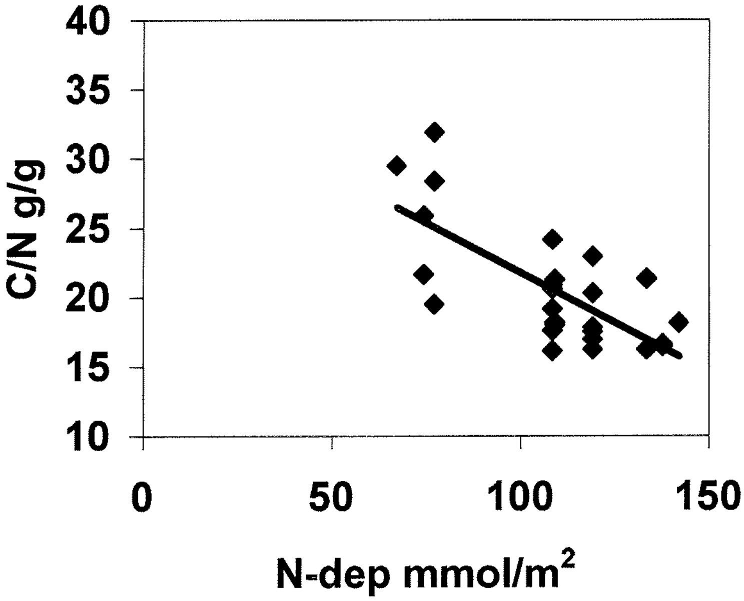
REPORT SNO 4130-99

Soils in mountain and upland regions of southwestern Norway: nitrogen leaching and critical loads

NATURENS TÅLEGRENSER

Miljøverndepartementet
Fagrapport nr. 103



Naturens Tålegrenser

Programmet Naturens Tålegrenser ble satt igang i 1989 i regi av Miljøverndepartementet. Programmet skal blant annet gi innspill til arbeidet med Nordisk Handlingsplan mot Luftforurensninger og til pågående aktiviteter under Konvensjonen for Langtransporterte Grensoverskridende Luftforurensninger (Genevekonvensjonen). I arbeidet under Genevekonvensjonen er det vedtatt at kritiske belastningsgrenser skal legges til grunn ved utarbeidelse av nye avtaler om utslippsbegrensning av svovel, nitrogen og hydrokarboner.

En styringsgruppe i Miljøverndepartementet har det overordnete ansvar for programmet, mens ansvaret for den faglige oppfølgingen er overlatt en arbeidsgruppe bestående av representanter fra Direktoratet for naturforvaltning (DN) og Statens forurensningstilsyn (SFT).

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Abstract

Soil data were collected from 36 points in mountain and upland areas of southwestern Norway. Sampling was at cross-points on the NIJOS' 9x9 km grid used for forest and soil monitoring. The soils were linked to water chemistry and deposition data from the Norwegian critical load database (12x12 km grid). Together the data were tested for relationships between N deposition, C/N ratio in soil, and NO_3 concentrations in surface waters. The absence of significant relationships was ascribed to soil heterogeneity and the course-scale of the sampling. Critical loads for soils were calculated using the MAGIC model and the criterion that Ca/Al molar ratio in soil solution does not exceed 1.0. Critical loads were lowest for sites somewhat inland. With full implementation of the Gothenburg protocol by 2010, and assuming no increase in % N leached, only at a few of the sites will the critical load for soils continue to be exceeded in the long run.

4 keywords, Norwegian	4 keywords, English
1. jord	1. soil
2. tålegrenser	2. critical loads
3. nitrogen	3. nitrogen
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Naturens Tålegrenser

Fagrapport nr. 103

Soils in mountain and upland regions of southwestern Norway: nitrogen leaching and critical loads

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Preface

The research reported here began in 1998 (soil sampling and chemical analyses) and was completed in 1999 (data analysis, calculation of critical loads, and reporting). The work was financed by "Naturens tålegrenser", in 1998 through contract number 981990 with SFT (Norwegian Pollution Control Authority) and contract number 98940616 with DN (Directorate for Nature Protection), and in 1999 through contract number 990900 with SFT. Jacqueline Esser (Norwegian Institute for Land Inventory NIJOS) was responsible for soil sampling; Jan Mulder (Institute for Soil and Water Sciences, Norwegian Agricultural University NLH) was responsible for the soil chemical analyses and interpretation; Richard F. Wright (Norwegian Institute for Water Research NIVA) was responsible for the critical load calculations, reporting and project co-ordination.

We thank Ann-Kristin Buan, NIVA, for assistance with the database and model applications.

Oslo, 15 November 1999

Richard F. Wright

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Sammendrag

Fysiske og kjemiske data for jord er nødvendige for å beregne tålegrenser for jord og risiko for nitrogen-lekkasje. For jord i skogsområder i Norge er slike data blitt samlet inn systematisk, men for jord i de 70% av Norge som er uten skog finnes det få data. Overflatevann i fjell- og hei-områder på Sørvestlandet er følsomt for tilførsler av sur nedbør. Mye av dette vannet har også høye konsentrasjoner av nitrat. Dette tyder på at en vesentlig del av nitrogentilførslene lekker fra nedbørfeltet.

Skogsflater i Europa som lekker mye nitrat og tilføres mye nitrogen har lave C/N forhold i de øverste organiske jordsjiktene. Målsettingen med det foreliggende arbeidet har vært å samle inn systematisk nye data for jord i fjell- og hei-områder på Sørvestlandet, og bruke disse, sammen med data for nedbør- og vann-kjemi, til å beregne tålegrenser for jord i slike områder. samt å teste eventuelle empiriske sammenhenger mellom N-deposisjon, N-avrenning og C/N-forholdet i jorda.

Det ble tatt jordprøver fra 36 lokaliteter lokalisert i krysspunktene i NIJOS (Norsk institutt for jord og skogkartlegging) 9x9 km rutenett. Fysiske og kjemiske parametre ble målt ved Norsk institutt for skogforskning (NISK) og ved Institutt for jord- og vannfag (IJVF) ved Norges landbrukshøyskole (NLH). Prøvetakings- og analyse-metodikkene var de samme som ble brukt ved tidligere undersøkelser av jordprøver fra skogsflater i Norge.

Tålegrenser for jord ble beregnet ved hjelp av MAGIC modellen. Fremgangsmåten var den samme som tidligere er brukt for skogsjord. Som kritisk grense ble Ca/Al-forholdet i jordløsning satt til 1.0. Tålegrensene var lave for disse 36 lokalitetene, og var i mange tilfelle overskredet ved deposisjonsnivået for svovel og nitrogen i 1985. Hvis Oslo-protokollen av 1994 blir implementert og nitrogen-lekkasjen ikke øker, vil tålegrensen være overskredet i bare noen få lokaliteter i 2010.

Nitrat-konsentrasjonene i jorda er korrelert til N-deposisjonen ved disse lokaliteter. Lokaliteter med høy N deposisjon har generelt lavt C/N-forhold i jorda. Dette tyder på at en del av N-tilførselen som er holdt tilbake i nedbørfeltet har bidratt til å senke C/N forholdet i jordsmonnet. Denne tendensen ser en også i skogsjord med høy N-deposisjon i Europa.

Det er stor spredning i jorddataene og det er ingen korrelasjon mellom jordas C/N forhold og nitrat-konsentrasjonen i overflatevann. Dette skyldes store naturlige variasjoner i jordas egenskaper fra sted til sted. De nye jorddataene som er samlet inn vil danne grunnlaget for regional modellering av forsuring og nitrogen-lekkasje i fjell- og hei-områder på Sørvestlandet.

Summary

Determination of critical loads for soils and risk of nitrogen leaching requires physical and chemical data for soil. Such data have been systematically collected for forest soils in Norway, but few soil data are available for the 70 % of Norway that is non-forested uplands.

Surface waters in upland areas of southwestern Norway are sensitive to deposition of acid. Many of these waters have high concentrations of nitrate, indicating that a substantial fraction of nitrogen deposition is leached from the terrestrial catchments. In Europe forests with high levels of nitrate leaching are characterised by both high N deposition and low C/N ratio in the uppermost organic soil horizons. The objectives of the work reported here were to systematically collect data for soils in upland areas of southwestern Norway, and to use these together with deposition and water chemistry data to calculate critical loads for soil and test for empirical relationships between N deposition, C/N ratio in soil, and N concentrations in surface waters.

Soils were collected at 36 sites in southwestern Norway on the 9x9 km grid used by NIJOS (Norwegian Institute for Land Inventory). Soils were analysed for physical and chemical parameters at NISK (Norwegian Forest Research Institute) and IJVF-NLH (Department of Soil and Water Science, Agricultural University of Norway). Sampling and analysis methods were the same as used in earlier surveys of soils in spruce, pine and birch forests in Norway.

Critical loads for soils were calculated by the MAGIC model, using the same procedures and criterion as previously done for forest soils in Norway. The criterion used was Ca/Al ratio molar ratio of 1 in soil solution. Critical loads for these soils are generally low, and at levels of acid deposition in 1986, the critical load is exceeded at most of the sites. With implementation of the second sulphur protocol, and assuming no change in % N leached, only a few of the sites will still be exceeded in the year 2010.

The data show correlation between N deposition and N concentration in lakes for these sites. Sites with high N deposition also have lower C/N ratio in the organic soil horizons. This suggests that the N retained in the terrestrial catchments has gone in part to reduce C/N ratio in the soil. The trends are thus similar to those found in forested sites in Europe.

The wide spread in the data and the lack of correlation between soil C/N ratio and NO_3 concentration in lakewater are probably due to spatial heterogeneity in soil characteristics. These new soil data provide a basis for regional modelling of acidification and N leaching in non-forested upland areas of southwestern Norway under future scenarios of acid deposition.

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1. Introduction

Upland areas in southwestern Norway receive high levels of S and N deposition and surface waters are highly acidified (SFT 1999) (**Figure 1**). This region of Norway is also characterised by high concentrations of nitrate (NO_3) in surface waters (Skjelkvåle et al. 1996) (**Figure 1**), an indication both that N deposition is high, but also that N retention on land and water is low.

About 70% of Norway is characterised by non-forested upland terrain. Very little soils data are available from such areas. With the exception of a few sites, it has thus not been possible to calculate critical loads for soils and risk of future N leaching for non-forested areas.

In contrast the soils of forested areas have been systematically sampled and mapped over the period 1988-92 by the Norwegian Institute for Land Inventory (NIJOS) (Esser and Nyborg 1992; Esser 1994). These data have been used together with deposition data and surface water chemistry data to calculate and map critical loads for forest soils, using the MAGIC model and the chemical criterion of Ca/Al ratio in soil solution (Frogner et al. 1993; Frogner et al. 1994). Further these data have been used to assess the risk of future N leaching from forests to waters (Wright 1999).

In 1998 a 2-year project was initiated to obtain systematic soils data from upland areas of southwestern Norway. The data provide a basis for evaluating the relationships between N deposition, soil characteristics and N leaching in upland areas. Further the data allow the calculation of critical loads for non-forested soils. The soil sampling and chemical analysis was carried out in 1998 using the same scheme as for NIJOS' survey of forested soils. This report presents these new data, critical load calculations and evaluation of nitrogen retention in non-forested areas of southwestern Norway.

