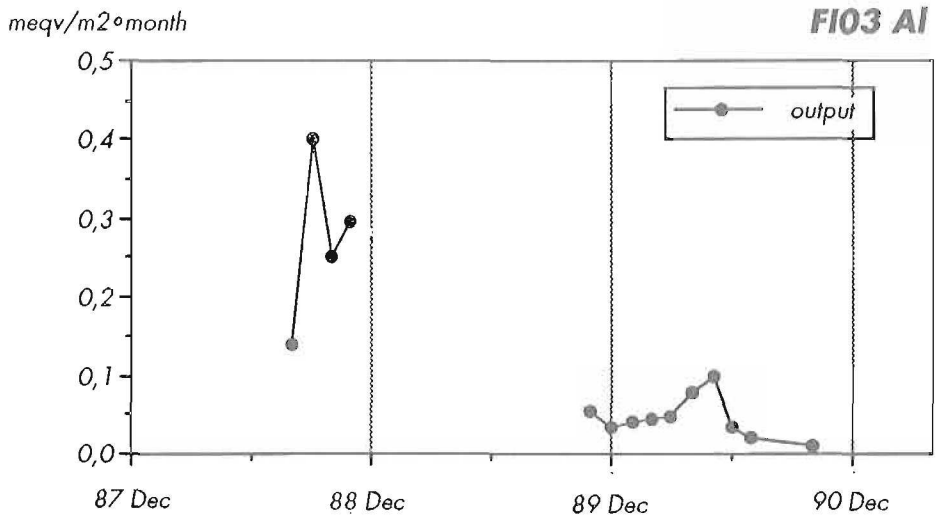
11.2 Long-term temporal variation (Al_{tot})

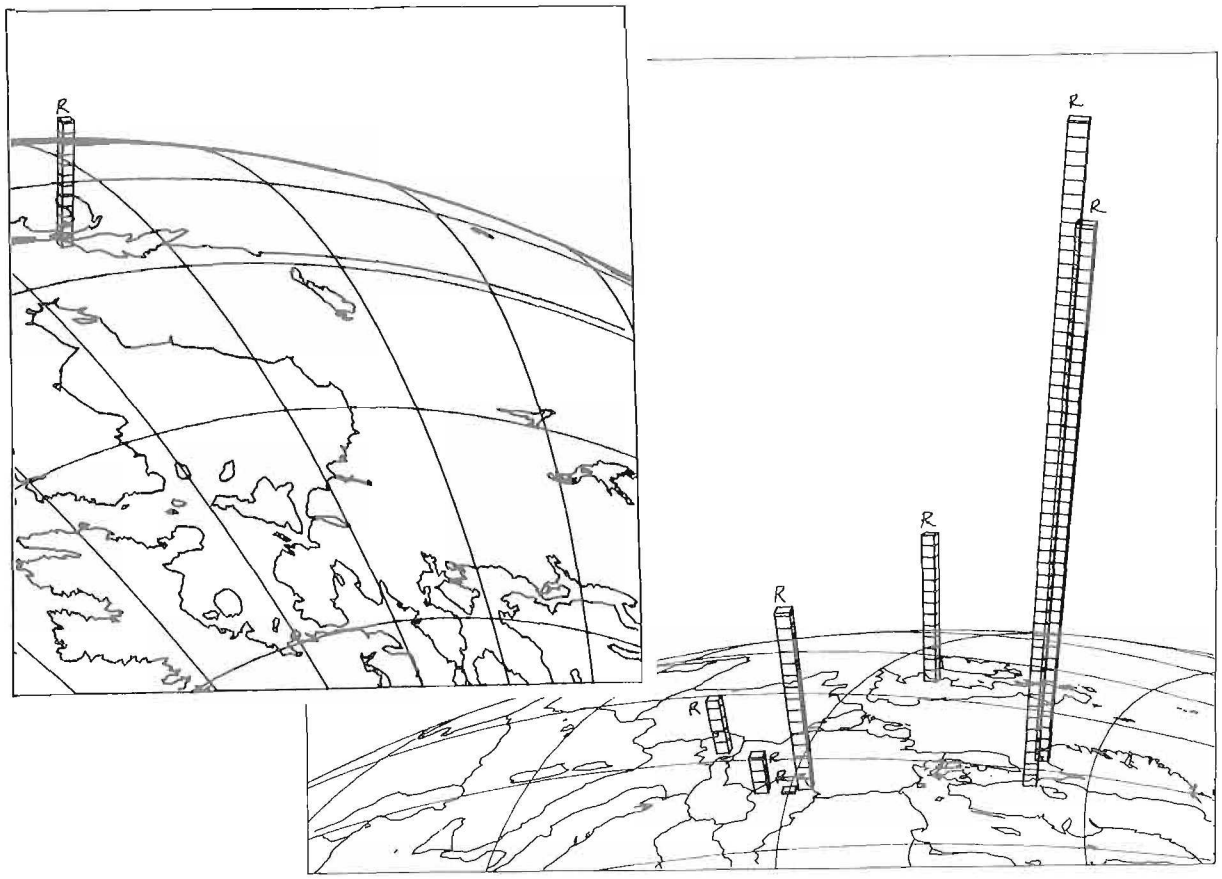
In this section, time series of monthly fluxes of aluminium expressed as meqv/(m²◦month) are shown for the IM area Hietajärvi (FI03).



11.3 Mass balances

Aluminium leaches from every area where measured. The highest losses are calculated for areas with the most acidic deposition in southernmost Scandinavia.

Al 1988-89, scale unit 10 mg/m²•a



Al 1989-90, scale unit 10 mg/m²•a

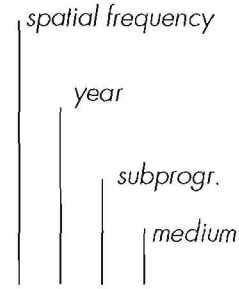
CHAPTER 12

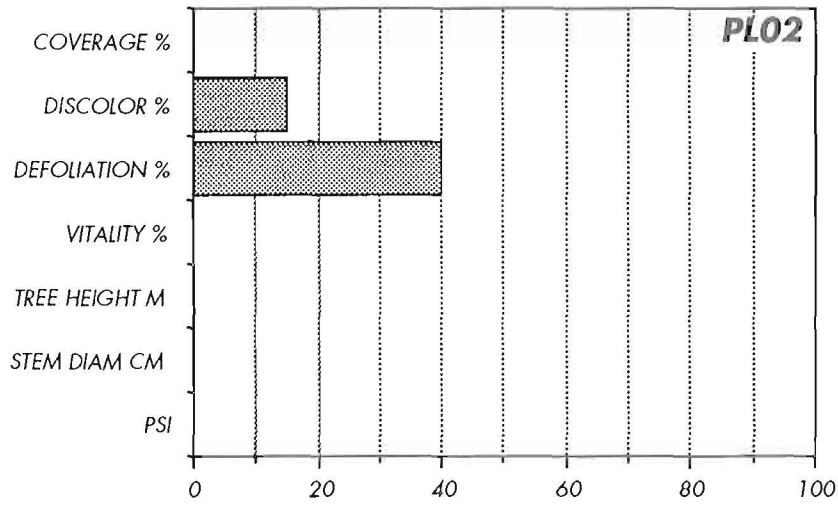
Tree stands

12.1 State and effect variables

Nemoral Region

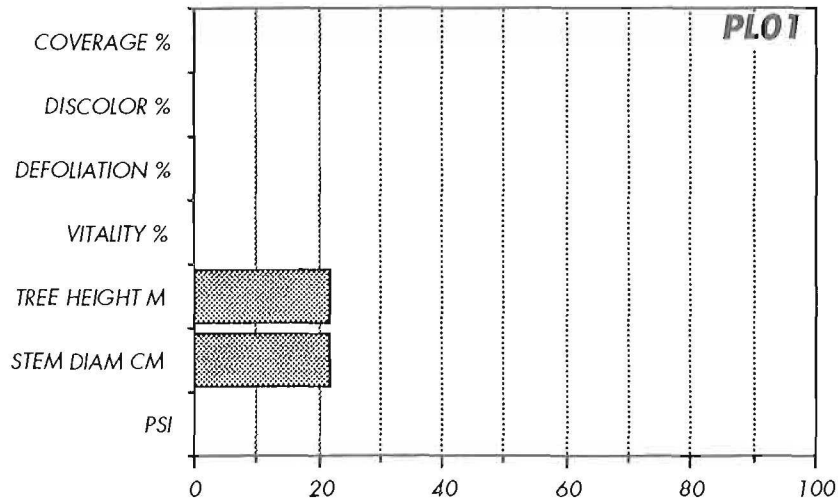
So far only records from Poland is available. The dominating tree in Gardliczno (PL02) is Scot's pine and in Lekuk (PL01) oak. The pines of Gardliczno show both high defoliation and discoloration.





2 90 AR PINU SYL

2 90 AR PINU SYL



1 88 AR QUER ROB

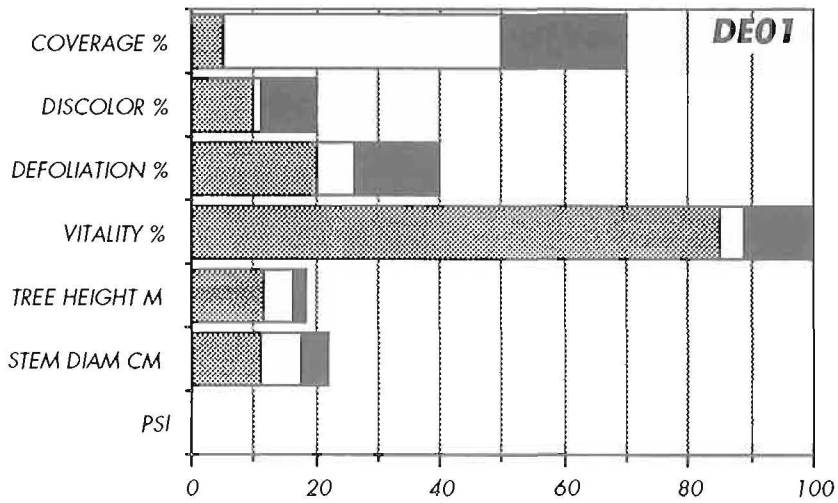
1 88 AR QUER ROB

Montaneous Central

Only data from Forellenbach (DE01) is available where the dominating tree species is beech, however with a very varying coverage in different parts of the drainage. The defoliation ranges between 20-40% and the discoloration between 10-20%. On the average 10% of the trees are dead. In Jezeri (CS03) considerable forest-die back occurs, although no data is available.