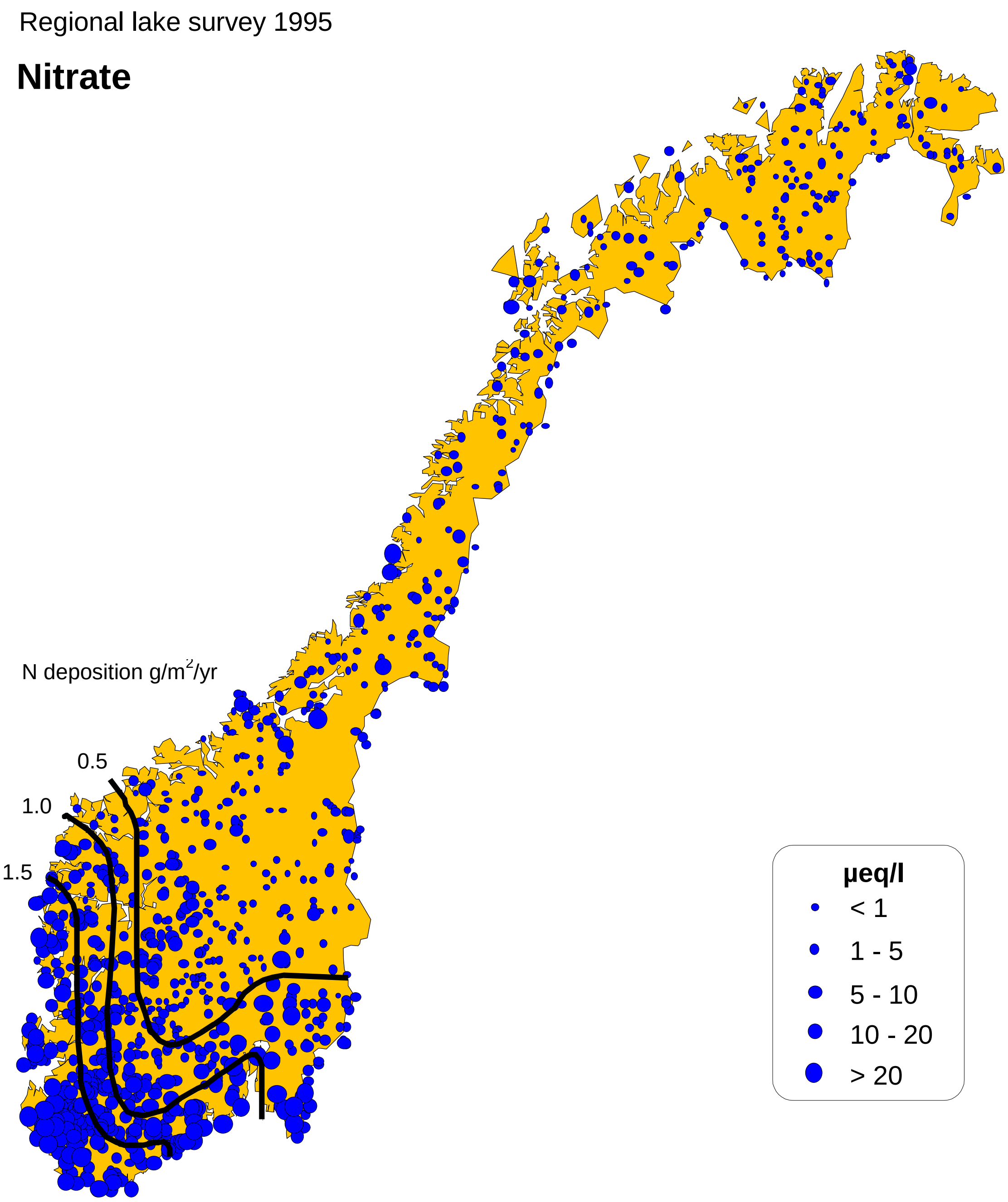


Figure 1. Nitrate concentrations in lakes sampled in 1995 (points) and isolines of N deposition (mean 1988-93) ($gN/m^2/yr$). Many lakes with high concentrations of nitrate are located in southwestern Norway. Lake data from Skjelkvåle et al. 1996; deposition data from Tørseth and Pedersen 1994.

2. Methods and data sources

2.1 Soil sampling

2.1.1 Site selection

The sites were selected from the NIJOS 9x9 km grid for Norway. This grid is used for monitoring forest health (Overvåking av skogens sunnhetstilstand) and was the basis for the sampling of soils in both coniferous and birch forests during the period 1988-92. The sites selected here were upland and heathland areas in southwestern Norway (western Vest-Agder County and southern Rogaland County) with one site in Telemark County (**Figure 2**). A total of 36 points were sampled.

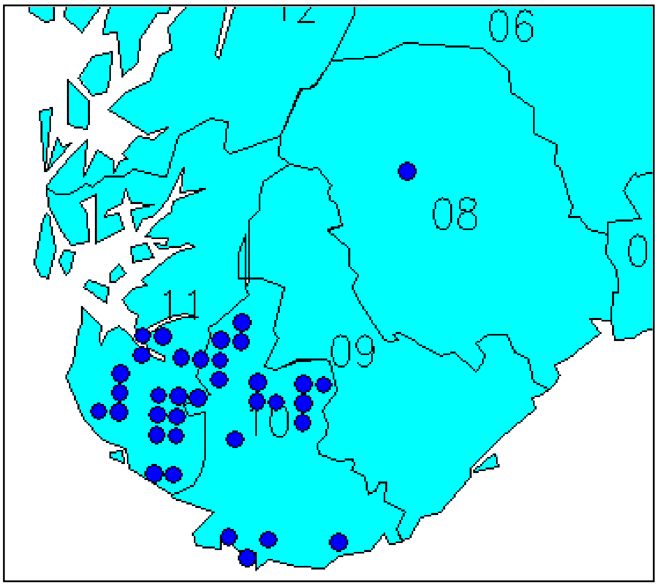


Figure 2. Map of southwestern Norway showing locations of soil sampling points 1998. Numbers indicate counties: 08= Telemark, 09= Aust-Agder, 10= Vest-Agder, 11= Rogaland.

2.1.2 Sampling procedure

The sampling procedure was the same as used by NIJOS for forest soils (Esser and Nyborg 1992; Esser 1994). The soil profile location was selected by an objective system. The profile location was selected such that it was representative for the area and did not fall on bare rock or water. The location was 12 m from the grid point in a compass direction chosen in the following order: N, E, S, W, NE, SE, SW, and NW. If none of these satisfied the selection criteria, the location was chosen subjectively.

The profile was dug to minimum 50 cm or until an impenetrable layer or obstacle was encountered.

Soil samples were collected from each horizon described, with the exception of poorly-defined and thin horizons. The samples were representative of both the profile and the site. Samples from each horizon were aggregates of cores taken by soil auger in the area in the vicinity of the soil pit plus material taken from the soil pit itself.

Two types of field data were recorded (**Table 1**): (1) area data, which comprise general information about the profile and the sampling location, and (2) horizon data, which comprise a morphological description of each horizon in the soil profile. The data are given in Appendix A.

Table 1. Overview of area data and horizon data (from Esser and Nyborg 1992).

Area data:	
profile number	stones on surface
date	bare rock
person	vegetation type
weather description	overburden type
county and municipality	drainage degree
NGO-coordinates	soil moisture
elevation above sealevel	depth to groundwater
terrain form	profile depth
slope aspect	sampling number
slope degree	
slope class	
Horizon data:	
profile and horizon number	% gravel
lithologic horizon	% stones
horizon description	organic material
horizon thickness	colour
horizon boundary definition	colour spots
horizon boundary form	structure
grain size distribution	roots

2.2 Soil chemical and physical analyses

The dry bulk density of the soil was determined in selected horizons. To this aim 100 cm^3 undisturbed soil cores were sampled using steel cylinders. The content of the cylinders was transferred quantitatively to a drying cabinet and dried at 65^{o}C (organic soil) and 105^{o}C (mineral soil). After drying the samples were weighed.

Mineral soil samples were also analysed with respect to particle size distribution (texture) according to the pipette method (Elonen 1971). After sieving, the fine earth fraction of the soil (< 2mm) was treated with a mixture of H_2O_2 and HCl to remove soil organic matter and carbonates, which may act as cementing substances. The fine earth fraction was divided into sand (60 – 2000 μm), silt (2 – 60 μm) and clay (<2 μm).

Field-moist soil samples were air-dried at 25^{o}C and sieved (<2 mm) prior to chemical analysis. Analysis of the fine earth fraction of the soil included pH(H_2O), pH($CaCl_2$), cation exchange capacity (CEC), exchangeable base cations, exchangeable acidity, total organic carbon, total organic nitrogen, and plant available phosphorus. For details concerning the methods reference is made to **Table 2**. The data are given in Appendix A.

Table 2. Analytical methods used for soil samples

Parameter	Method	Reference	Laboratory
$pH(H_2O)$	1:2.5 (v:v)	Ogner et al. 1991	NISK*
$pH(CaCl_2)$	1:2.5 (v:v)	Ogner et al. 1991	NISK*
CEC	Sum NH_4NO_3 extr. cations	Ogner et al. 1991	NISK*
Exchangeable base cations	NH_4NO_3 extr., ICP	Ogner et al. 1991	NISK*
Exchangeable acidity	NH_4NO_3 extr., titration	Ogner et al. 1991	NISK*
Total organic carbon	Element analyser	Nelson and Sommers 1982	IJVF**
Total nitrogen	Element analyser	Bremner and Mulvaney 1982	IJVF**
Phosphorus, plant avail.	NH_4-lactate extr.	Krogstad 1992	IJVF**
Bulk density	100 cm^3 steel cylinders	Blake and Hartge 1986	NISK*
Texture	Pipette	Krogstad 1992	IJVF**

*NISK=Norwegian Forest Research Institute
**IJVF=Deptartment of Soil and Water Sciences, Agricultural University of Norway

2.3 Calculation of critical loads: MAGIC model

2.3.1 Deposition and water chemistry data

The Norwegian critical load database held at the National Focal Centre at NIVA is based on grid size of 12x12 km. Critical loads for water have been calculated for all 2300 grid squares using the static models SSWC (steady-state water chemistry) and FAB (first-order acidity balance), following the procedures specified in the mapping manual (UBA 1996). The soils data from the NIJOS 9x9 km grid were thus translated and grouped to the critical load 12x12 km gird. The original 36 soil profiles correspond to 27 critical load grid squares.

The Norwegian Institute for Air Research (NILU) has estimated present-day deposition (wet plus dry) of sulphur and nitrogen compounds to each square in the 12 x 12 km grid. The estimates are largely based on deposition measurements taken in 1988-93 at monitoring stations throughout Norway (Tørseth and Pedersen 1994) and interpolated to the 12 x 12 km grid. Estimated dry-deposition takes into account vegetation type.

The Norwegian Institute for Water Research (NIVA) has assembled a database for surface water chemistry for each square in a 12x12 km grid. The data come mainly from the 1000 lake survey conducted in 1986 and supplemented by similar data from other sources as described by Henriksen 1990). The database contains values for concentrations of major ions and specific discharge. The database is used for calculating critical loads and exceedances with the static models SSWC (Henriksen et al. 1990) and FAB (Henriksen 1998).

2.3.2 Description of MAGIC

MAGIC (Model of Acidification of Groundwater In Catchments) is an intermediate complexity process-oriented dynamic model for constructing acidification history and predicting future acidification over time periods of decades to centuries (Cosby et al. 1985a; Cosby et al. 1985b). MAGIC focuses on changes in the soil caused by atmospheric deposition, forest growth, and leaching to runoff. The soil chemical processes in MAGIC include sulphate adsorption, cation exchange, CO_2 dissolution and equilibrium, precipitation, dissolution and speciation of Al, chemical weathering, and dissociation of organic acids. A new version of MAGIC (version 7) also incorporates simple functions for nitrogen retention and loss, largely determined by the C/N ratio in the soil (Wright et al. 1998).

MAGIC was used to calculate critical load for soil and water using largely the same procedures as previously for forest soils (Frogner et al. 1994). Several assumptions were necessary.

1. It was assumed that prior to the onset of acid deposition (for example, prior to the year 1850) the soil was in steady-state with respect to inputs of major ions in deposition and weathering and output in runoff.
2. It was assumed that the critical load is exceeded if the Ca/Al molar ratio in soil solution in the rooting zone (taken as 0-50 cm) falls below the chemical criterion of 1. This criterion is used for forest soils and in the absence of a better criterion is used here for non-forested soils.
3. It was assumed that the critical load will protect the ecosystem (in this case soil) for 50 years into the future. This means that the chemical criterion is not violated; for systems already damaged (critical load exceeded) the criterion will be met within 50 years if deposition is decreased to the critical load. For ecosystems not yet exceeded, the criterion will be reached within 50 years if deposition is increased to the critical load.

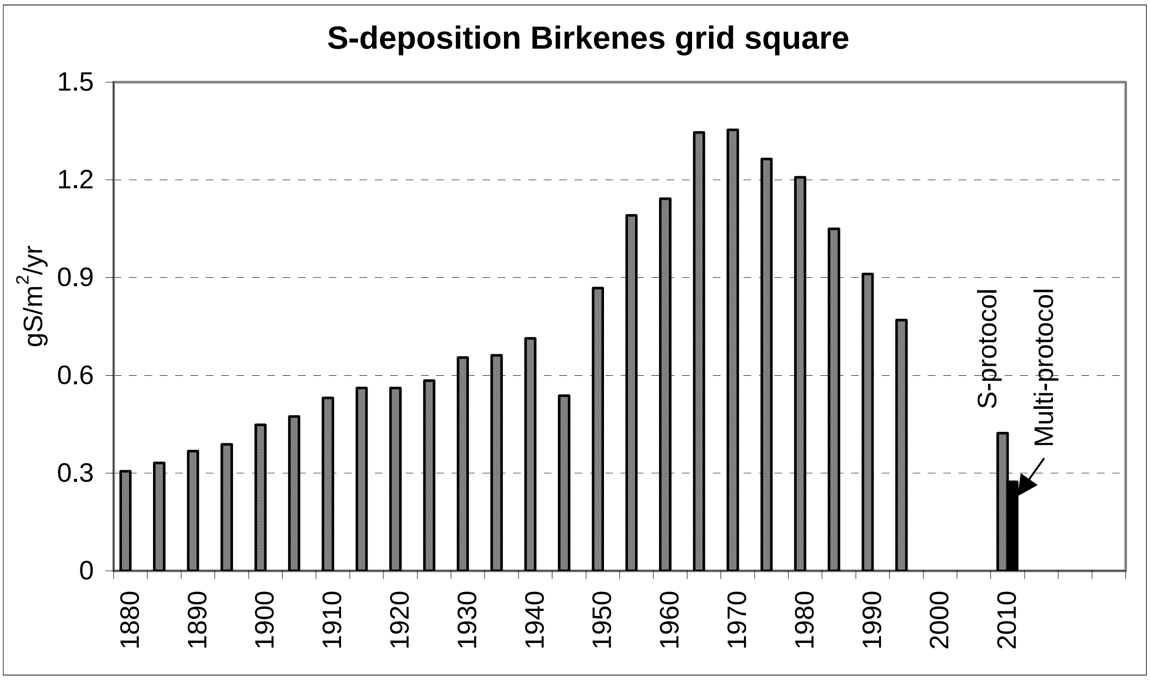
2.3.3 Calibration procedures

The soil data from the 9x9 km grid were aggregated to the 12x12 km critical loads grid net. The horizon data were aggregated to obtain single values for soils less than 60 cm in depth, and values for 0-50 and > 50 cm for soils with total depth greater than 60 cm. The aggregation procedure weighted horizons by thickness and bulk density. The MAGIC calibrations used a 1-box version for those sites with soil depth less than 60 cm and a 2-box version for those sites with soils greater than 60 cm in depth. Standard values for pCO2 in soil air of 0.005 atmosphere, and dissolved organic carbon in soil solution of 50 mmol/l were used. Net uptake of base cations in biomass was assumed to be zero. (No biomass harvest.)