Boreonemoral Ecotone

Norwegian spruce dominates in the monitoring areas of Birkenes (NO01), Berg (SE02) and Tiveden (SE01). Defoliation is highest at Berg and lowest at Birkenes. In Berg some 30% of the stand is dead. The lichen index, PSI (cf. Bråkenhielm in ASR 1, 1990) is also low at Berg.



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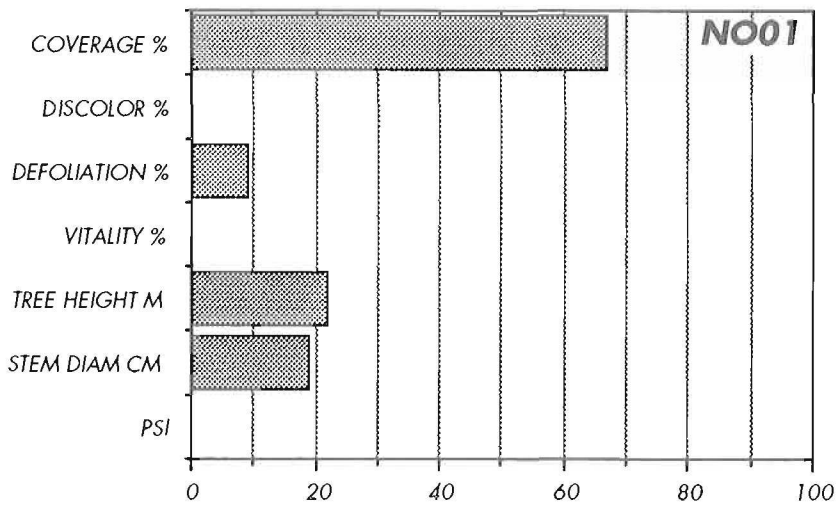
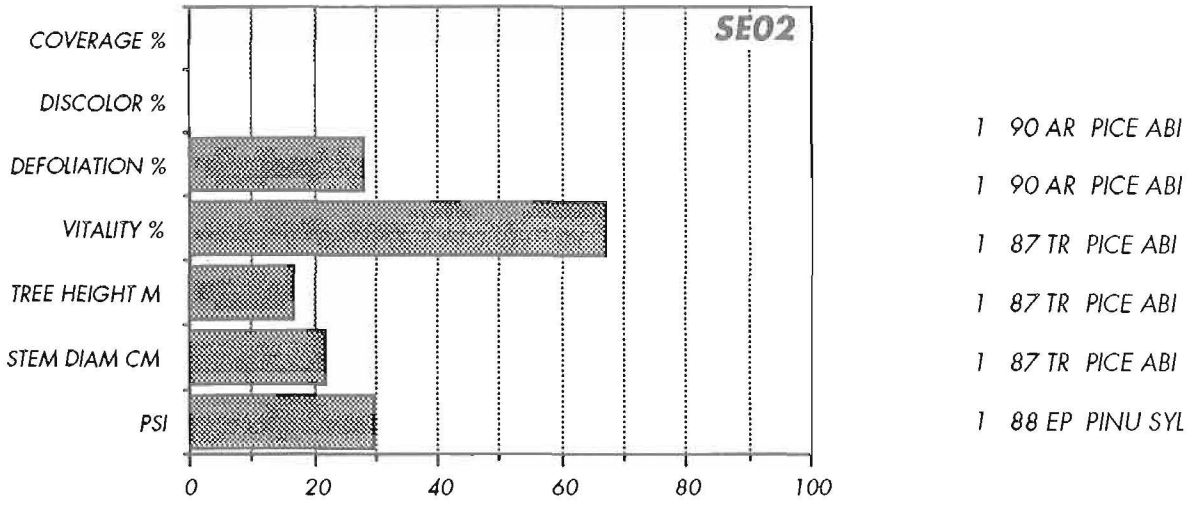
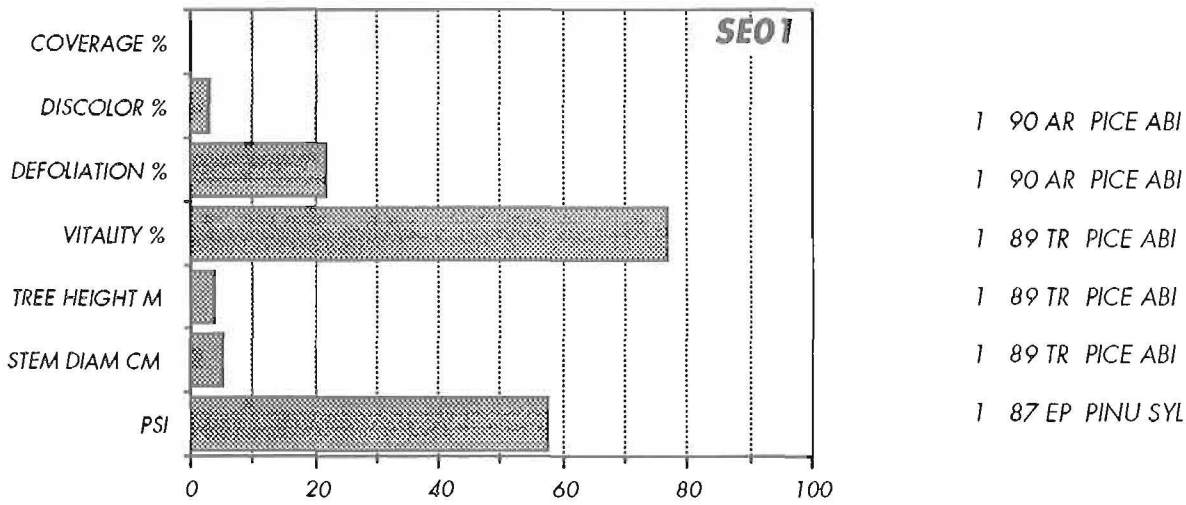
9 90 FAGU SYL
9 90 FAGU SYL
5 90 FAGU SYL
5 90 FAGU SYL
5 90 FAGU SYL



1 86 AR PI AB.AB
1 90 AR PI AB.AB
1 90 AR PI AB.AB

1 86 AR PI AB.AB
1 86 AR PI AB.AB



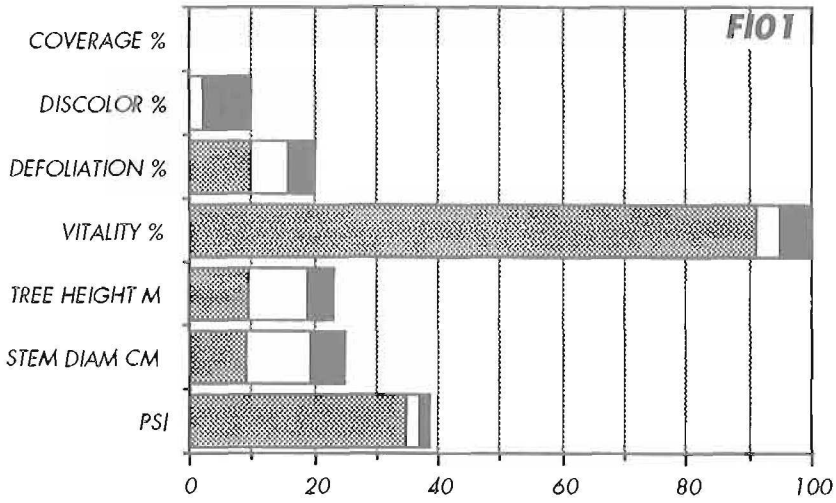


Boreal Region

Dominating species are either Norwegian spruce (FI01, SE03) or Scot's pine (NO02, FI03, FI04, except in FI05 - where Betula pubescens tortuosa has a wider areal coverage). Defoliation is highest in Pesosjärvi (50%), but the stand is still vital and the PSI is very high, > 250. The highest discoloration is found in Reivo (SE03) where the portion of dead trees are higher. PSI-values are high in the north, in particular along the Finnish/Carelian border but drop towards the Arctic (FI05, SU16).

Forest Steppe - Submediterranean Ecotone

No data exist.



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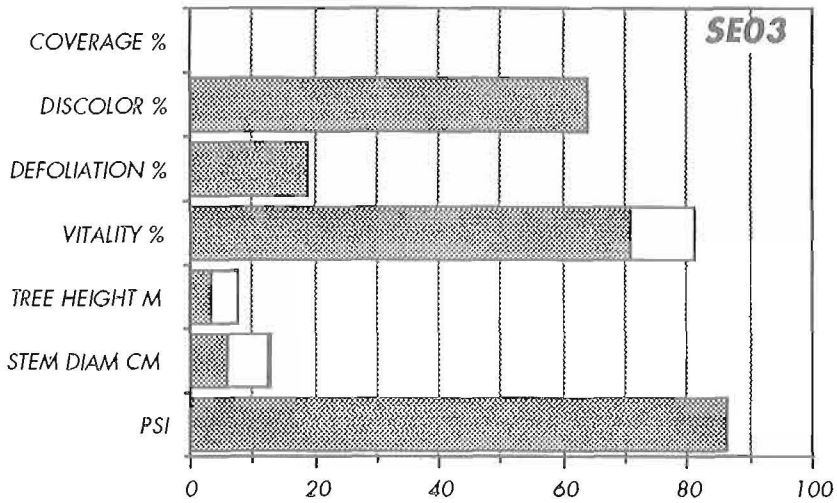
5 90 AR PICE ABI
7 87 TR PICE ABI
7 87 TR PICE ABI
7 87 TR PICE ABI
2 88 EP PINU SYL



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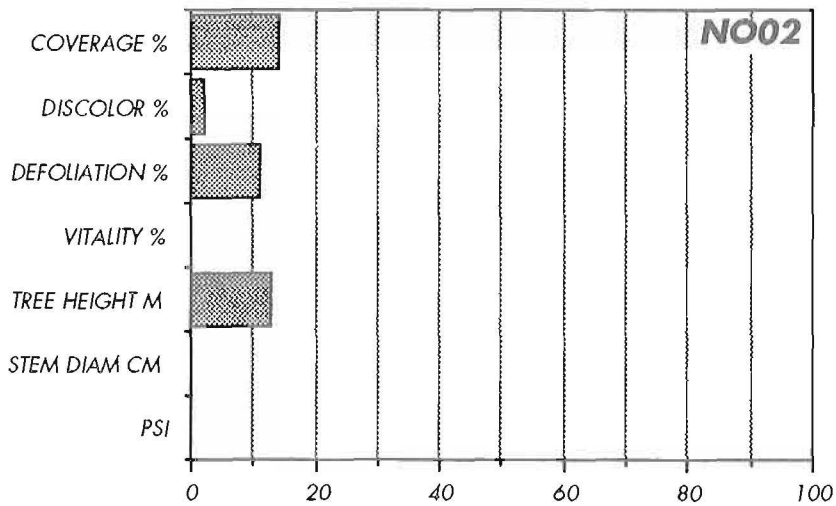
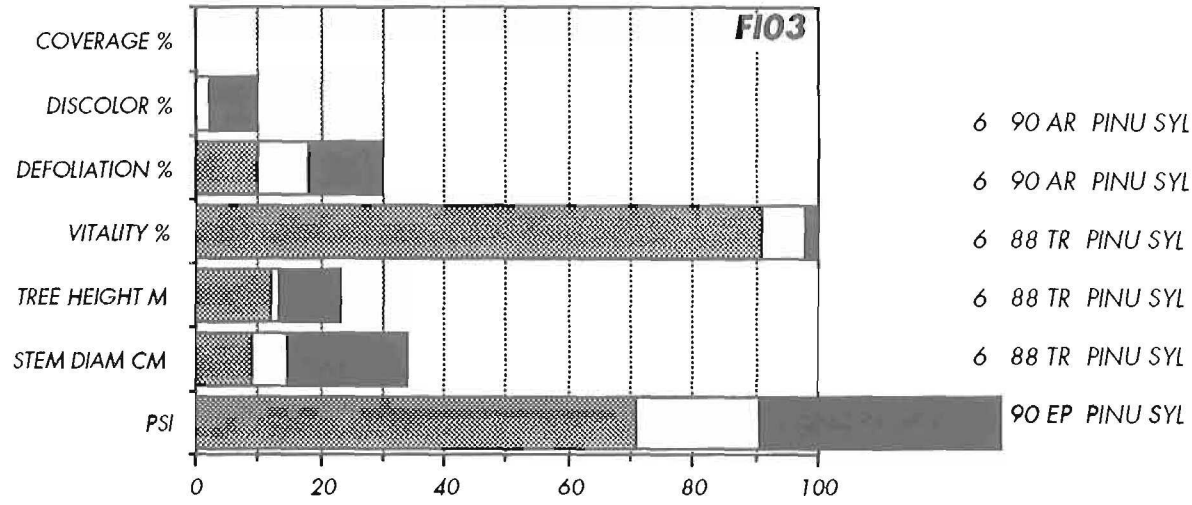
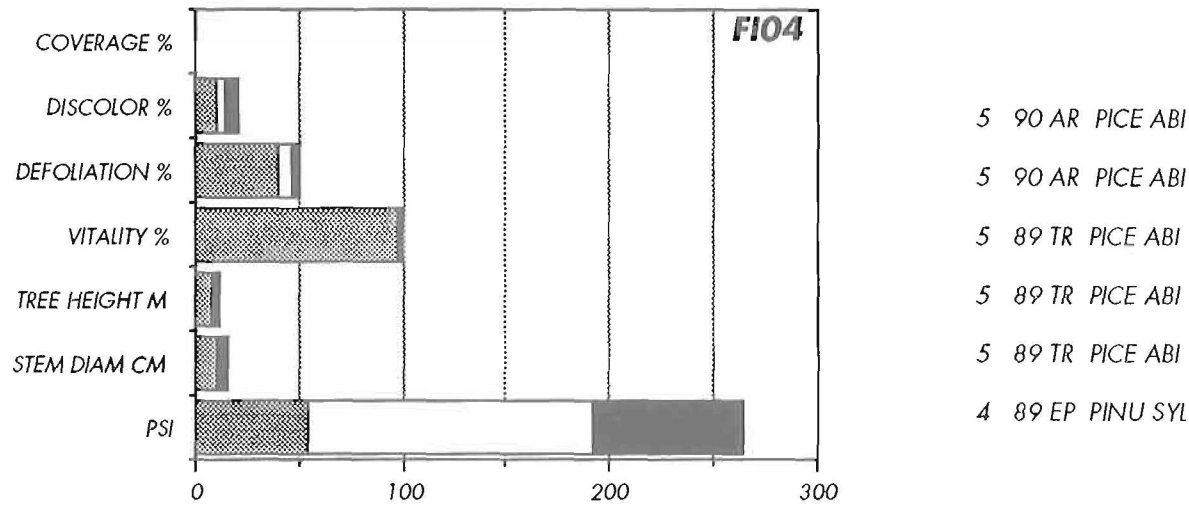
1 89 AR PICE ABI
2 90 TR PICE ABI
2 90 TR PICE ABI
2 90 TR PICE ABI
1 84 EP PINU SYL

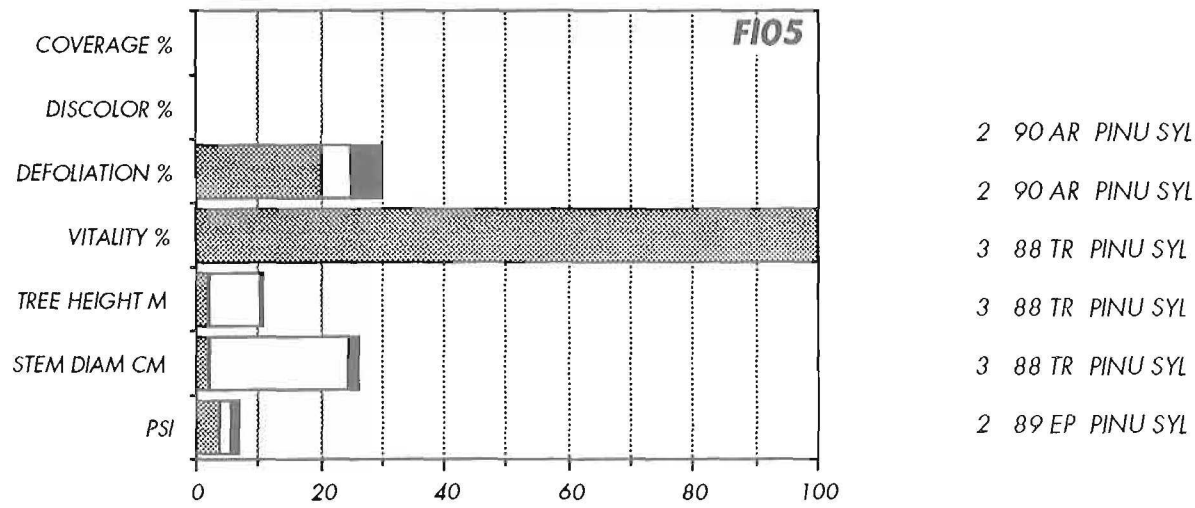


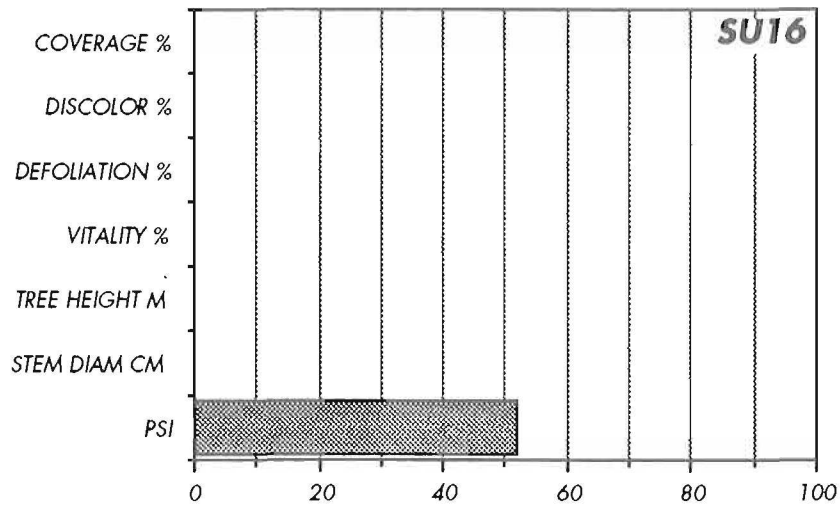
1 89 AR PINU SYL
1 90 AR PINU SYL
1 90 AR PINU SYL

1 89 AR PINU SYL


FI03
COVERAGE %
DISCOLOR %
DEFOLIATION %
VITALITY %
TREE HEIGHT M
STEM DIAM CM
PSI
0
20
40
60
80
100
6 90 AR PINU SYL
6 90 AR PINU SYL
6 88 TR PINU SYL
6 88 TR PINU SYL
6 88 TR PINU SYL
90 EP PINU SYL


FI04
COVERAGE %
DISCOLOR %
DEFOLIATION %
VITALITY %
TREE HEIGHT M
STEM DIAM CM
PSI
0
100
200
300
5 90 AR PICE ABI
5 90 AR PICE ABI
5 89 TR PICE ABI
5 89 TR PICE ABI
5 89 TR PICE ABI
4 89 EP PINU SYL

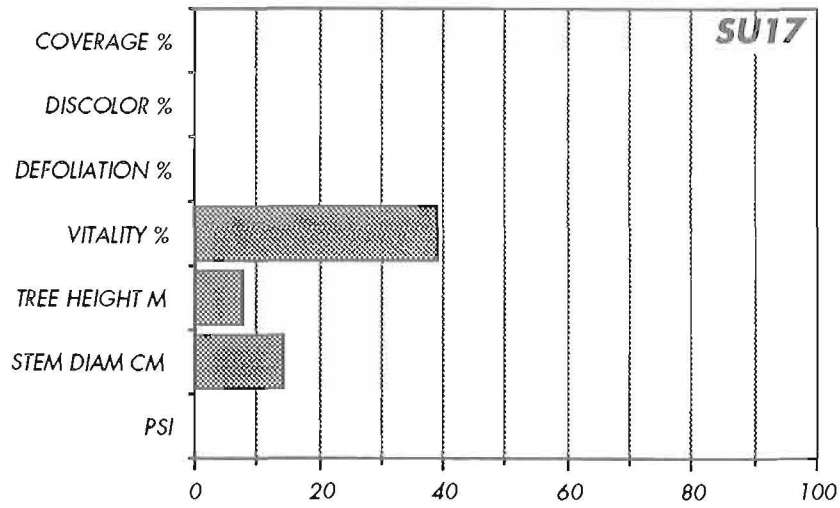

FI05
COVERAGE %
DISCOLOR %
DEFOLIATION %
VITALITY %
TREE HEIGHT M
STEM DIAM CM
PSI
0
20
40
60
80
100
2 90 AR PINU SYL
2 90 AR PINU SYL
3 88 TR PINU SYL
3 88 TR PINU SYL
3 88 TR PINU SYL
2 89 EP PINU SYL



2 89 EP PINU SYL

Nemoral and Montaneous East

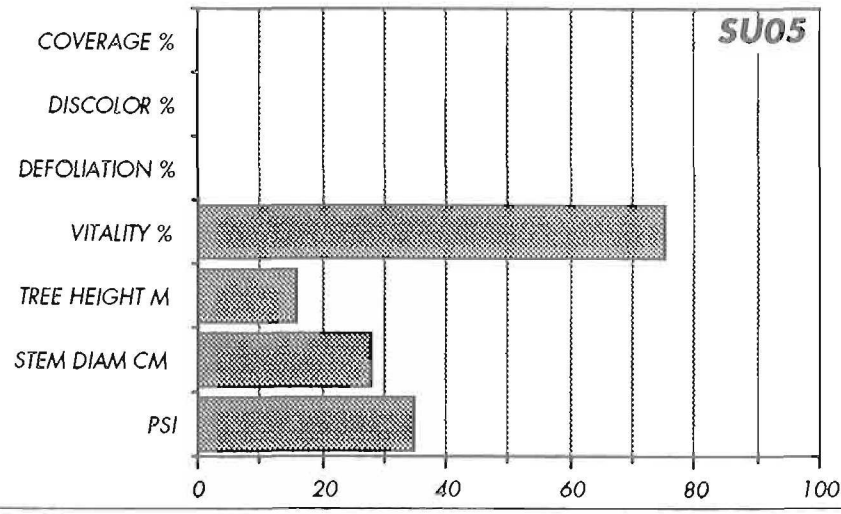
Few data exist. In Karadag (SU17) on the Crimean peninsula the vitality of Pinus palustris is very low and in the Juga Massif of Caucasus (SU05) Abies nordmanniana has a relatively low vitality and a low PSI-value (35).