Present-day deposition of major ions was estimated from the water chemistry and specific discharge under the assumptions that all sulphur and chloride comes from atmospheric deposition and that the lakes are in steady-state with atmospheric inputs. Further, it was assumed that deposition of Na, Mg, and K is of seasalt origin and the atmospheric inputs of these ions were set using the previously-calculated chloride deposition. Deposition of Ca, NO_3, and NH_4 were estimated from ratios of these ions to sulphate in precipitation in southern Norway (from the critical loads database).

Nitrogen retention, the fraction of the deposited NH_4 and NO_3 leached as runoff, was taken as the value measured in 1986 (from deposition and surface water data in the critical loads database), and assumed not to change over time.

Calibrations were made for each grid square based on deposition, soil chemistry, and water chemistry for that particular square. The calibration was made to the year 1986, inasmuch as the water chemistry data are for that year. This assumes that there has been no major change in soil chemistry since 1986. The MAGIC calibration procedure assumes steady-state conditions 140 years in the past (year 1846). Historical deposition of S in southern Norway has been reconstructed by Mylona (1996) from the estimated emissions of S in Europe. The EMEP Meteorological Synthesizing Centre at the Norwegian Meteorological Institute (Meteorological Synthesizing Centre - West 1998) has made similar estimates for N deposition (**Figure 3**).



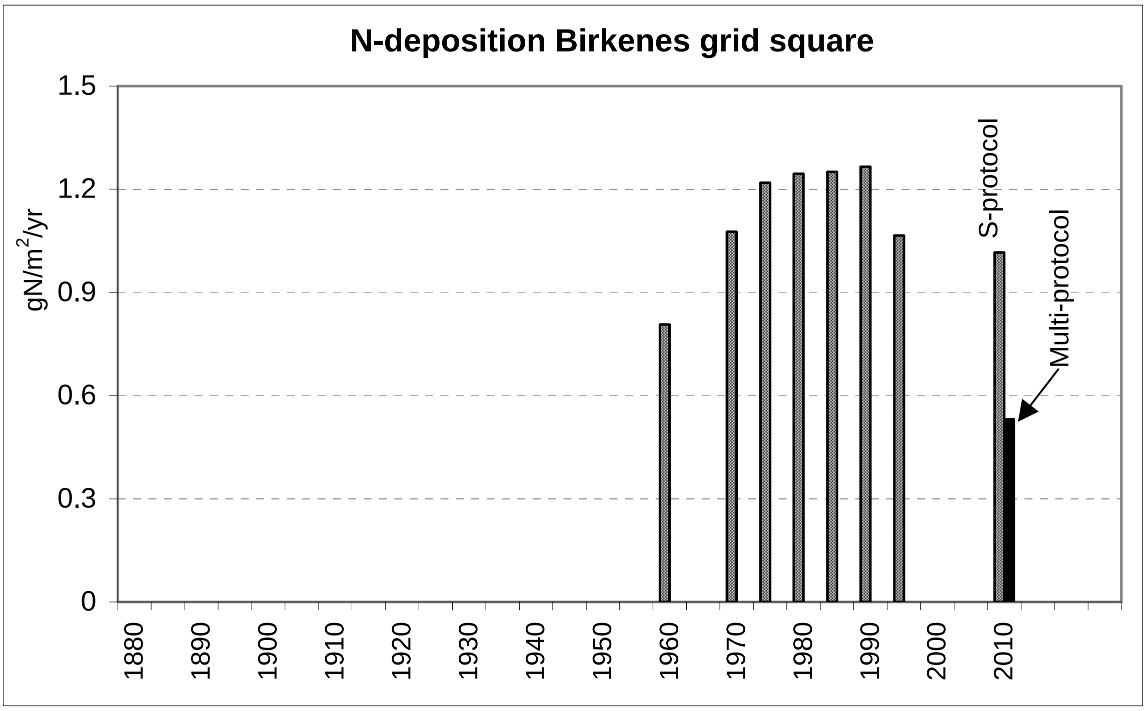


Figure 3. Historical and future deposition of S and N in the Birkenes EMEP grid square (southernmost Norway) as derived from historical estimates of S and N emissions, measurements since 1974, and estimates for the future assuming full implementation of the protocols to the Convention on Long-Range Transboundary Air Pollution (from Mylona 1996 and Meteorological Synthesizing Centre - West 1998).

An automated calibration routine (Jenkins and Cosby 1989) was used to obtain estimates of weathering rates and original base saturation in the soil such that, when subjected to the 140-year changes in S and N deposition, the simulated water and soil chemistry for the year 1986 agreed with the measured values.

2.3.4 Critical load calculations

The critical load at each grid square was calculated using the same procedures and scenarios as previously used for forest soils in Norway (Frogner et al. 1994). The critical load was calculated under the assumption that the deposition is suddenly changed to a new level and then held constant for 50 years. MAGIC is run repeatedly with different levels of deposition until the criterion of Ca/Al molar ratio = 1.0 in the soil solution is met. This deposition is then the critical load for soil.

First the critical load for sulphur was calculated assuming no change in N deposition or N retention relative to levels in 1986. Second the critical load for acidity was calculated for two scenarios of future N retention, both with future deposition of sulphur assumed to decrease by 60% relative to 1986 levels and future deposition of N assumed to remain at 1986 levels. The worst case N retention scenario assumes that all N deposition exceeding 70 meq/m^2/yr will leach. The best case assumes that 50% of N deposition exceeding 175 meq/m^2/yr will leach. These threshold values come from the empirical relationship between N deposition and N leaching at about 70 forested sites in Europe (Dise and Wright 1995).

Text box 1. The literature on nitrogen fluxes and amounts uses several different units. The following table gives conversion of units for nitrogen.

gN/m^2	kgN/ha	mmolN/m^2	meqN/m^2
1	10	70	70
2	20	140	140
3	30	210	210

3. Results and discussion

3.1 Nitrogen

Nitrogen deposition for the 27 grid squares ranges from 67 to 142 mmolN/m^2/yr (about 1-2 gN/m^2/yr) (**Figure 4**). Highest levels are found along the coast. Concentrations of nitrate in lakes ranges from 3-38 mmol/l with only a weak gradient from high levels nearer the coast to low levels inland (**Figure 4**). C/N ratios in organic horizons range from 19 to 37 with the 3 sites with highest C/N lying inland (**Figure 5**). There is no pattern in the carbon content of the organic horizons, which range from 150 to 4000 molC/m2 (**Figure 5**).

Data from intensively studied coniferous forest stands in Europe show a clear relationship between deposition and leaching of inorganic N (NO_3 + NH_4) (**Figure 6**) (Dise and Wright 1995). A closer analysis of these data revels that C/N ratio in the organic soil horizons (forest floor) explains a significant part of the variation in fraction of deposited N that leaches (**Figure 6**) (Gundersen et al. 1998; Dise et al. 1998).

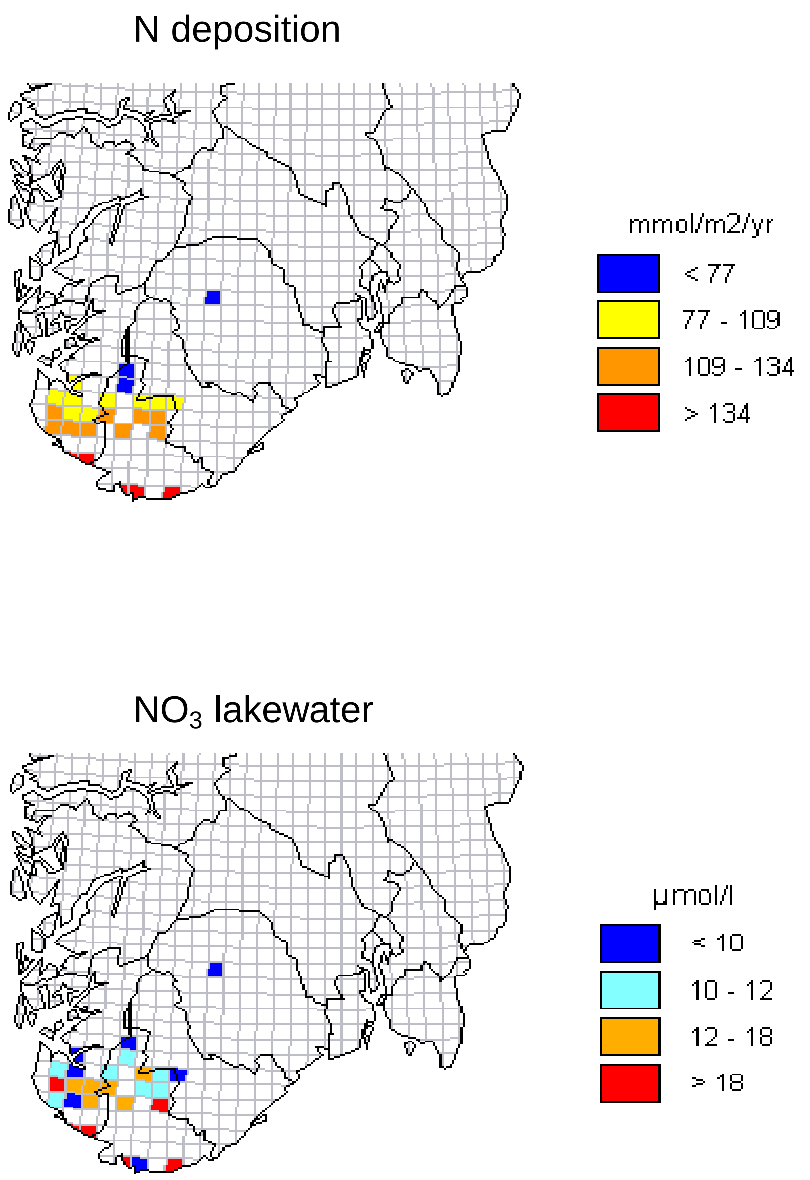
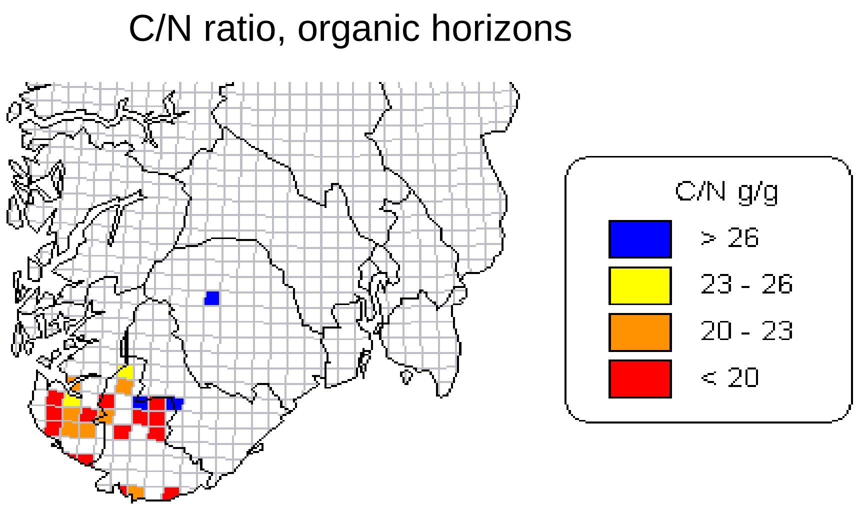


Figure 4. Nitrogen deposition (mean 1988-93) (top panel) and nitrate concentrations in lakes (bottom panel) at the 26 grid squares in southwestern Norway. Data from the Norwegian critical loads database. Deposition data extrapolated from Tørseth and Pedersen 1994.