1 90 TR PINU PAL

1 90 TR PINU PAL

1 90 TR PINU PAL



1 90 TR ABIE NOR

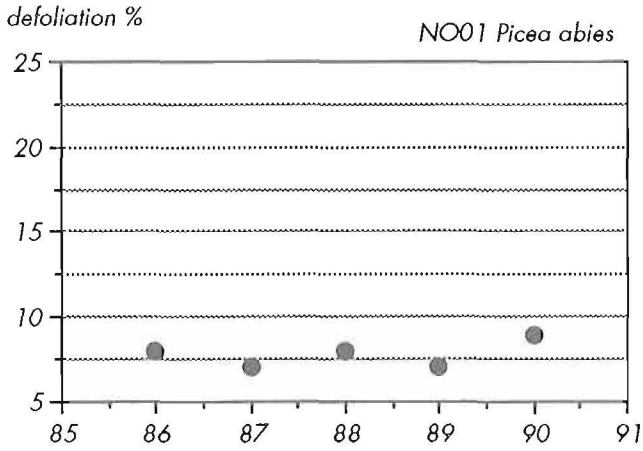
1 90 TR ABIE NOR

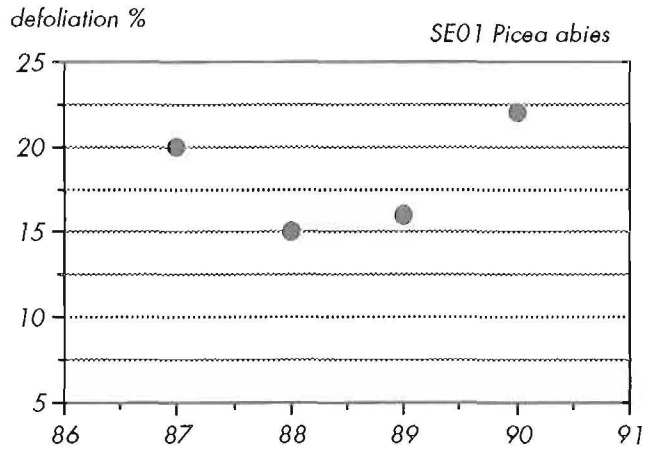
1 90 TR ABIE NOR

1 90 EP ABIE NOR

12.2 Long-term variation

Two time-series of changes in defoliation are presented. The available data are too scarce for making any conclusions.





CHAPTER 13

Understorey vegetation

13.1 State and effect variables

Data is still sparse, mainly from Norden.

Nemoral Region

No data exist.

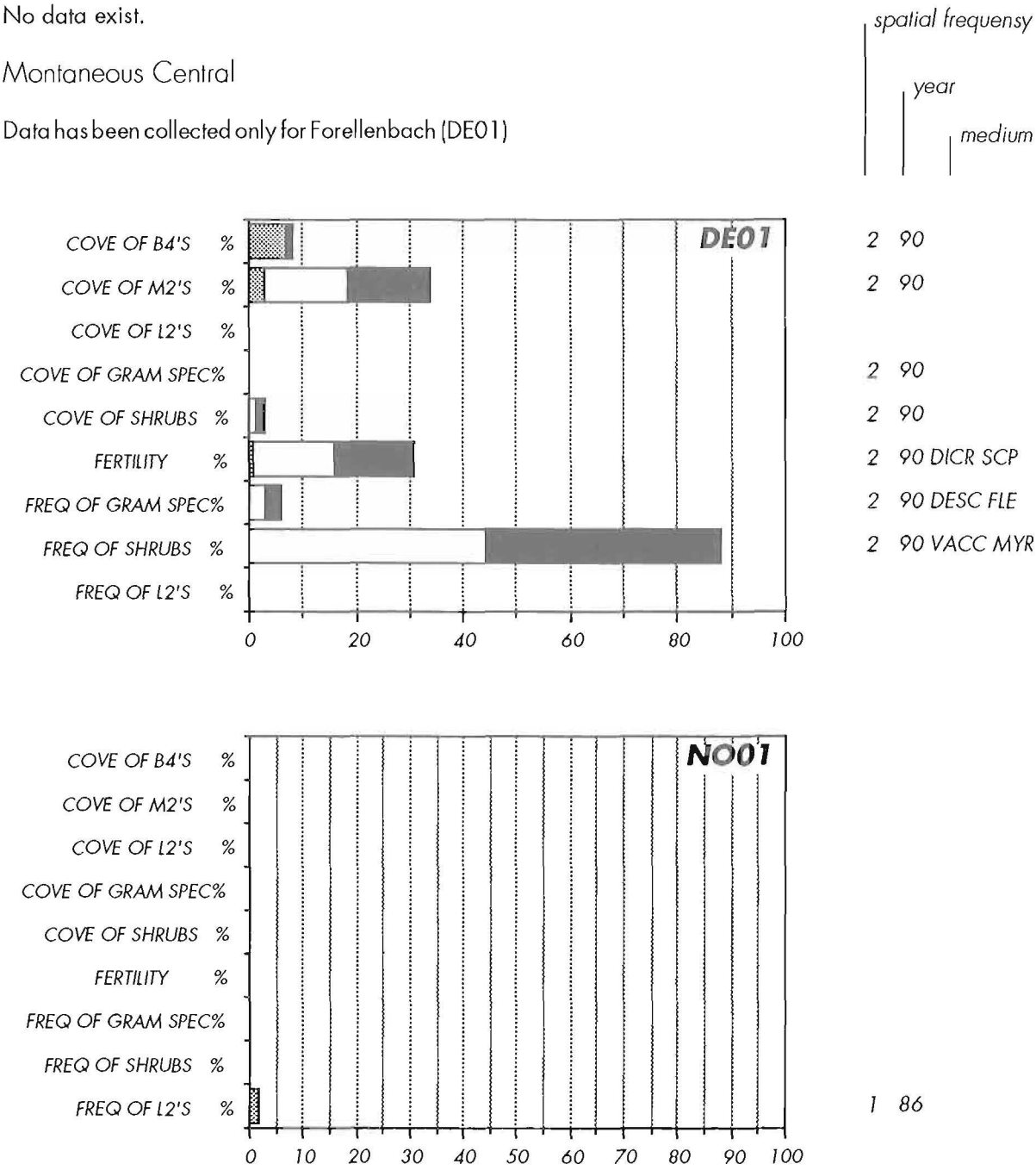
Montaneous Central

Data has been collected only for Forellenbach (DE01)

where mosses have the largest coverage but also a high patchiness. The lichen coverage is insignificant. Herbaceous plants dominate over shrubs and dwarf-shrubs. The herbs also have a high fertility. Shrub species are few but frequent.

Boreonemoral Ecotone

Data exist only for Berg (SE02) and Tiveden (SE01). In both areas mosses predominate the coverage. Lichens are few and insignificant in coverage. The



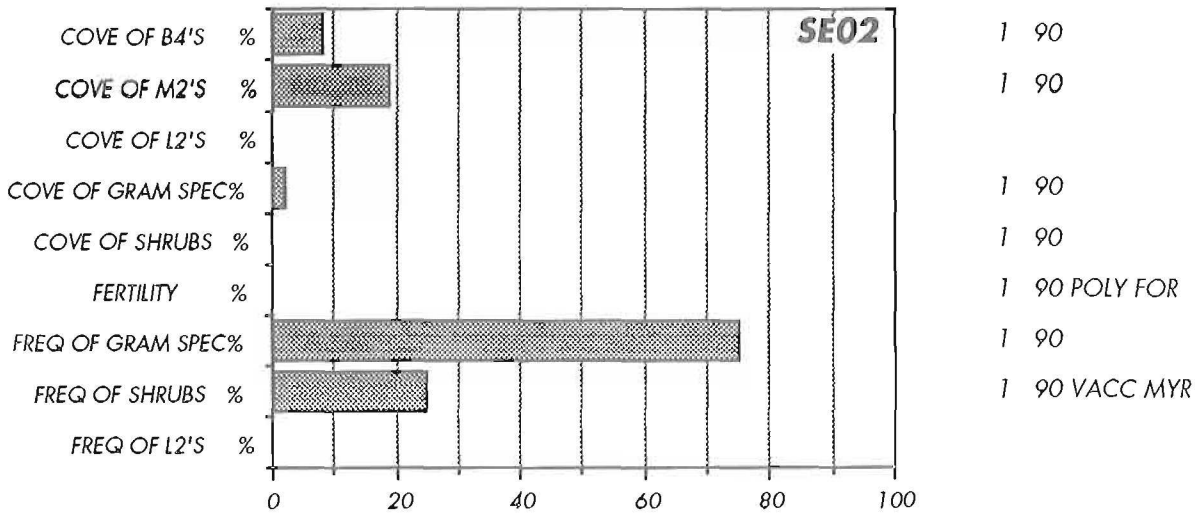
graminaceous coverage are quite similar for both areas. Shrubs and dwarf-shrubs dominate the plant coverage in Tiveden and the dominating species is also very frequent. In Berg the frequency of the dominating grass exceeds the frequency of the dominating dwarf-shrub.