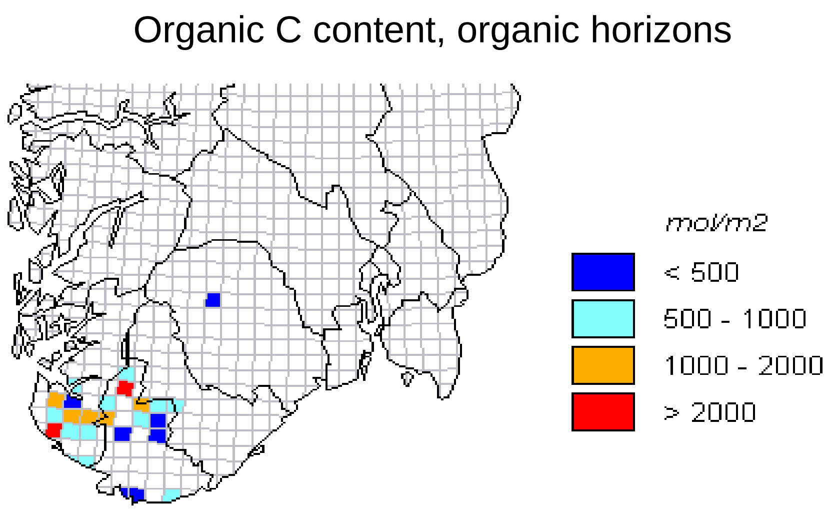


Figure 5. C/N ratio (top panel) and C content (bottom panel) of the organic soil horizons sampled in 1998 in the 26 grid squares in southwestern Norway.

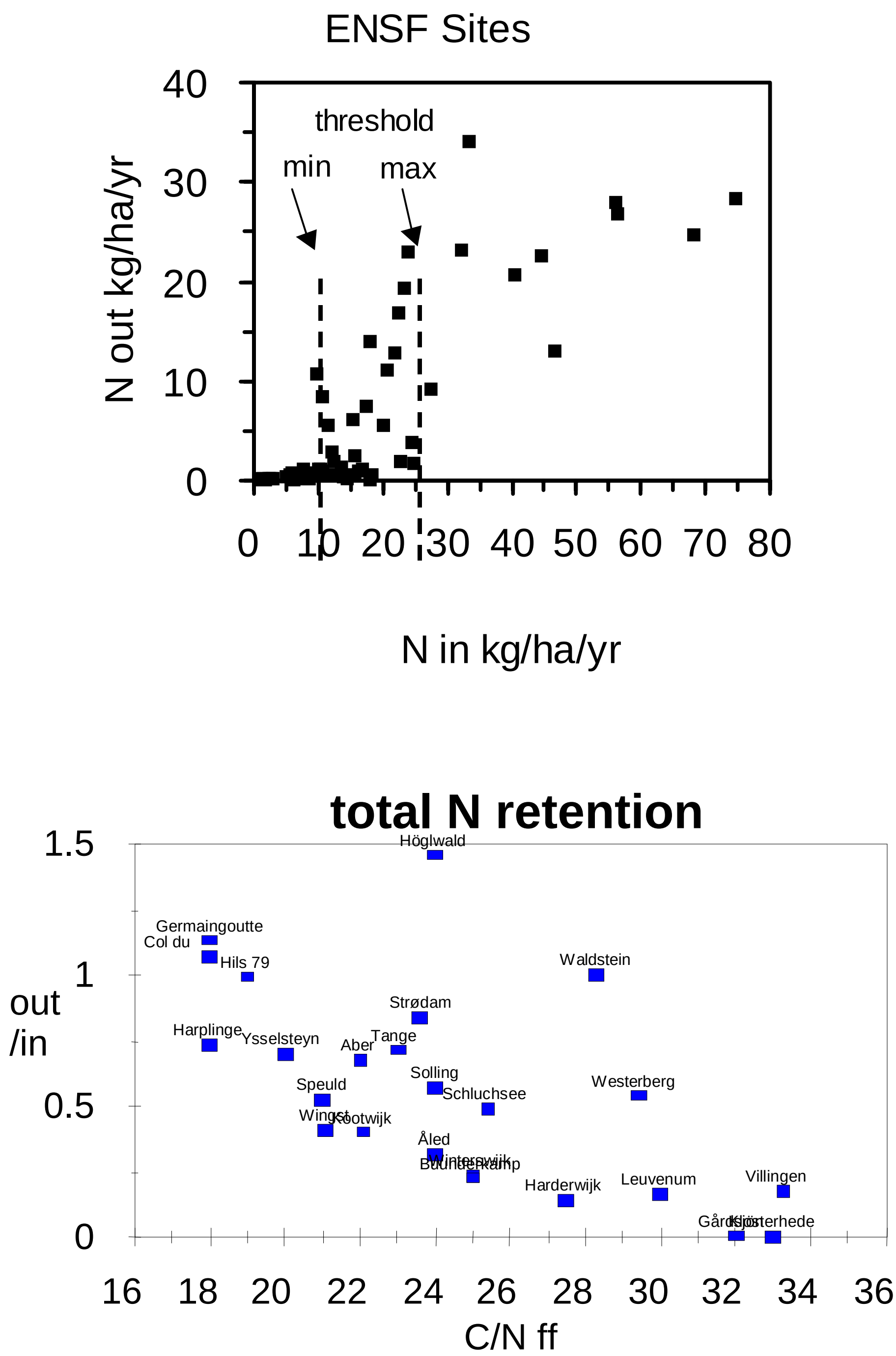


Figure 6. Top panel: Relation between deposition and leaching of inorganic N at coniferous forest stands in Europe. At deposition levels below about 9 kgN/ha/yr (equivalent to 0.9gN/m^2/yr) there is little leaching; at deposition levels above 25 kgN/ha/yr (equivalent to 2.5 gN/m^2/yr there is significant leaching at all stands (from Dise and Wright 1995). Bottom panel: Relation between the fraction of deposited N that leaches (in/out) and C/N ratio (g/g) in the organic soil horizon (forest floor) at the same coniferous forest stands (from Gundersen et al. 1998). These data indicate that chronic high deposition of N results in lower C/N ratio in the forest floor, and consequently higher N leaching.

The data from non-forested areas of southwestern Norway also show a significant relationship between N deposition and N leaching, in this case NO_3 concentrations in lakes (**Figure 7** bottom panel). But the spread in the data is not significantly related to C/N ratio in the organic soil horizon (**Figure 7** top panel). There is no correlation between N deposition and C pool in the soil.

Inorganic nitrogen flux from lakes is generally only a minor fraction of the N deposition; most N deposition is thus retained either in the terrestrial catchment or in the lake itself. If the C pool in soil does not change, then sites with high N deposition should have lower C/N ratios. The results for the 26 grid squares indicate such a trend. The data thus suggest that increased N deposition results in both increased leaching and lower C/N ratio in the soil.

The lack of significant relationship between C/N in organic soil and fraction of N leached may be due to spatial heterogeneity. The soils data are from specific points, whereas the lake nitrate concentrations represent a sample of N leached integrated both over space (i.e. the entire lake catchment) and over time. Soils are notoriously heterogeneous over relatively small distances, and there is no guarantee that the C/N ratio measured at one point in a lake catchment is characteristic for the C/N ratio for soils over the entire catchment. In addition the soil sample may not even come from within the lake catchment, as the 9x9 km grid size is in most cases much larger than the catchment area of the lakes sampled.

Furthermore NO_3 concentrations in runoff in this area commonly show a strong seasonal pattern with high levels in the autumn, winter and spring, and low levels during the summer (Kaste et al. 1997). Even though the lakewater samples were collected in the autumn during a time of hydrological mixing, in lakes with short hydraulic flushing times the water will be mainly autumn runoff, whereas in lakes with long flushing times a significant fraction will be from summer runoff.

Both the spatial and temporal factors are well accounted for in the European forest stand dataset of Gundersen et al. 1998. These sites are intensively-studied stands commonly of only a few hundred m^2 in area, and with leachate monitored in multiple samples over the year. For these data the spatial relationship between soil and leachate chemistry is quite tight. This may explain why there are clear and significant empirical relationships in the European forest stand dataset, but not in the much more course net Norwegian critical load data base for forest soils (Wright 1999) and now the new data for non-forested areas in SW Norway.

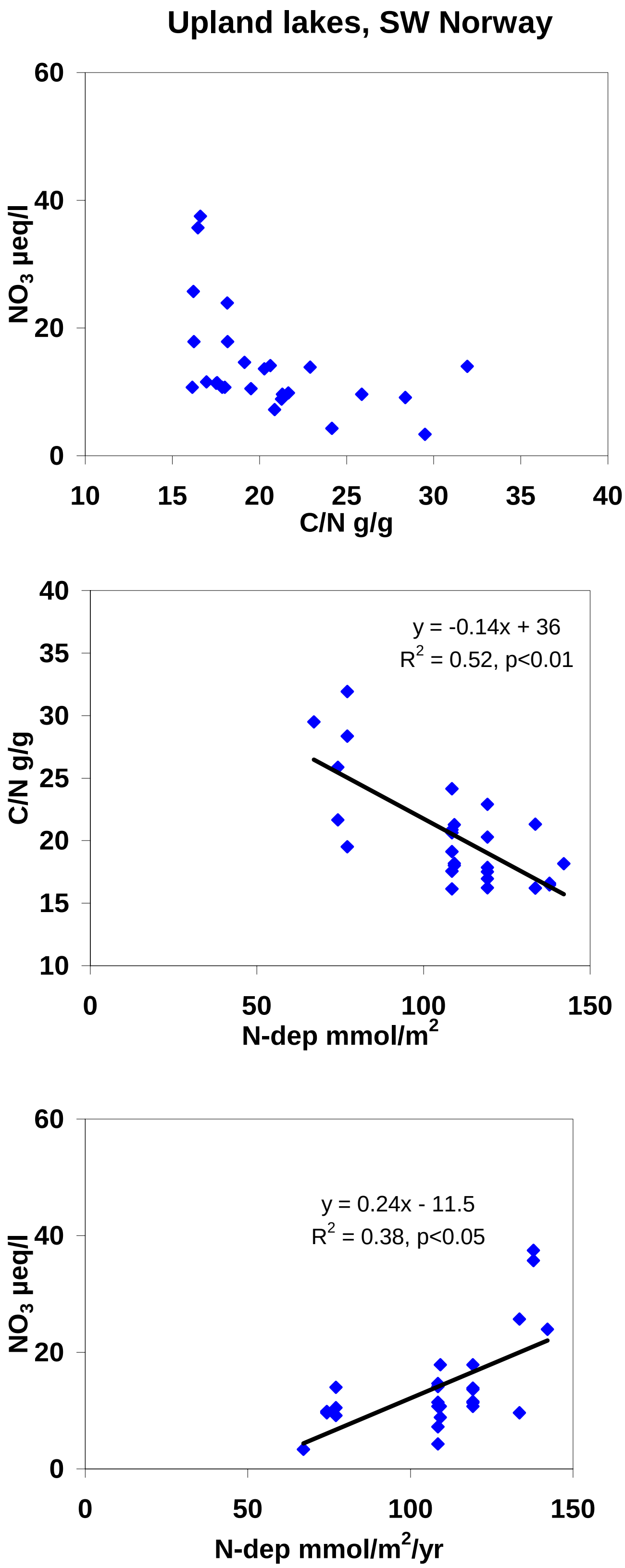


Figure 7. Relationships between C/N ratio in organic soil horizon, N deposition, and NO_3 concentration in lakes for 26 grid squares in non-forested uplands of SW Norway. The linear regression of NO_3 lake on C/N soil is not significant.

3.2 Critical loads

As expected the calculated critical loads for the soils in the 27 upland grid squares in southwestern Norway were generally very low (**Figure 8**). Sites near the coast have higher critical loads, a reflection of generally thicker soils and higher % base saturation. Critical load was exceeded at nearly all sites in 1990, regardless of assumption made regarding N retention (**Figure 8**). Reduced deposition in the year 2010 will result in a fewer number of sites being exceeded. Exceedance increases, of course, if future N retention decreases. The general picture is similar to that for many forest soils in southernmost Norway (Frogner et al. 1994).

In contrast to critical loads calculated using static models, critical loads calculated by dynamic models will vary in time. The longer the time with high deposition, the lower the critical load. This is a consequence of the assumption that prior to onset of acid deposition the catchment-lake ecosystem was in steady-state with respect to inputs and outputs of all ions, and that acid deposition causes leaching of base cations from the soil ion-exchange complex. Thus the longer the leaching is allowed to occur, the lower the critical load. The result is that the critical loads differ somewhat between the three deposition and N leaching scenarios (**Figure 8**).

These estimates for critical loads for non-forested soils assume that the Ca/Al criterion used for forest soils also holds for non-forest soils. The Ca/Al criterion is based on empirical evidence linking Ca/Al ratio in soil solution to damage to roots of major tree species, and in the absence of better criteria, is the standard used for mapping critical loads for soils in Europe (Posch et al. 1997). It is by no means clear, however, that this criterion holds for other types of vegetation, such as heather and other species typical of heathlands and upland regions in Norway. The critical loads for soils reported here, therefore, could be too high (in the event that heathland vegetation is more sensitive than forest trees) or too low (in the event that heathland vegetation is less sensitive).

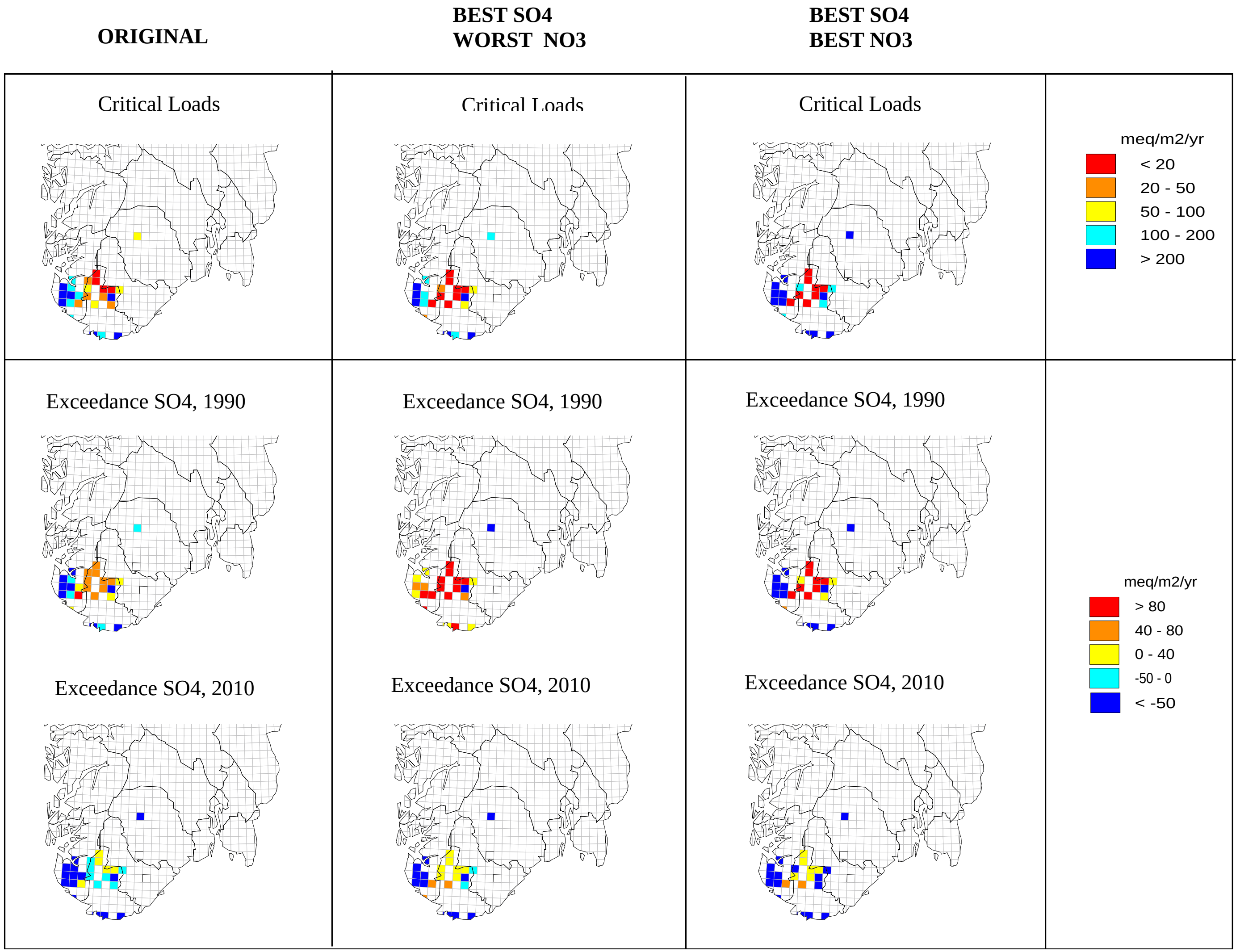


Figure 8. Critical loads for soil and exceedance for 3 scenarios of S deposition and N retention. The left-hand column is based on the assumption that N deposition and leaching does not change from the situation in 1990 (termed "original"). The middle and right-hand columns are for 2 scenarios of future N leaching (see text for details).

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Appendix A. Soil sampling descriptions, field data, and soil chemistry

Table A1. Site descriptions. NIJOS' field data codes.

BLR	PROFNR	DATO	KOMM	AKSE	OV	NS	HOH	HELL%	FORM	KLASSE	RETN	STEIN	FJELL	EROS	VEGTYPE
58006005	32509	290798	1111	A	105	405	250	42	3	H	S	4	7		H3g
58006006	32508	290798	1111	A	195	405	235	25	2	G	SO	1	7		H3e
58006016	32504	230798	1032	A	555	45	80	55	1	9	SO	1	7		41
58006016	32505	240798	1003	A	465	135	90	52	1	9	SV	4	5		
58007013	32503	220798	1032	A	645	135	245	35	9	7	SO	4	6	2	122
58007015	32502	210798	1018	B	-405	135	220	5	1	2	SO	2	5		5
58505008	32506	270798	1122	A	-75	855	140	12	2	D	N	3	1		
58505012	32522	280798	1121	A	-75	765	346	53	3	H	N	2	2		H3g
58505016	32507	280798	1119	A	-165	675	250	5	0	B	N	1	1		L2
58505016	32523	280798	1114	A	-75	675	282	35	3	G	SV	3	5		H3g
58506001	32513	10898	1112	A	15	1035	150	57	3	H	S	5	5		H3g
58506001	32524	290798	1129	A	105	1035	814	25		G	SV	4	4		S3g
58506003	32531	30898	1046	A	375	1035	870	10	1	C	S	7	7		T4a
58506004	32535	60898	1046	A	465	1035	612	0	0	A		1			K4aO
58506005	32527	310798	1122	A	15	945	625	26	1	F	NO		6		S1g
58506007	32530	20898	1122	A	285	945	995	33	3	7	SO	3	8		T5c
58506007	32533	40898	1046	A	375	945	885	5	3	3	N	3	8		K3a
58506007	32534	50898	1046	A	375	855	804	10	8	3	S	4	8		K3a
58506009	32529	10898	1114	A	105	765	570	48	3	8	V	2	7		H3g
58506010	32528	10898	1114	A	195	765	465	65		I	N	7			F1d
58506011	32512	310798	1114	A	285	765	720	29	6	5	SV	6	1		H3f
58506013	32510	300798	1101	A	105	585	360	9	7	C	O	6	1		H3a
58506013	32526	300798	1114	A	105	675	570	20	9	E	S	4	6		H3a
58506014	32511	290798	1112	A	195	585	395	72	3	1	S	7	7		A7c
58506014	32525	300798	1101	A	195	675	475	110	3	I	SO	3	4	7	F1b
58506016	32519	210898	1037	A	465	585	687	80	3	I	V	1	6		H3g
58507005	32520	220898	1037	A	555	855	630	11	5	C	O	2	1		K3a
58507006	32517	190898	1026	B	-585	855	664	41	3	8	V	2	8		H3g
58507007	32514	180898	1026	B	-495	855	606	22	1	E	SO	4	8		A6a
58507009	32518	200898	1037	A	645	765	880	18	3	D	NV	4	8		
58507009	32521	220898	1037	A	555	765	560	70	7	9	V	4	8		H3g
58507010	32516	190898	1026	B	-585	765	652	50	3	8	O	3	4		H3g
58507014	32515	180898	1026	B	-585	675	645	38	1	G	SO	2	8		H1e
59006016	32532	30898	1046	A	465	1125	830	25	8	E	S	3	6		S1b
59508009	32501	190798	834	B	-135	1845	1120	32	8	F	N	5	6	0	117a

Table A1. Site descriptions (cont.)

BLR	PROFNR	AVS1	AVS2	DREN	FUKT	VANNDYB	PROFDYB	FELTNR	ROTDYBDE	MERKN	VALG	VALGMERK
58006005	32509	M		L	5	20	38	JME09	-20	BEITET; BLÅTOPP I KLØFT MELLOM FJELLVEGG		10,5 M
58006006	32508	O	D	N	4		56	JME08	28	GROPA PÅ BASEN AV FJELL-MYE AVRENNING	1	
58006016	32504	O		K	7		7	JME04	7	IKKE INNMÅLT	2	
58006016	32505	M		E	3		58	JME05	58		1	12 M
58007013	32503	M	R	G	4		50	JME03	38	FLATA ER 1/2 FJELL, BRATT	3	12 M
58007015	32502	O	M	M	5	26	40	JME02	25		4	
58505008	32506	O	M	N	4	35	63	SYB01	37	KULTURBEITE, IKKE GJØDSLET; SIGEVANN	1	
58505012	32522	M		M	3		50	JAH01	35		1	
58505016	32507	O		P	5	10	93	JME07	30		3	
58505016	32523	O	M	N	3		62	JAH02	25		1	
58506001	32513	R		K	3		38	JME13	32		8	
58506001	32524	M		F	2		60	JAH03	35		5	
58506003	32531	M		K	3		24	JAH10	15		5	
58506004	32535					5	110	JAH14	60	PRØVER TATT MED BOR PGA GRUNNVANN	3	
58506005	32527	M		K	3		63	JAH06	25		1	
58506007	32530	R		N	3		27	JAH09	27		2	
58506007	32533	M		N	4		18	JAH12	18		1	
58506007	32534	M		N	3		32	JAH13	15		1	
58506009	32529	O			3		40	JAH08	30		1	
58506010	32528	R		G	3		23	JAH07	16		1	
58506011	32512	O		R	4	30	50	JME12	30	HOVEDDELEN AV FLATA LIGGER I BJØNNSKJEGG-DOM. SØKK OMGITT AV TUETE BLOKKOMRÅDE	1	
58506013	32510	M		N	5	28	42	JME10	28	BEITET; BLÅTOPP I KLØFT MELLOM FJELLVEGG	1	
58506013	32526	M		L	3		57	JAH05	30		1	
58506014	32511	R		J	3		35	JME11	35			50¤, 2 M
58506014	32525	R		D	3		21	JAH04	15		1	
58506016	32519	R		L	4		28	JME20	28	EN FJELLHYLLE MED NOEN STORE BJØRKETRÆR	1	
58507005	32520	O		S	5		35	JME21	35	MYR > 1 M DYP	1	
58507006	32517	O	F	L	3		14	JME17	14		2	12 M
58507007	32514	O	F	K	3		16	JME14	16	RØSSLYNG SOM LIGGER PÅ FJELL	1	
58507009	32518	O	R	N	5	28	51	JME18	17	"SCOURED" FJELL MED NOE GRESS I SVALENE	6	
58507009	32521	R		K	3		50	JME22	43	V/ BASIS AV FJELLHYLLE	1	15 M
58507010	32516	O		L	3		19	JME16	19		2	
58507014	32515	O		L	3		12	JME15	12	PATETISK RØSSLYNG I FJELLSPREKK; SAUMØKK	1	
59006016	32532	M		N	3		22	JAH11	21		3	
59508009	32501	M			3		22	JME01	9	NÆR KONVEKSFORMET RYGGTOPP		

Table A2. Profile descriptions. Part1.

BLR	PROFNR	SJNR	LITH	SBET1	SBET2	OVRE	NEDRE	GSKARP	GFORM	TEKSTUR	GRUS	STEIN	ORG	HUE1	VALUE1	CHROMA1
58006005	32509	1		LFH		-5	0	1	1				24			
58006005	32509	2		O	m	0	13	2	1			5	6	C	2,5	1
58006005	32509	3		B		13	33				1	5		C	4	3
58006006	32508	1		LFH		-6	0	1	1				24			
58006006	32508	2		O	m1	0	12	1	1				6	C	2,5	1
58006006	32508	3		C		12	19	1	4	G				F	3	1
58006006	32508	4		O	m2	19	50	1	1				6	D	2,5	1
58006016	32504	1		LFH		-7	0						24	D	3,1	2
58006016	32505	1		LFH		-3	0	2	2				24			
58006016	32505	2		A	hg	0	10	2	2	E	1	1		D	4	1
58006016	32505	3		AB		10	20			E	1	1		D	3	3
58006016	32505	4		B	f	20	55			E	1	4		C	3,1	4
58007013	32503	1		LFH		-14	-6	1	2				24			
58007013	32503	2		H		-6	0	2	2				22	C	2,1	1
58007013	32503	3		A	hg	0	6	2	2	E	1	1		E	2	1
58007013	32503	4		B	f1	6	19	2	2	E	1	4		C	3	2
58007013	32503	5		B	f2	19	36			J				C	3	1
58007015	32502	1		O	m1	0	11	2	1				4	D	3	1
58007015	32502	2		O	m2	11	25	2	1				7	C	2,5	1
58007015	32502	3		A	hg	25	35	2	1	E	1	3		E	3,1	1
58007015	32502	4		C	g	35	38	1	1	E	1	3		E	5	3
58505008	32506	1		H		-5	0	2	4				22			
58505008	32506	2		O	m1	0	24	2	1			3	6	C	2	1
58505008	32506	3		O	m2	24	48	1	2			3	7	C	1,7	1
58505008	32506	4		C		48	58			E	1	5		E	3	2
58505012	32522	1		O	m	0	35	1	2			6	7	E	1,7	1
58505012	32522	2		O	h?	35	39	2	2			6	15	C	2	1
58505012	32522	3		B	hg	39	50			E	1	6		C	3	2
58505016	32507	2		O	m1	6	30	2	1				5	D	3	1
58505016	32507	3		O	m2	30	93						7	B	2,1	1
58505016	32523	1		F		-2	0	2	1				25			
58505016	32523	2		O	m	0	40	3	2				7	A	1,7	1
58505016	32523	3		B	hg	40	60	1	1	E	1	4		D	4	3
58506001	32513	1		LF		-7	0	1	2			1	24			
58506001	32513	2		H		0	16	2	2		1	5				
58506001	32513	3		A	eg	16	31			B	1	7		E	5	2
58506001	32524	1		O	m	0	13	1	2				7	A	2	1
58506001	32524	2		A	e	13	21	2	1	E	1	2		C	4	2
58506001	32524	3		A	b	21	29	3	1	E	1	2		D	1,7	1
58506001	32524	4		B	f	29	60			E	1	2		D	4	4
58506003	32531	1		A	h	0	3	1	2	E	1	1		D	3	1
58506003	32531	2		B	h1	3	6	1	2	E	1	1		E	2	3
58506003	32531	4		B	h2	8	24							D	3	4

Table A2. Profile descriptions. Part1. (cont.)