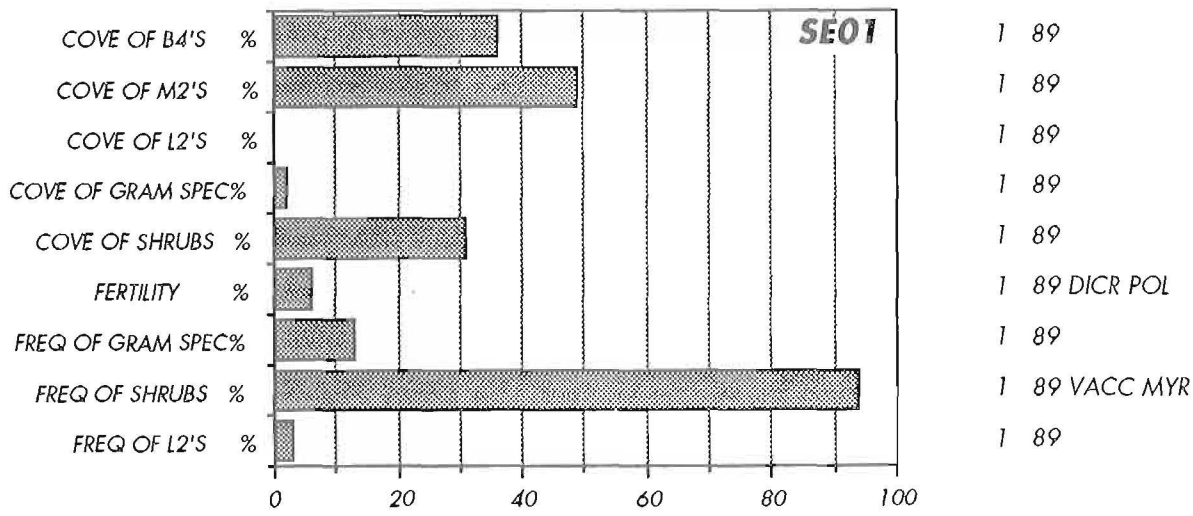
Boreal Region

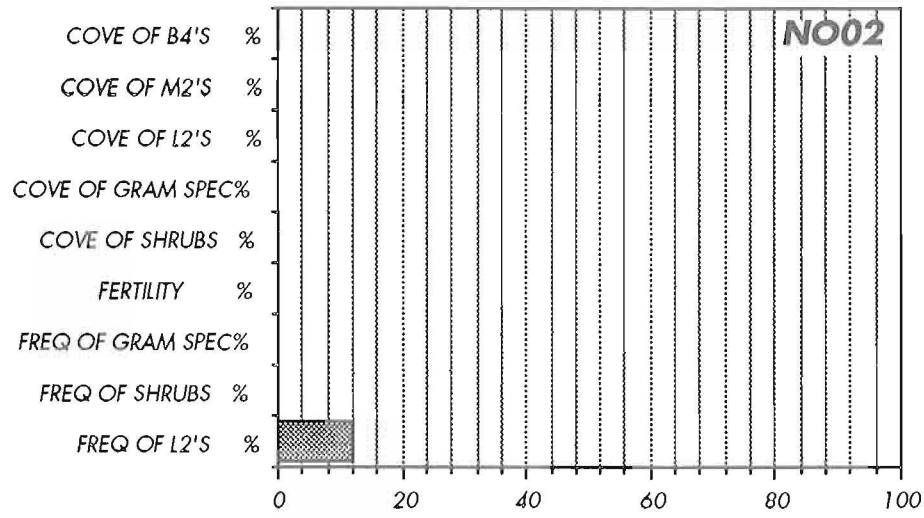
Data is available for the Finnish areas and for Reivo (SE03). Except for Valkeakotinen (FI01) mosses have a larger coverage than higher plants. The lichen coverage is insignificant except for Vuoskojärvi (FI05). Most plants are shrubs or dwarf-shrubs and the dominating species also have a high frequency (not in Pesosjärvi, FI04). The grass-coverage is usually low, in some areas mainly comprising 1-2 species which however are frequent. The highest fertility values are recorded in Hietajärvi (FI03), otherwise they are very low.

Montaneous East

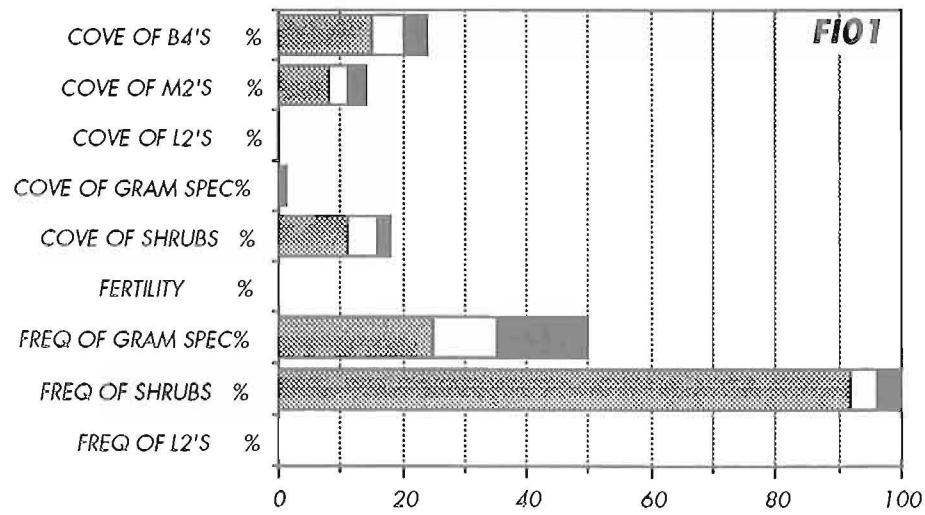
Herbaceous species dominates over grass; the grass-species are however frequent.



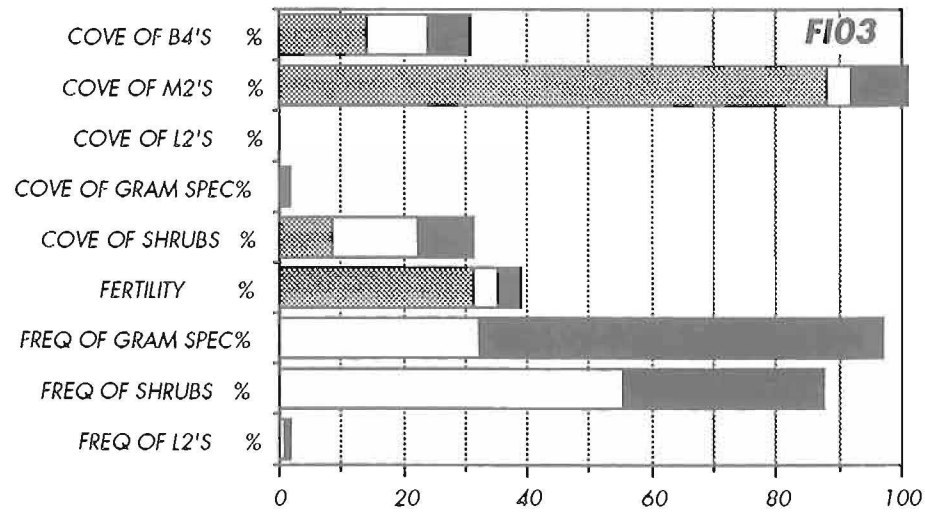




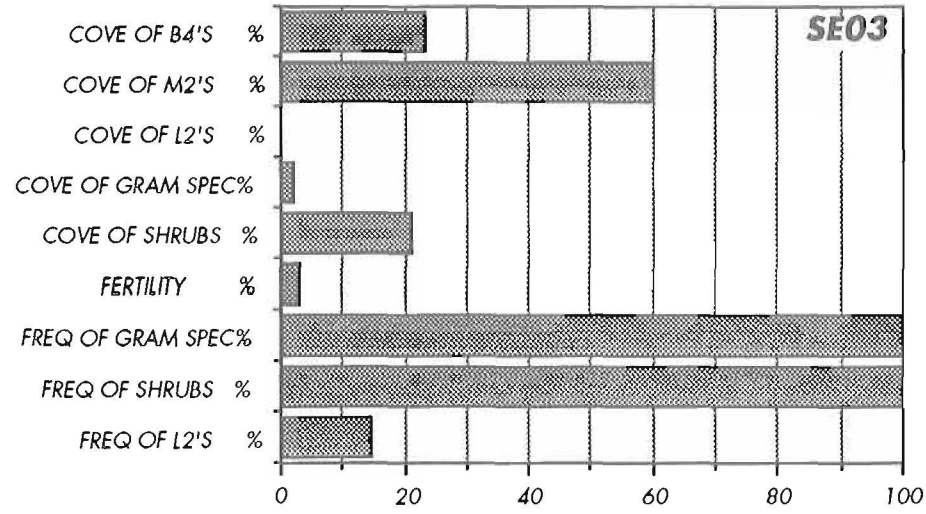
1 89



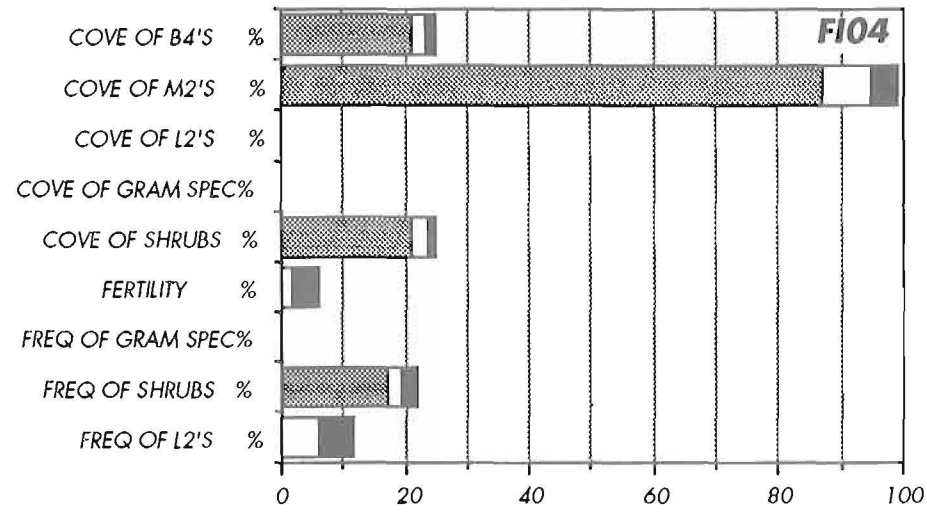
3 90
3 90
3 90
3 90
2 90 VACC MYR
3 90 CALA ARU
3 90 VACC MYR