BLR	PROFNR	SJNR	LITH	SBET1	SBET2	OVRE	NEDRE	GSKARP	GFORM	TEKSTUR	GRUS	STEIN	ORG	HUE1	VALUE1	CHROMA1
58506004	32535	1		O	f	0	30						2			
58506004	32535	2		O	m	30	110						6	D	3	1
58506005	32527	1		F		-3	0	1	1					C	2	2
58506005	32527	2		O	m	0	4	2	4				7	B	1,7	1
58506005	32527	3		A	e	4	8	2	4	E	1	3		D	4	1
58506005	32527	4		B	h	8	37	2	2	E	1	3		C	1,7	1
58506005	32527	5		B	h	37	60			F	1	3		D	4	4
58506007	32530	1		O	m	0	4						6	C	1,7	1
58506007	32530	2		B	h1	4	7			E	1	1		F	2	1
58506007	32530	3		B	h2	7	16			E	1	1		C	4	2
58506007	32530	4		A	hb	16	19			E	1	1		E	3	1
58506007	32530	5		B	h3	19	27			E	1	1		B	3	1
58506007	32533	1		O	m	0	6	2	1				7	A	1,7	1
58506007	32533	2		B	h	6	18	1	1	E	1	1		C	2	2
58506007	32534	1		O	m	0	16	2	1				7	B	2	1
58506007	32534	2		B		16	29	1	1	E	1	1		D	2	2
58506009	32529	1		F		-5	0	2	1					B	3	2
58506009	32529	2		O	m	0	18	2	1				7	A	1,7	1
58506009	32529	3		B	h	18	28	2	1	E	1	1		B	2	1
58506009	32529	4		O	f	28	35	1	1				8	C	1,7	1
58506010	32528	1		F		-7	0	2	1					E	3	3
58506010	32528	2		O		0	16	1	1					C	1,7	1
58506011	32512	1		O	m	0	19	2	1			4	7	D	3	1
58506011	32512	2		O	h	19	50					5	9	D	3	1
58506013	32510	1		LFH		-9	0	2	2			1	24			
58506013	32510	2		O	m	0	16	1	2			7	6			
58506013	32510	3		A	hg	16	33				2	7				
58506013	32526	1		F		-4	0	1	1			1		F	3	2
58506013	32526	2		O	m	0	22	2	1			1	7	F	1,7	1
58506013	32526	3		A	he	22	27	2	1	E	1	1		G	4	1
58506013	32526	4		B	h	27	43	2	1	E	1	2		C	2	1
58506013	32526	5		B	f	43	53							D	3	4
58506014	32511	1		LFH		-6	0	1	2			6				
58506014	32511	2		A	he	0	11			E	1	6		D	3	1
58506014	32511	3		B	h	11	29			G	1	7		D		
58506014	32525	1		A	h	0	5	3	1	E	2	3		D	2	1
58506014	32525	2		B	m	5	21	1	1	E	2	3		D	3	1
58506016	32519	1		LFH		-5	0	2	2				24	D	5	3
58506016	32519	2		O		0	7	1	2				7	D	2,5	1
58506016	32519	3		A	he	7	23			E	1	1		D	4	1
58507005	32520	1		O	f	0	6	2	1				2	D	4	3
58507005	32520	2		O	m	6	24	3	1				5	D	3	2
58507005	32520	3		O	h	24	35						9	C	2,5	2

Table A2. Profile descriptions. Part1. (cont.)

BLR	PROFNR	SJNR	LITH	SBET1	SBET2	OVRE	NEDRE	GSKARP	GFORM	TEKSTUR	GRUS	STEIN	ORG	HUE1	VALUE1	CHROMA1
58507006	32517	1		LFH		-7	0	2	2				22	C	2,5	1
58507006	32517	2		A	h	0	7			B	1	1		E	4	1
58507007	32514	1		LFH		-7	0	1	2							
58507007	32514	2		A	he	0	9			B	1	7		D	4	1
58507009	32518	1		O	m	0	10	2	1		1	6				
58507009	32518	2		O	f	10	15	1	1			1	9			
58507009	32518	3		A	hg	15	28	2	2	B	1	2				
58507009	32518	4		OC		28	51			B	1	6				
58507009	32521	1		LFH		-9	0	1	2				24			
58507009	32521	2		A	he	0	9	2	2	B	1	1		D	3	1
58507009	32521	3		B	w	9	33	3	2	B	1	1		D	4	1
58507009	32521	4		C		33	41			B	1	5		C	5	2
58507010	32516	1		LFH		-6	0						24			
58507010	32516	2		O	m	0	8	1	2				5	C	3	1
58507010	32516	3		O	h	8	13	1	2				8	E	2	1
58507014	32515	1		LFH		-6	0	2	2				22	C	2,5	1
58507014	32515	2		A	he	0	6			B	1	1		D	3	1
59006016	32532	1		L		-1	0	1	1							
59006016	32532	2		O		0	17	1	1					D	2	2
59006016	32532	3		B	h	17	21	1	1	E	1	1		D	4	3
59508009	32501	1		LFH		-9	0	1	2				22	C	3	2
59508009	32501	2		A	hg	0	13	2	4	E	1	4		D	3	1

Table A2. Profile descriptions. Part2.

BLR	PROFNR	OPPTR	HUE2	VALUE2	CHROMA2	FFMENGDE	FFSTORR	FFKONTR	FFSKARP	FFHUE	FFVALUE	FFCHROMA	STRUKTUR	MERKN	PRØVEANT	Db-prøver	LABKODE
58006005	32509														1	1	1377
58006005	32509														1	1	1378
58006005	32509												9	PRØVER	1	1	1379
58006006	32508														1		1373
58006006	32508														1		1374
58006006	32508												0	NHENGE	1		1375
58006006	32508													SANDKO	1		1376
58006016	32504														1	3	1366
58006016	32505														1	2	1367
58006016	32505												9	SANDKO	1	2	1368
58006016	32505												9	RK	1	2	1369
58006016	32505												9	BEGREN	1	2	1370
58007013	32503													MANGE	1		1361
58007013	32503													INNBLAN	1	2	1362
58007013	32503												9		1	2	1363
58007013	32503														1	3	1364
58007013	32503													STEIN,	1		1365
58007015	32502														2	3	1357
58007015	32502														2	3	1358
58007015	32502													VÅT	1	3	1359
58007015	32502					1	4	2	2	D	4	6		VÅT	1		1360
58505008	32506													E PÅ	1	2	1391
58505008	32506														1	2	1392
58505008	32506														1	2	1393
58505008	32506					2	5	1	2	E	4	2	9	FARGER,	1	2	1394
58505012	32522														1	2	1395
58505012	32522													ORG. C	1	2	1396
58505012	32522					2	3	3	1	D	4	6	9	IG FLERE	1		1397
58505016	32507														1	2	1371
58505016	32507													VANN!	1		1372
58505016	32523														1		1398
58505016	32523														1	2	1399
58505016	32523		D	3	3	1	2	3	2	G	4	3		MED OM	1		1400
58506001	32513														1	2	1388
58506001	32513													BLEKETE	1	2	1389
58506001	32513	5	C	4	2								1	STEIN;	1		1390
58506001	32524														1	2	1401
58506001	32524														1		1402
58506001	32524														1		1403
58506001	32524	1	F	2	2										1	2	1404
58506003	32531														1		1615
58506003	32531														1		1616
58506003	32531					2	3	2	2	D	5	6		STEIN	1		1617

Table A2. Profile descriptions. Part2. (cont.)

BLR	PROFNR	OPPTR	HUE2	VALUE2	CHROMA2	FFMENGDE	FFSTORR	FFKONTR	FFSKARP	FFHUE	FFVALUE	FFCHROMA	STRUKTUR	MERKN	PRØVEANT	Db-prøver	LABKODE
58506004	32535														1		1625
58506004	32535														1		1626
58506005	32527														1		1412
58506005	32527														1		1413
58506005	32527														1		1414
58506005	32527														1	2	1415
58506005	32527	2	C	3	2	2	3	2	2	C	4	6			1		1416
58506007	32530													PROFILE	1		1610
58506007	32530														1		1611
58506007	32530	3	C	1.7	1									ORG.	1	2	1612
58506007	32530														1		1613
58506007	32530													TYNNE	1	2	1614
58506007	32533														1	2	1621
58506007	32533														1	2	1622
58506007	32534														1	2	1623
58506007	32534														1	2	1624
58506009	32529														1		1606
58506009	32529														1	2	1607
58506009	32529														1		1608
58506009	32529														1	2	1609
58506010	32528														1		1604
58506010	32528													STEIN	1		1605
58506011	32512														1	2	1386
58506011	32512													SAND	1	2	1387
58506013	32510														1	2	1380
58506013	32510														1	2	1381
58506013	32510												9	STEIN	1		1382
58506013	32526														1		1407
58506013	32526														1	2	1408
58506013	32526														1		1409
58506013	32526														1	2	1410
58506013	32526					2		1		D	3	2			1		1411
58506014	32511														1		1383
58506014	32511												9	STEIN	1		1384
58506014	32511												9	STEIN	1		1385
58506014	32525														1		1405
58506014	32525														1		1406
58506016	32519		D	3	1										1	2	1594
58506016	32519														1	2	1595
58506016	32519	2	D	3	2								9	NEDERS	1	2	1596
58507005	32520	2	D	3	3									NEDERS	1		1597
58507005	32520													ANN	1		1598
58507005	32520														1		1599

Table A2. Profile descriptions. Part2. (cont.)

BLR	PROFNR	OPPTR	HUE2	VALUE2	CHROMA2	FFMENGDE	FFSTORR	FFKONTR	FFSKARP	FFHUE	FFVALUE	FFCHROMA	STRUKTUR	MERKN	PRØVEANT	Db-prøver	LABKODE
58507006	32517														1	2	1588
58507006	32517	5	D	4	3								9		1	2	1589
58507007	32514														1	2	1581
58507007	32514	2	D	3	3								9	SVART	1		1582
58507009	32518														1		1590
58507009	32518														1		1591
58507009	32518												9		1		1592
58507009	32518													GSSJIKT	1		1593
58507009	32521														1	2	1600
58507009	32521												9	HVITE	1	2	1601
58507009	32521												9		1	2	1602
58507009	32521	5	D	4	2								9	INNIMELL	1		1603
58507010	32516													VEV AV	1	2	1585
58507010	32516													VEV AV	1	2	1586
58507010	32516													LOMMER	1	2	1587
58507014	32515													SANDKO	1	1	1583
58507014	32515												9	BLEIKED	1		1584
59006016	32532														1		1618
59006016	32532														1	2	1619
59006016	32532														1		1620
59508009	32501														2		1355
59508009	32501	1	D	2.5	1	2	5	2	2	D	5	4		MED MYE	2		1356

Table A3. Soil chemistry.

BLR	PROFNR	SJNR	CEC	BS	Exch Ca	Exch Mg	Exch K	Exch Na	totC	totN	C/N	bulk dens
			meq/kg	%	meq/kg	meq/kg	meq/kg	meq/kg	%	%	g/g	g/cm^3
58006005	32509	1	166.5	25.66	10.16	11.66	12.59	8.33	49.54	2.860	17.32	0.115
58006005	32509	2	118.4	16.08	5.42	4.44	4.74	4.44	37.42	2.397	15.61	0.250
58006005	32509	3	29.6	15.94	1.60	0.66	1.20	1.26	4.41	0.313	14.09	1.119
58006006	32508	1	250.8	66.71	95.24	53.42	10.90	7.76	45.81	2.214	20.69	0.085
58006006	32508	2	109.0	17.31	5.96	4.82	3.70	4.38	24.21	1.884	12.85	0.327
58006006	32508	3	22.9	10.88	0.76	0.46	0.36	0.91	3.77	0.290	12.99	0.942
58006006	32508	4	53.8	10.75	2.34	1.00	0.74	1.70	13.79	0.848	16.26	0.547
58006016	32504	1	202.1	41.53	42.90	26.00	6.26	8.78	36.43	2.150	16.94	0.123
58006016	32505	1	99.1	41.14	17.26	12.04	7.50	3.95	18.04	1.165	15.48	0.102
58006016	32505	2	42.6	24.11	1.66	4.34	2.50	1.76	6.19	0.435	14.22	0.751
58006016	32505	3	22.1	13.61	0.86	0.72	0.52	0.91	2.42	0.156	15.48	1.004
58006016	32505	4	16.2	14.81	0.90	0.28	0.28	0.94	1.86	0.111	16.75	1.120
58007013	32503	1	278.6	51.97	80.48	43.36	12.25	8.70	48.55	2.139	22.70	0.132
58007013	32503	2	89.1	11.96	2.14	2.62	2.89	3.00	15.10	0.757	19.95	0.347
58007013	32503	3	48.3	10.99	1.04	1.34	1.25	1.68	6.36	0.362	17.56	0.578
58007013	32503	4	36.0	10.38	0.94	0.76	0.67	1.37	4.55	0.265	17.17	0.737
58007013	32503	5	59.3	10.39	1.78	1.08	0.85	2.45	10.15	0.522	19.44	1.067
58007015	32502	1	196.3	44.37	28.78	26.90	12.79	18.62	49.24	2.358	20.88	0.085
58007015	32502	2	189.2	26.34	15.48	13.74	7.79	12.83	47.80	3.100	15.42	0.168
58007015	32502	3	35.2	13.73	1.24	0.72	0.70	2.18	3.77	0.296	12.74	1.121
58007015	32502	4	22.5	13.29	0.72	0.32	0.32	1.63	2.51	0.192	13.09	1.211
58505008	32506	1	255.1	74.33	86.46	68.50	22.35	12.32	46.61	2.137	21.81	0.113
58505008	32506	2	200.8	83.67	109.96	44.46	2.19	11.42	35.21	2.428	14.50	0.227
58505008	32506	3	122.6	74.95	61.30	22.64	0.73	7.20	24.32	1.484	16.39	0.497
58505008	32506	4	18.8	50.11	5.92	2.08	0.30	1.14	1.49	0.092	16.23	1.481
58505012	32522	1	132.9	21.49	11.58	8.22	4.03	4.72	24.79	1.579	15.70	0.246
58505012	32522	2	43.7	14.48	2.64	0.92	1.08	1.69	7.74	0.375	20.64	0.267
58505012	32522	3	22.5	12.37	0.92	0.38	0.51	0.97	1.86	0.125	14.90	1.238
58505016	32507	2	228.9	69.85	90.62	44.36	4.54	20.37	54.63	3.236	16.88	0.121
58505016	32507	3	354.7	94.47	229.04	83.78	1.97	20.34	57.17	2.769	20.65	0.298
58505016	32523	1	139.7	36.41	9.34	18.16	17.60	5.75	49.90	2.872	17.37	0.342
58505016	32523	2	172.2	14.15	7.84	5.44	4.55	6.53	42.92	2.504	17.14	0.222
58505016	32523	3	17.2	22.49	1.64	0.30	0.58	1.34	2.85	0.212	13.45	1.067
58506001	32513	1	144.0	47.22	30.94	23.80	9.21	4.04	29.38	1.317	22.31	0.184
58506001	32513	2	92.3	19.73	5.12	6.06	4.45	2.58	14.11	0.746	18.91	0.633
58506001	32513	3	20.1	9.86	0.46	0.46	0.48	0.58	1.24	0.089	13.90	0.903
58506001	32524	1	219.6	66.07	65.36	64.74	7.00	7.98	34.20	1.599	21.39	0.196
58506001	32524	2	26.0	17.34	1.64	1.40	0.52	0.95	1.93	0.115	16.77	0.903
58506001	32524	3	75.9	8.56	2.88	1.46	0.62	1.54	4.75	0.232	20.46	0.903
58506001	32524	4	45.1	7.16	1.44	0.54	0.38	0.87	2.99	0.127	23.50	1.117

Table A3. Soil chemistry.

BLR	PROFNR	SJNR	CEC	BS	Exch Ca	Exch Mg	Exch K	Exch Na	totC	totN	C/N	bulk dens
			meq/kg	%	meq/kg	meq/kg	meq/kg	meq/kg	%	%	g/g	g/cm^3
58506003	32531	1	57.4	31.05	4.46	10.38	2.33	0.66	4.80	0.366	13.12	0.903
58506003	32531	2	53.6	15.11	1.80	4.86	0.74	0.70	1.95	0.156	12.50	1.067
58506003	32531	4	60.9	9.94	1.36	3.04	0.83	0.82	2.81	0.199	14.13	1.067
58506004	32535	1	249.5	18.94	29.00	12.38	1.59	4.28	53.80	2.484	21.66	0.298
58506004	32535	2	460.9	33.78	99.08	41.64	4.81	10.13	52.29	1.103	47.41	0.298
58506005	32527	1	244.5	74.32	104.74	55.24	11.45	10.29	42.36	1.621	26.13	0.342
58506005	32527	2	259.6	67.38	85.80	71.04	8.80	9.30	46.33	2.089	22.18	0.298
58506005	32527	3	19.5	23.71	1.78	1.64	0.41	0.80	2.10	0.125	16.77	0.903
58506005	32527	4	62.4	10.91	2.70	2.06	0.71	1.34	9.40	0.453	20.75	0.826
58506005	32527	5	33.9	10.40	1.22	0.58	0.50	1.23	2.16	0.142	15.20	1.067
58506007	32530	1	122.2	22.31	5.48	8.40	10.21	3.16	27.33	1.860	14.69	0.298
58506007	32530	2	37.0	12.58	1.08	1.64	1.08	0.85	4.69	0.365	12.84	1.067
58506007	32530	3	22.3	9.46	0.68	0.60	0.41	0.42	2.57	0.216	11.91	1.106
58506007	32530	4	21.4	10.75	0.74	0.44	0.32	0.80	2.26	0.176	12.81	0.903
58506007	32530	5	20.2	8.91	0.66	0.38	0.20	0.56	3.91	0.290	13.48	0.907
58506007	32533	1	82.2	15.06	3.38	4.26	2.90	1.84	18.99	1.107	17.15	1.220
58506007	32533	2	32.8	5.98	0.52	0.32	0.31	0.81	3.24	0.195	16.64	1.460
58506007	32534	1	159.8	36.93	22.64	22.20	9.35	4.82	40.90	2.469	16.57	0.269
58506007	32534	2	36.7	8.07	1.00	0.88	0.44	0.64	4.90	0.344	14.25	1.054
58506009	32529	1	275.4	65.83	115.22	47.58	12.21	6.30	51.02	2.076	24.58	0.342
58506009	32529	2	158.9	39.52	25.38	22.40	8.72	6.29	31.23	1.793	17.42	0.478
58506009	32529	3	33.7	7.04	0.72	0.66	0.30	0.69	4.92	0.252	19.52	1.067
58506009	32529	4	87.3	7.35	2.08	1.62	0.56	2.16	23.11	1.163	19.87	0.527
58506010	32528	1	214.1	49.92	18.12	60.38	19.46	8.91	37.32	2.334	15.99	0.342
58506010	32528	2	434.4	78.20	215.52	87.42	30.98	5.74	53.39	2.396	22.28	0.298
58506011	32512	1	202.8	36.58	24.38	27.70	12.51	9.57	56.56	2.788	20.29	0.199
58506011	32512	2	180.4	17.57	11.38	9.28	3.20	7.83	59.47	1.763	33.73	0.189
58506013	32510	1	281.6	44.89	59.90	37.36	19.60	9.57	45.07	1.799	25.05	0.102
58506013	32510	2	170.0	20.78	8.60	10.38	10.38	5.97	45.05	2.658	16.95	0.177
58506013	32510	3	31.1	9.70	1.04	0.56	0.51	0.91	4.09	0.263	15.57	0.903
58506013	32526	1	272.3	58.65	84.66	52.48	13.28	9.28	52.70	2.458	21.44	0.342
58506013	32526	2	235.1	31.12	30.00	29.04	6.00	8.11	51.04	2.359	21.64	0.192
58506013	32526	3	37.3	8.34	1.14	0.82	0.22	0.93	2.56	0.146	17.52	0.903
58506013	32526	4	61.6	10.80	2.62	2.02	0.67	1.34	5.14	0.260	19.78	1.197
58506013	32526	5	29.1	7.12	0.80	0.24	0.30	0.73	1.83	0.089	20.51	1.067
58506014	32511	1	343.0	78.57	163.56	80.22	18.28	7.43	51.70	2.257	22.91	0.339
58506014	32511	2	72.4	30.89	11.14	6.88	2.57	1.76	9.24	0.423	21.83	0.570
58506014	32511	3	68.9	12.81	3.16	1.64	1.93	2.10	19.69	1.114	17.68	1.067

Table A3. Soil chemistry.

BLR	PROFNR	SJNR	CEC	BS	Exch Ca	Exch Mg	Exch K	Exch Na	totC	totN	C/N	bulk dens
			meq/kg	%	meq/kg	meq/kg	meq/kg	meq/kg	%	%	g/g	g/cm^3
58506014	32525	1	64.3	15.25	3.96	2.12	1.85	1.88	10.21	0.674	15.15	0.903
58506014	32525	2	44.9	13.42	1.76	1.64	1.34	1.29	6.51	0.475	13.70	1.067
58506016	32519	1	342.7	66.53	136.74	62.98	20.77	7.53	51.80	2.768	18.71	0.075
58506016	32519	2	296.3	47.45	56.54	60.56	15.09	8.40	48.85	3.214	15.20	0.218
58506016	32519	3	31.0	11.26	1.18	0.94	0.40	0.97	2.56	0.199	12.88	1.035
58507005	32520	1	514.4	23.21	33.42	31.68	23.26	31.01	48.76	1.101	44.29	0.298
58507005	32520	2	187.3	28.66	19.72	19.64	5.45	8.86	56.53	2.890	19.56	0.298
58507005	32520	3	292.4	33.78	47.18	33.34	2.17	16.08	61.89	1.463	42.30	0.298
58507006	32517	1	251.9	36.05	43.72	24.28	16.11	6.71	51.16	2.623	19.50	0.185
58507006	32517	2	36.3	18.99	3.32	1.50	1.13	0.94	4.09	0.371	11.02	0.919
58507007	32514	1	286.0	41.78	70.48	28.06	14.29	6.65	46.41	1.636	28.37	0.207
58507007	32514	2	34.1	12.93	1.52	1.16	1.11	0.62	4.17	0.268	15.56	0.903
58507009	32518	1	152.4	20.58	9.20	9.82	8.82	3.52	52.10	3.567	14.61	0.220
58507009	32518	2	137.3	7.91	4.28	2.52	1.15	2.91	46.65	2.707	17.23	0.310
58507009	32518	3	16.0	6.25	0.32	0.14	0.16	0.38	1.23	0.085	14.46	1.262
58507009	32518	4	17.8	5.41	0.36	0.10	0.12	0.38	2.56	0.134	19.11	1.110
58507009	32521	1	197.7	22.01	19.00	9.32	10.33	4.87	37.49	1.830	20.49	0.131
58507009	32521	2	33.5	16.29	1.54	1.18	1.67	1.06	5.66	0.317	17.86	0.643
58507009	32521	3	18.4	16.62	1.42	0.44	0.50	0.69	2.05	0.126	16.29	1.092
58507009	32521	4	14.8	31.85	3.08	0.30	0.51	0.83	1.09	0.088	12.40	1.211
58507010	32516	1	243.2	28.46	31.62	18.44	12.11	7.05	52.20	3.125	16.70	0.101
58507010	32516	2	202.8	24.47	14.42	14.46	14.97	5.79	52.74	3.155	16.72	0.203
58507010	32516	3	132.9	16.05	8.14	5.24	4.92	3.03	32.07	1.675	19.15	0.373
58507014	32515	1	113.6	25.89	15.04	6.88	5.34	2.16	26.98	1.662	16.23	0.212
58507014	32515	2	21.4	17.33	1.08	1.16	0.91	0.56	4.50	0.373	12.07	0.903
59006016	32532	1	54.8	84.49	32.68	8.84	4.29	0.50	57.48	2.190	26.25	0.320
59006016	32532	2	452.5	36.18	71.04	62.42	19.66	10.61	47.99	1.883	25.49	0.220
59006016	32532	3	51.8	8.25	0.84	1.00	1.33	1.10	4.16	0.151	27.54	1.067
59508009	32501	1	348.5	55.93	131.70	33.46	16.98	12.77	50.66	1.717	29.50	0.101
59508009	32501	2	46.8	10.88	1.70	0.68	0.82	1.89	5.52	0.213	25.93	1.061

Table B4. Soil physical characteristics.