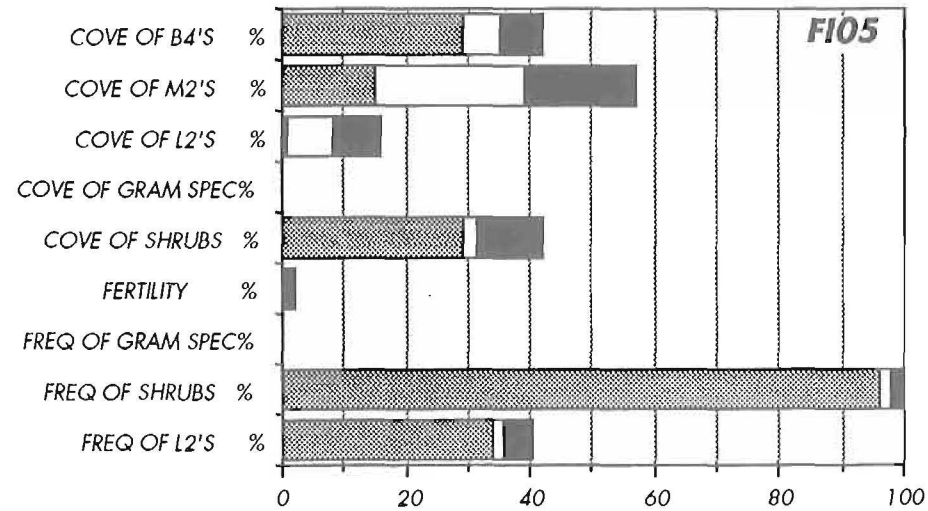
3 90
3 90
3 90
3 90
3 90
2 90 PLEU SCH
3 90 ERIO VAG
3 90 VACC MYR
3 90



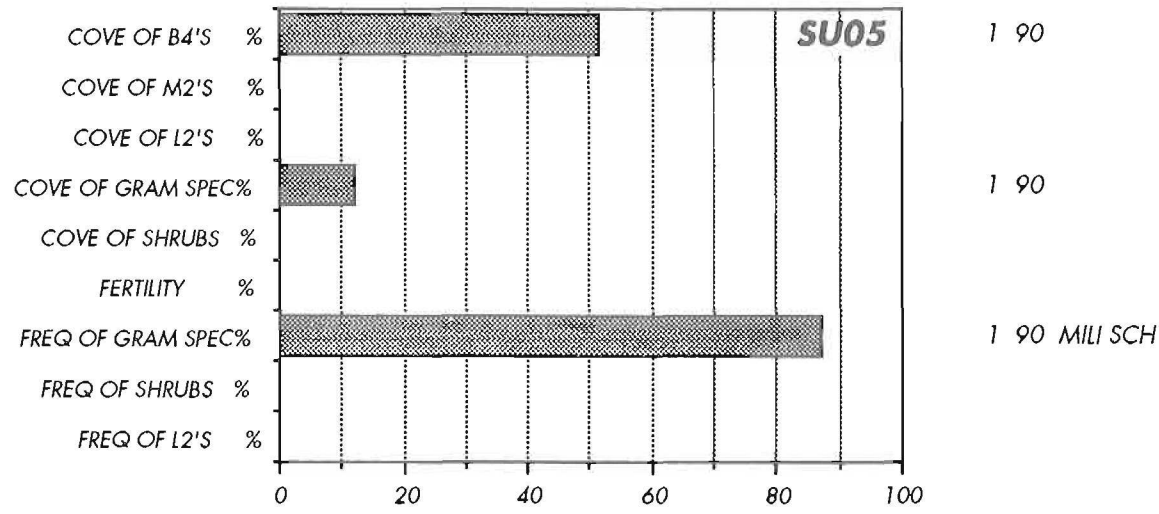
1 90
1 90
1 90
1 90
1 90
1 90 PLEU SCH
1 90 DESC FLE
1 90 VACC MYR
1 90



5 89
5 89
5 89
5 89
5 89
5 89 PLEU SCH
5 89 VACC MYR
5 89

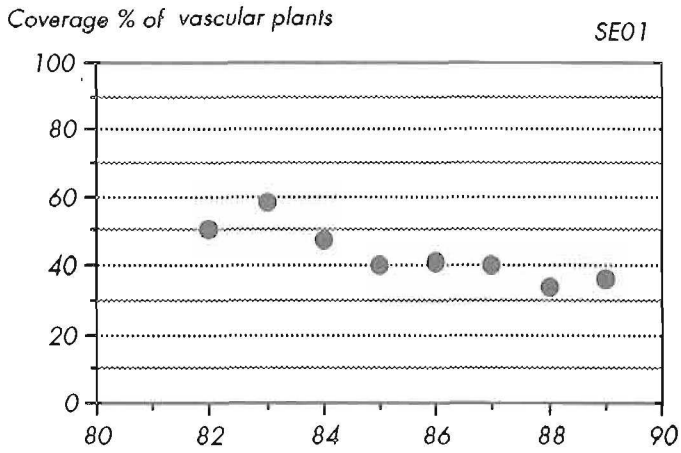


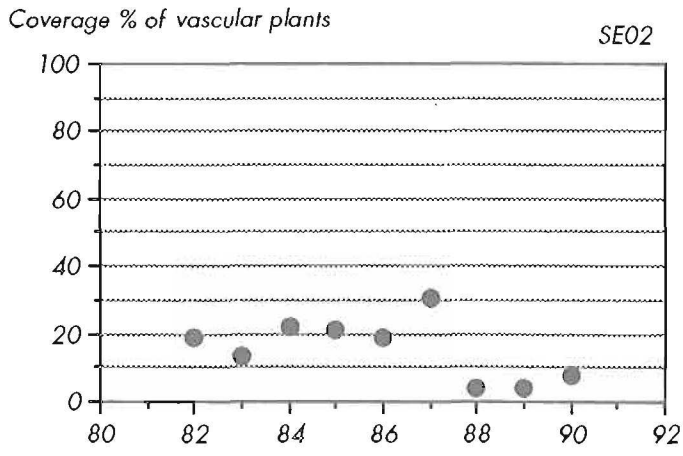
4 89
4 89
4 89
4 89
4 89
4 89 PLEU SCH
4 89 EMPE HER
4 89



13.2 Long-term variation

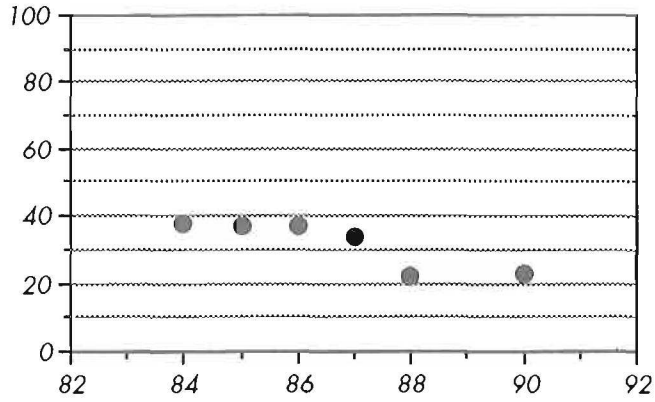
Some time-series are shown for three Swedish areas. Both declining trends as sudden changes can be seen. As to what extent these are objective/subjective must be determined by later detailed evaluation.





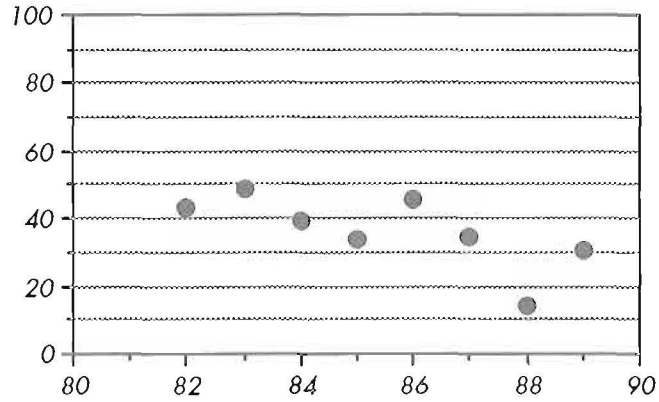
Coverage % of vascular plants

SE03



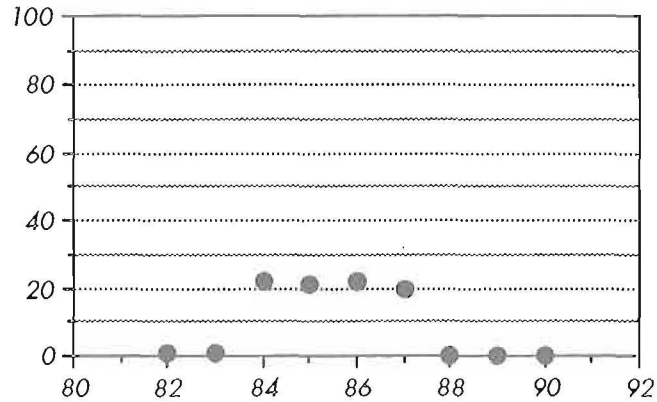
Coverage % of shrubs

SE01



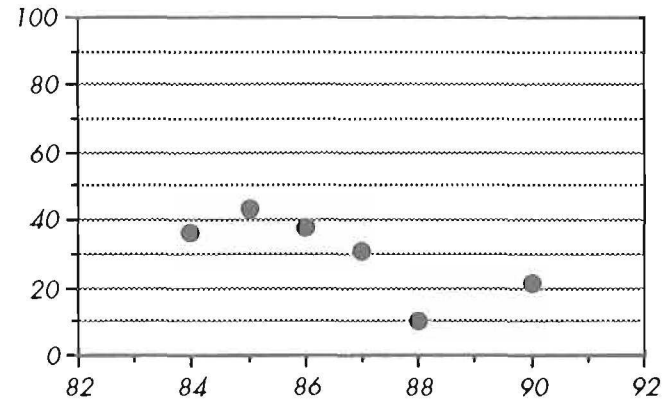
Coverage % of shrubs

SE02



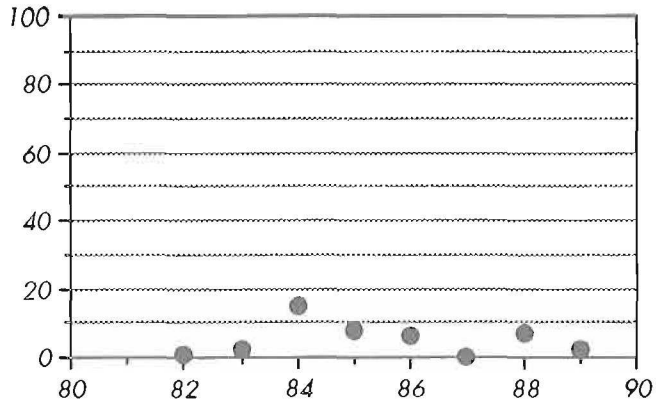
Coverage % of shrubs

SE03



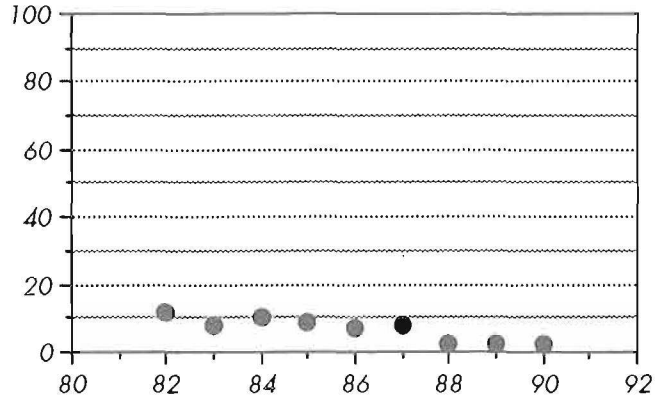
Coverage % of graminaceous species

SE01



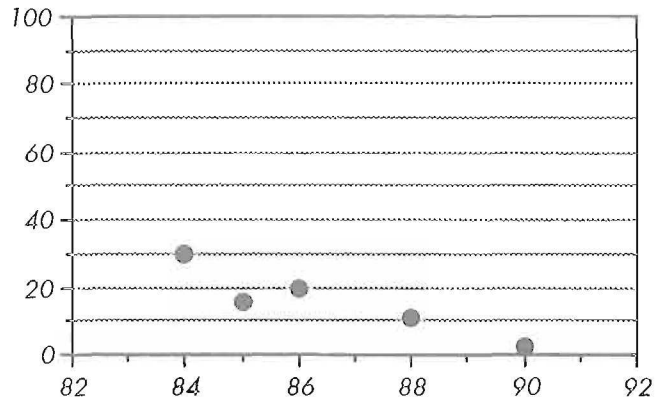
Coverage % of graminaceous species

SE02



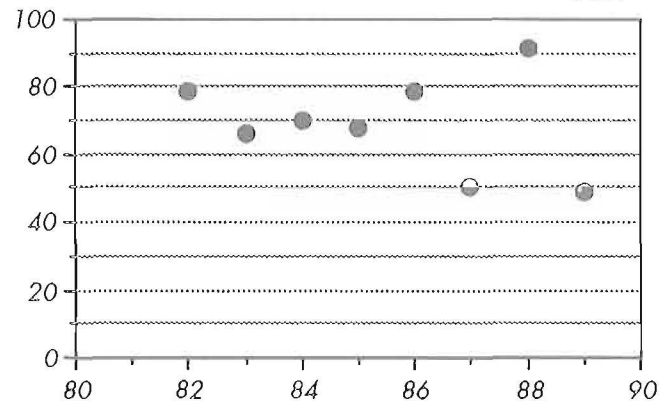
Coverage % of graminaceous species

SE03



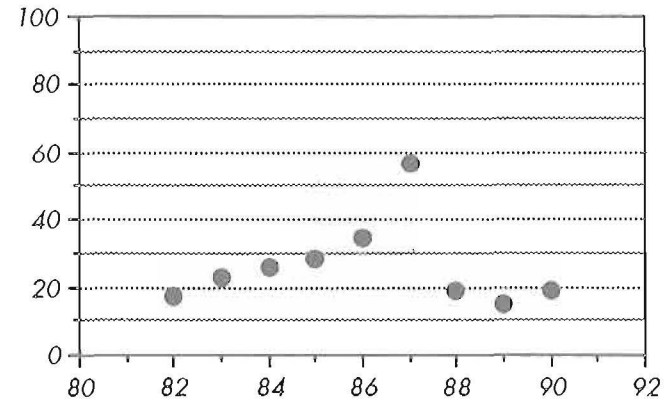
Coverage % of mosses

SE01



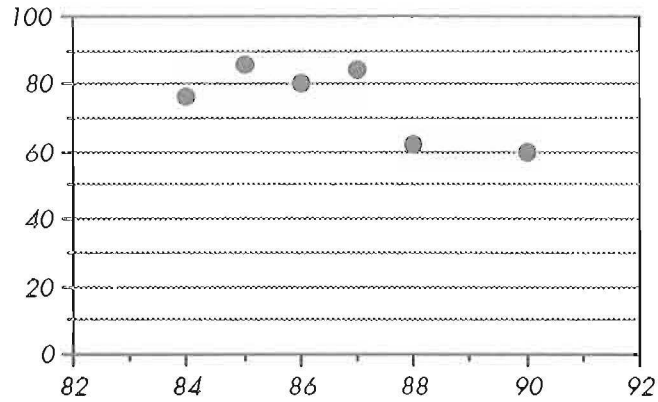
Coverage % of mosses

SE02



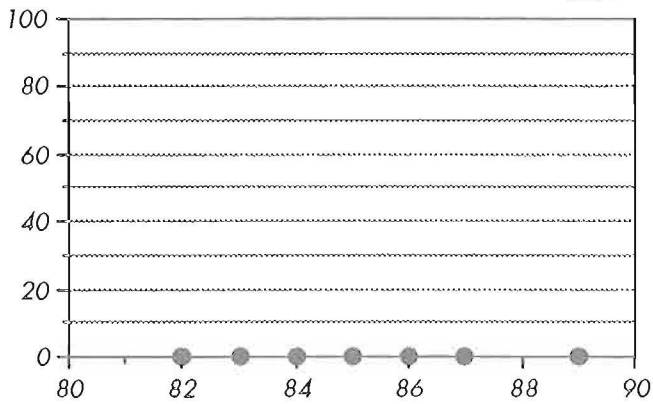
Coverage % of mosses

SE03



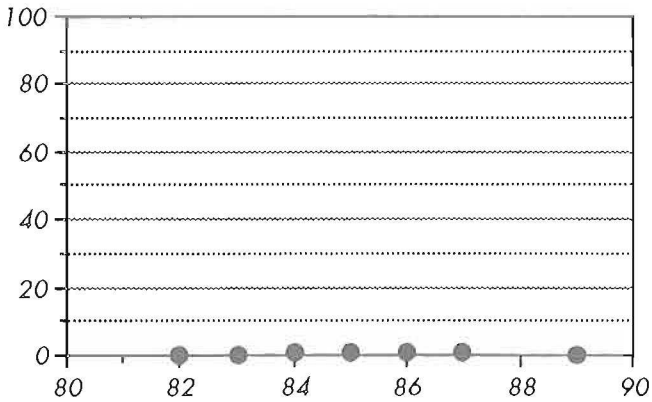
Coverage % of epigaeic lichens

SE01



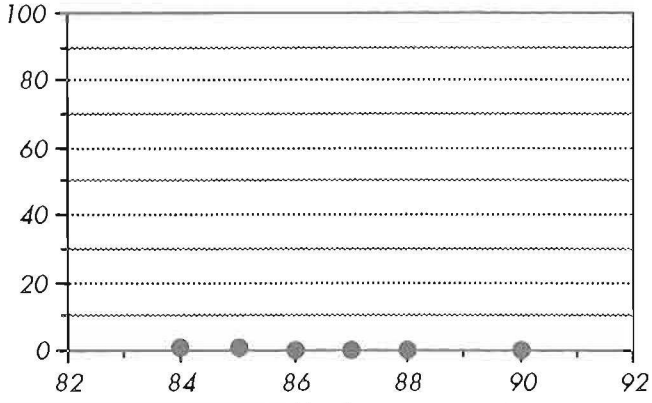
Coverage % of epigaeic lichens

SE02



Coverage % of epigaeic lichens

SE03



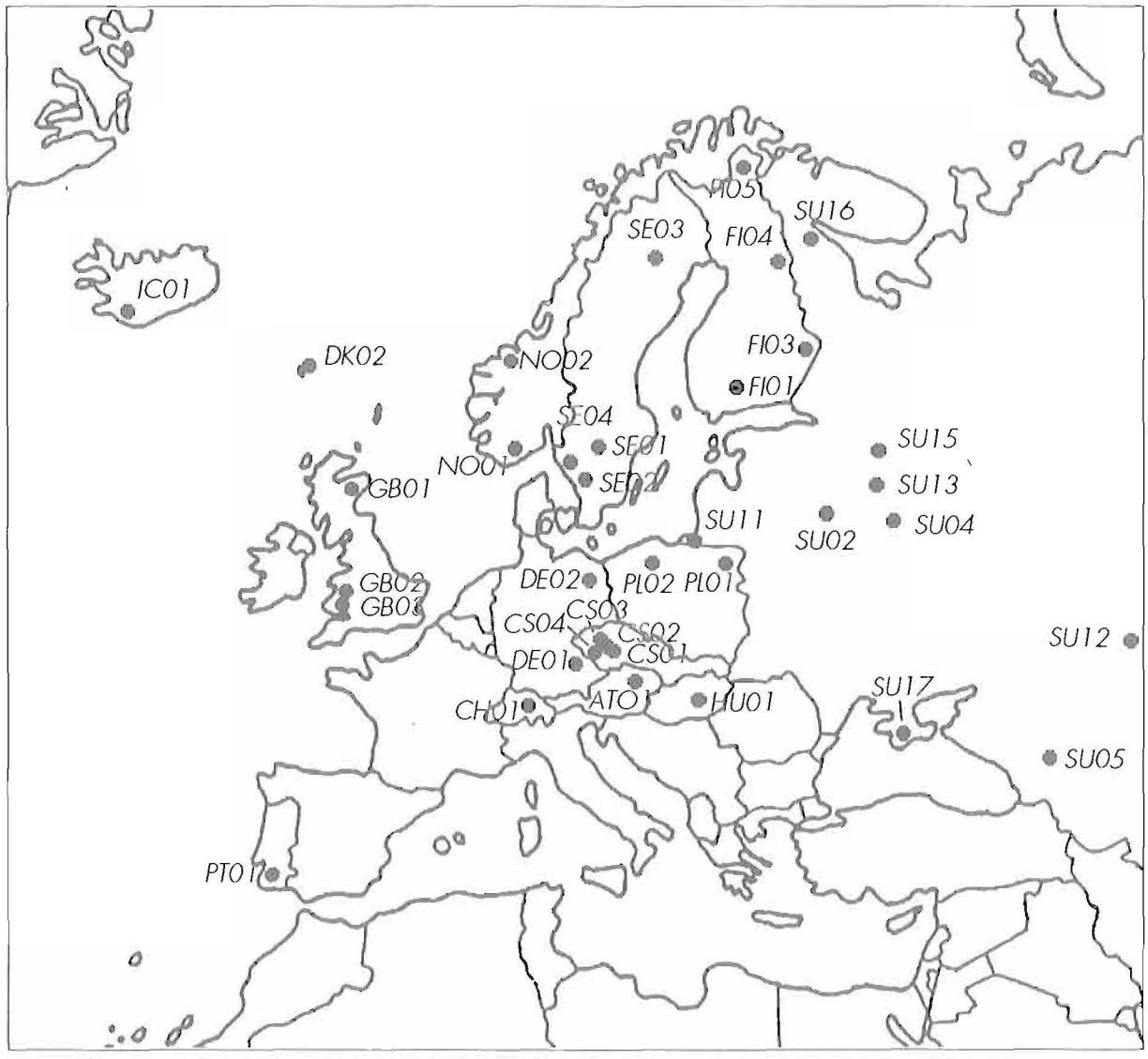
ANNEX

Programme activity report

Siting of areas

IM - National Focal Centres

***Austria**, Federal Environmental Agency*
***Canada**, Canada Centre for Inland Waters, Ontario*
***Czech and Slovak Federal Republic**, Geological Survey, Praha*
***Denmark**, Environmental Research Institute, Copenhagen*
***Finland**, Environment Data Centre, Helsinki*
***Germany**,Umweltsbundesamt, Pilotstation ,Frankfurt*
***Hungary**, Water Resource Research Institute, Budapest*
***Iceland** Agricultural Research Institute, Reykjavik*
***Netherlands**, Institute for Public Health and Env. Protection, Bilthoven*
***Norway**, Air Research Institute, Lillestrom*
***Poland**, Environmental Protection Institute, Warszawa*
***Portugal**, Dir. Geral da Qualidade do Ambiente, Lisboa*
***Soviet Union**, Institute of Global Climate and Ecology, Moscow*
***Sweden**, Environmental Protection Agency, Uppsala*
***Switzerland**, Federal Institute for Forest, Snow and Landscape Research*
***United Kingdom**, Institute of Hydrology, Oxon*
***United States**, Environment Protection Agency, N Carolina*




CA01
CA02

Phase	Activities \ Codes	AT01 Vienna Wood	CA01 Turkey Lakes	CA02 Lake Clair	CH01 Erlenlabel	CS01 Anenske	CS02 Mlynaruv	CS03 Jezeri	CS04 Liz-Sumava	DD01 Stechlin	DE01 Forellenbach
Initial phase (meas.)	meteorology		•	o	•	•	•	•	•	o	•
	deposition		•	o	•	•	•	•	•	•	•
	runoff		•	o	•	•	•	•	•	o	•
	water chemistry		•	o	•	•	•	•	•	•	•
Basic phase (meas.)	air chemistry		o	o	•	•	•			•	•
	throughfall		o	o	o	o					•
	stemflow		o	o							•
	soil water		o	o							•
	groundwater		•		o						•
	soil chemistry			o	o	o				•	•
	forest stands		o	o	o						•
	trees			o	o						•
	understorey veg.										•
	epiphytes									o	
	litterfall				o						o
	foliage chemistry		o	o	•	o				•	o
	moss chemistry					•				•	o
	nutrient uptake		o								
Basic phase (surveys)	vegetation survey		o								•
	soil survey										o
	plant survey										
	geochemical survey										o
Extended phase	hydrobiology		o							o	o
	lake chemistry		o		-	-	-	-	-	o	-
	decomposition										
	bird census					o					o
	bark chemistry					o				o	
	immision in aquatic org.		o								
	immision in terrestrial org.					o					
	sediments		o			-	-	-	-	o	-

Phase	Activities \ Codes	DK02 Kollur	FI01 Valkeakolinen	FI03 Hietajärvi	FI04 Pesosjärvi	FI05 Vuoskojärvi	GB01 Allt a Mharcaidh	GB02 Afon Hafren	GB03 Llyn Brianne	HU01 Komlosi	IC01 Hredavatn
Initial phase (meas.)	meteorology	o	•	•	•	•	•	•	o	•	
	deposition	o	•	•	•	•	o	•	o	•	
	runoff		•	•	•	•	•	•	o	-	
	water chemistry		•	•	•	•	•	•	o	-	
Basic phase (meas.)	air chemistry	o			o	o				•	
	throughfall		•	•	•	•	-		o	•	-
	stemflow		•	•	•	•			o	•	-
	soil water		•	•	•	•				o	
	groundwater						o			o	
	soil chemistry		•	•	•	•			o	•	
	forest stands		o	o	o	o			o		-
	trees		•	•	•	•				o	-
	understorey veg.		•	•	•	•					
	epiphytes		•	•	•	•					-
	litterfall		o	o	o	o				o	-
	foliage chemistry		•	•	•	•				o	-
	moss chemistry		•	•	•	o					
	nutrient uptake									o	
Basic phase (surveys)	vegetation survey		•	•	•		o	o	o		
	soil survey		o	o	o	o	o	o			
	plant survey		•		o						
	geochemical survey										