Soil physical parameters determined at NISK (bulk density) and at IJVF (particle size distribution)
Texture analysis (sand (60 - 2000 um), silt (2 - 60 um), clay (< 2um)) determined in selected samples o

NISK lab code	Profile	Dybde ID	Horizon	bulk dens. (g/cm3)	>2mm % of bulk	sand	silt	clay
						<---------% fine earth------------->		
1355	JME01	1	LFH	0.10	************	************	************	************
1356	JME01	2	Ahg	1.06	************	************	************	************
1357	JME02	1	O1	0.08	************	************	************	************
1358	JME02	2	O2	0.17	************	************	************	************
1359	JME02	3	Ahg	1.12	************	************	************	************
1362	JME03	2	H	0.35	************	************	************	************
1363	JME03	3	Ah	0.58	************	************	************	************
1364	JME03	4	Bf1	0.76	21.0	73.0	24.8	2.1
1366	JME04	1	LFH	0.12	************	************	************	************
1367	JME05	1	LFH	0.10	************	************	************	************
1368	JME05	2	Ah	0.75	************	************	************	************
1369	JME05	3	AB	1.00	11.0	83.0	14.5	2.4
1370	JME05	4	Bf	1.12	34.0	85.5	12.9	1.7
1371	JME07	2	O2	0.12	************	************	************	************
1373	JME08	1	LFH	0.09	************	************	************	************
1374	JME08	2	O	0.33	************	************	************	************
1375	JME08	3	C	0.94	************	************	************	************
1376	JME08	4	O	0.55	************	************	************	************
1377	JME09	1	LFH	0.12	************	************	************	************
1378	JME09	2	O	0.25	************	************	************	************
1379	JME09	3	B	1.12	38.0	65.0	25.2	9.9
1380	JME10	1	LFH	0.10	************	************	************	************
1381	JME10	2	O	0.18	************	************	************	************
1383	JME11	1	LFH	0.34	************	************	************	************
1384	JME11	2	Ahe	0.57	************	************	************	************
1386	JME12	1	O1	0.20	************	************	************	************
1387	JME12	2	O2	0.19	************	************	************	************
1388	JME13	1	LFH	0.18	************	************	************	************
1389	JME13	2	H	0.63	************	************	************	************
1391	SYB01	1	H	0.11	************	************	************	************
1392	SYB01	2	O1	0.23	************	************	************	************
1393	SYB01	3	O2	0.50	************	************	************	************
1394	SYB01	4	C	1.48	************	************	************	************
1395	JAH01	1	O1	0.25	************	************	************	************
1396	JAH01	2	O2	0.27	************	************	************	************
1397	JAH01	3	Bhg	1.24	28.0	82.8	15.4	1.8
1399	JAH02	2	O	0.22	************	************	************	************
1401	JAH03	1	O	0.25	************	************	************	************
1404	JAH03	4	Bf	1.12	34.0	74.4	23.9	1.9
1408	JAH05	2	O	0.19	************	************	************	************
1410	JAH05	4	Bh	1.20	35.0	66.9	24.3	8.9
1415	JAH06	4	Bh	0.83	23.0	86.9	11.5	1.6
1581	JME14	1	LFH	0.21	************	************	************	************
1583	JME15	1	LFH	0.21	************	************	************	************
1585	JME16	1	LFH	0.10	************	************	************	************
1586	JME16	2	O1	0.20	************	************	************	************
1587	JME16	3	O2	0.37	************	************	************	************
1588	JME17	1	LFH	0.18	************	************	************	************
1589	JME17	2	Ab	0.92	************	************	************	************

1590	JME18	1	O1	0.22	************	************	************	************
1591	JME18	2	O2	0.31	************	************	************	************
1592	JME18	3	Ahg	1.26	************	************	************	************
1594	JME20	1	LFH	0.07	************	************	************	************
1595	JME20	2	OH	0.22	************	************	************	************
1596	JME20	3	Ahe	1.04	************	************	************	************
1600	JME22	1	LFH	0.13	************	************	************	************
1601	JME22	2	Ahe	0.54	************	************	************	************
1602	JME22	3	Bw	1.09	19.0	86.8	12.0	1.3
1607	JAH08	2	O	0.48	************	************	************	************
1609	JAH08	4	Ob	0.53	************	************	************	************
1612	JAH09	3	Bh2	1.11	14.0	85.9	12.4	1.8
1614	JAH09	5	Bh3	0.91	17.0	86.1	12.6	1.4
1619	JAH11	2	O	0.22	************	************	************	************
1621	JAH12	1	O	1.22	************	************	************	************
1622	JAH12	2	Bh	1.46	35.0	77.4	21.3	1.4
1623	JAH13	1	O	0.27	************	************	************	************
1624	JAH13	2	B	1.05	20.0	76.1	22.3	1.6

Appendix B. Input data for MAGIC 5.01

Table B1. Water chemistry and deposition data

	surface water chemistry											discharge	deposition		
BLR	ph	Ca	Mg	Na	K	Cl	SO4	NO3	alk	Al	H+	Q	NO3/SO4	NH4/SO4	CA/SO4
		µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	µeq/l	m	eq/eq	eq/eq	eq/eq
58006005	-99	25.0	47.7	180.5	4.4	217.2	97.9	35.7	-99	-99	-99	1.577	0.824	0.798	0.147
58006006	-99	25.0	47.7	180.5	4.4	217.2	97.9	37.5	-99	-99	-99	1.577	0.824	0.798	0.147
58006016	-99	124.8	92.1	315.4	16.1	366.7	158.2	25.7	-99	-99	-99	0.946	0.824	0.798	0.147
58007013	-99	62.9	60.9	208.8	10.5	242.6	124.9	9.6	-99	-99	-99	1.104	0.821	0.762	0.136
58007015	-99	99.8	66.6	201.8	15.9	220.0	141.6	23.9	-99	-99	-99	1.104	0.821	0.762	0.136
58505008	-99	74.9	56.0	190.1	10.5	228.5	83.3	11.4	-99	-99	-99	1.419	0.849	1.339	0.194
58505012	-99	54.9	52.7	160.9	15.6	200.3	72.9	17.9	-99	-99	-99	1.735	0.849	1.339	0.194
58505016	-99	35.9	58.4	226.2	5.6	186.2	75.0	10.7	-99	-99	-99	1.419	0.849	1.339	0.194
58506001	-99	34.9	39.5	157.5	4.4	186.2	60.4	7.2	-99	-99	-99	1.892	0.691	0.768	0.228
58506003	-99	8.5	-99	-99	-99	62.1	37.5	11.9	-99	-99	-99	2.839	0.691	0.768	0.228
58506004	-99	15.0	13.2	44.4	4.6	48.0	43.7	9.9	-99	-99	-99	1.577	0.691	0.768	0.228
58506005	-99	28.9	34.6	127.9	2.8	143.9	56.2	4.3	-99	-99	-99	2.366	0.691	0.768	0.228
58506007	-99	13.0	15.6	53.5	2.8	64.9	41.6	10.7	-99	-99	-99	2.523	0.691	0.768	0.228
58506009	-99	34.4	48.6	166.2	3.3	197.5	72.9	14.1	-99	-99	-99	2.208	0.691	0.768	0.228
58506010	-99	22.0	29.6	106.1	3.6	124.1	52.1	14.6	-99	-99	-99	2.839	0.691	0.768	0.228
58506011	-99	13.5	21.4	87.0	3.3	95.9	45.8	13.6	-99	-99	-99	1.892	0.691	0.768	0.228
58506013	-99	36.9	37.0	152.2	3.8	191.8	79.1	21.1	-99	-99	-99	1.892	0.691	0.768	0.228
58506014	-99	17.0	27.2	91.3	3.3	115.7	64.5	13.9	-99	-99	-99	2.208	0.691	0.768	0.228
58506016	-99	17.0	23.1	75.7	7.2	81.8	66.6	11.6	-99	-99	-99	1.892	0.691	0.768	0.228
58507005	-99	10.0	8.2	30.0	2.6	28.2	43.7	14.0	-99	-99	-99	1.735	0.671	0.671	0.182
58507006	-99	15.0	10.7	35.2	2.6	36.7	47.9	10.5	-99	-99	-99	1.577	0.671	0.671	0.182
58507007	-99	21.5	12.3	31.3	3.8	31.0	64.5	9.1	-99	-99	-99	1.262	0.671	0.671	0.182
58507009	-99	15.0	13.2	44.8	3.6	50.8	50.0	10.7	-99	-99	-99	1.892	0.671	0.671	0.182
58507010	-99	15.0	66.7	201.8	15.9	33.9	52.1	11.4	-99	-99	-99	1.577	0.671	0.671	0.182
58507014	-99	15.0	12.3	38.3	3.3	45.1	58.3	17.9	-99	-99	-99	1.419	0.671	0.671	0.182
59006016	-99	10.5	10.7	40.5	1.8	48.0	29.2	9.6	-99	-99	-99	1.892	0.691	0.768	0.228
59508009	-99	44.9	9.9	17.8	2.1	16.9	50.0	3.4	-99	-99	-99	0.789	0.742	0.653	0.135

Table B2. Soil chemistry

	soil 1							soil 2							uptake		
BLR	depth1	bulk dens1	CEC1	Ca1	Mg1	Na1	K1	depth2	bulk dens2	cec2p	Ca2	Mg2	Na2	K2	Ca-upt	Mg-upt	K-upt
	m	kg/m^3	meq/kg	%	%	%	%	m	kg/m^3	meq/kg	%	%	%	%	meq/m^2/yr		
58006005	0.38	689.3	43.7	5.18	3.14	4.15	4.33	0	0	0	0	0	0	0	0	0	0
58006006	0.50	493.7	58.4	7.56	4.36	3.50	2.26	0.06	546.5	53.8	4.35	1.86	3.16	1.38	0	0	0
58006016	0.33	553.2	111.7	13.17	8.69	4.67	3.09	0	0	0	0	0	0	0	0	0	0
58007013	0.50	686.5	60.2	6.50	4.00	3.81	2.18	0	0	0	0	0	0	0	0	0	0
58007015	0.38	476.8	60.9	7.22	6.03	7.05	3.55	0	0	0	0	0	0	0	0	0	0
58505008	0.50	328.8	153.0	51.15	20.54	5.73	1.28	0.13	1253.5	28.3	38.78	13.98	5.98	1.20	0	0	0
58505012	0.50	465.5	64.2	7.69	5.14	3.72	2.86	0	0	0	0	0	0	0	0	0	0
58505016	0.50	287.4	209.2	32.40	13.18	5.25	2.04	0.25	682.5	185.9	37.06	12.68	6.77	1.97	0	0	0
58506001	0.49	758.3	55.6	7.87	7.10	2.60	2.96	0	0	0	0	0	0	0	0	0	0
58506003	0.22	1044.6	59.4	3.01	7.00	1.32	1.67	0	0	0	0	0	0	0	0	0	0
58506004	0.50	298.0	334.0	17.07	7.21	1.98	0.86	0.60	298.0	460.9	21.50	9.04	2.20	1.04	0	0	0
58506005	0.50	808.8	61.5	11.81	8.15	2.80	1.85	0.13	1067.0	33.9	3.60	1.71	3.63	1.47	0	0	0
58506007	0.25	967.0	47.3	5.21	5.27	2.43	3.12	0	0	0	0	0	0	0	0	0	0
58506009	0.40	616.6	102.1	17.10	11.39	3.18	4.01	0	0	0	0	0	0	0	0	0	0
58506010	0.23	311.4	360.7	41.45	21.73	1.88	7.52	0	0	0	0	0	0	0	0	0	0
58506011	0.50	192.3	189.2	8.71	8.73	4.50	3.62	0	0	0	0	0	0	0	0	0	0
58506013	0.50	577.5	69.7	8.98	6.93	3.03	3.27	0	0	0	0	0	0	0	0	0	0
58506014	0.28	907.0	69.5	11.62	6.58	2.79	3.30	0	0	0	0	0	0	0	0	0	0
58506016	0.28	659.2	59.2	14.34	12.03	2.90	3.42	0	0	0	0	0	0	0	0	0	0
58507005	0.35	298.0	276.4	11.11	9.41	5.40	2.70	0	0	0	0	0	0	0	0	0	0
58507006	0.14	551.8	72.3	13.93	7.34	2.63	5.02	0	0	0	0	0	0	0	0	0	0
58507007	0.16	598.5	72.2	16.55	7.24	2.12	4.30	0	0	0	0	0	0	0	0	0	0
58507009	0.50	874.2	26.2	6.32	2.75	2.92	2.97	0	0	0	0	0	0	0	0	0	0
58507010	0.19	215.2	177.0	7.97	6.13	2.67	5.63	0	0	0	0	0	0	0	0	0	0
58507014	0.12	557.5	38.9	9.59	5.77	2.22	4.50	0	0	0	0	0	0	0	0	0	0
59006016	0.22	378.2	231.6	14.48	12.45	2.31	4.17	0	0	0	0	0	0	0	0	0	0
59508009	0.22	668.5	65.4	14.88	4.14	3.92	2.78	0	0	0	0	0	0	0	0	0	0

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