Extended phase	hydrobiology		o	o					o		
	lake chemistry		•	•	•	•				-	
	decomposition		o	o	o	o					
	bird census		•	•	•	•					
	bark chemistry										
	immision in aquatic org.										-
	immision in terrestrial org.										
	sediments			o						-	

Phase	Activities \ Codes	NO01 Birkenes	NO02 Kårvatn	PL01 Lekuk	PL02 Gardliczna	PT01 Alentejo	SE01 Tiveden	SE02 Berg	SE03 Reivo	SE04 Gårdsjön	SU16 Velikiy
Initial phase (meas.)	meteorology	•	•	•		•	•	•	•	•	
	deposition	•	•	•		•	•	•	•	•	
	runoff	•	•				•	•	•	•	
	water chemistry	•	•	•			•	•	•	•	
Basic phase (meas.)	air chemistry	•	•	•		•	o			o	
	throughfall	•	•				o	o	o	•	
	stemflow									o	
	soil water	•	•				•	•	•	•	•
	groundwater	•	o				•	•	•	•	•
	soil chemistry	•	•	•	•		•	•	•	o	•
	forest stands			•	•		•	•	•	o	
	trees	•	•				•	•	•	o	
	understorey veg.	•	•	o			•	•	•	o	
	epiphytes	•	o	o			•	•	•	o	•
	litterfall	o	o				o	o	o	o	
	foliage chemistry	•	•	•						o	o
	moss chemistry	o	•	•			o	o	o	o	•
	nutrient uptake					o					
Basic phase (surveys)	vegetation survey						•	•	•		
	soil survey						•	•	•	o	
	plant survey						o	o	o		
	geochemical survey									o	
Extended phase	hydrobiology						•	o	o	o	
	lake chemistry	-	-		•	•				o	
	decomposition						o	o	o	o	
	bird census						o	o	o	o	
	bark chemistry										
	immision in aquatic org.							o			
	immision in terrestrial org.			o			o	o		o	
	sediments	-	-							o	

Phase	Activities \ Codes	SU02 Berezina	SU03 Caucasus BR	SU05 Jugo Massif	SU04 Oka-Terrace BR	SU11 Preila	SU12 Astrakhan BR	SU13 Central Forest BR	SU 15 Valday	SU17 Kara-dag
Initial phase (meas.)	meteorology	•	•	•	•	o		o	•	•
	deposition	•	•	•	•	•		o	•	
	runoff								•	
	water chemistry			•					•	
Basic phase (meas.)	air chemistry	•	•		•	•			•	
	throughfall			•					•	
	stemflow									
	soil water									
	groundwater			•					•	
	soil chemistry								•	
	forest stands									•
	trees			•						
	understorey veg.			•						
	epiphytes			•					o	
	litterfall									
	foliage chemistry									
	moss chemistry				•					
	nutrient uptake	o								
Basic phase (surveys)	vegetation survey								o	
	soil survey								o	
	plant survey									
	geochemical survey									
Extended phase	hydrobiology									
	lake chemistry	o								
	decomposition									
	bird census									
	bark chemistry									
	immision in aquatic org.									
	immision in terrestrial org.							o		
	sediments									

o stored • reported - not possible

Characteristics of areas in this report

Code	Area	Ecoregion	Lithology	ha	Forest type
CS01	Anenske Povodi	CNemoral	Gneisses	270	Spruce - Pine
CS02	Mlynaruv Luh	CNemoral	Volcanites	202	Spruce - Pine
DD01	Stechlin	CNemoral	Unconsolidated	2139	Oak - Beech
PL01	Lekuk Lake	CNemoral	Unconsolidated	1950	Spruce - Oak
PL02	Gardliczno Male	CNemoral	Unconsolidated	400	Pine - Alder
SU11	Preila	CNemoral	Sandstones	5	
GB01	Allt a Mharcaidh	WNemoral	Granites	998	Calluna-heath
GB02	Afon Hafren	WNemoral	Shales	358	Pine - Spruce
CH01	Erlentobel	COrobiome	Sandstones	70	Spruce - White fir
CS03	Jezeri	COrobiome	Gneisses	216	Spruce - Beech
CS04	Liz-Sumava	COrobiome	Gneisses	100	Spruce
DE01	Forellenbach	Corobiome	Granites	25	Spruce - White fir
NO01	Birkenes	BNemoral	Granites	41	Spruce
SE01	Tiveden	BNemoral	Granites	42	Pine - Spruce
SE02	Berg	BNemoral	Gneisses	93	Pine - Spruce
SE04	Gårdsjön F1	BNemoral	Gneisses	4	Pine - Oak
SU02	Berezina	BNemoral	Sandstones	76200	
SU04	Oka-Terrace	BNemoral	Limestones	4945	
SU15	Valday	BNemoral	Limestones	45	
FI01	Valkeakotinen	SBoreal	Granodiorites	30	Pine - Spruce
NO02	Kårvatn	SBoreal	Gneisses	2500	Pine - Birch
FI03	Hietajärvi	MBoreal	Granodiorites	600	Pine - Spruce
SE03	Reivo	MBoreal	Granitoporphyres	1090	Spruce - Pine
FI04	Pesosjärvi	NBoreal	Greenstones	605	Spruce
FI05	Vuoskojärvi	NBoreal	Granulites	200	Pine - Birch
SU16	Velikiy Island	NBoreal	Granites	33	Spruce
HU01	Komlosi	Forest Steppe	Unconsolidated	1000	Pine - Poplar
PT01	Alentejo	Submediterranean	Quartz schists	157600	Eucalyptus
SU03	Caucasus BR	EOrobiome	Granites	263477	
SU05	Juga Massif	EOrobiome	Granites	6500	
CA01	Turkey Lakes/B	NWNemoral	Greenstones	110	Sugar maple - Yellow birch