SVERIGES
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SOILN model
User's Manual

Input files | Switches | Parameters | Outputs | Execute

Technical
Model specific

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Table of Contents

1 Background

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The SOILN model is a model which considers all major N-flows in agricultural and certain forest soils. The model can conceptually be divided into three submodels: the soil submodel, the crop submodel and the forest submodel. The soil submodel (which actually is the largest and the central part of the model) is described in detail by Johnsson et al. (1987) (Fig. 1). Other papers dealing with applications to different fields are found in the reference list.

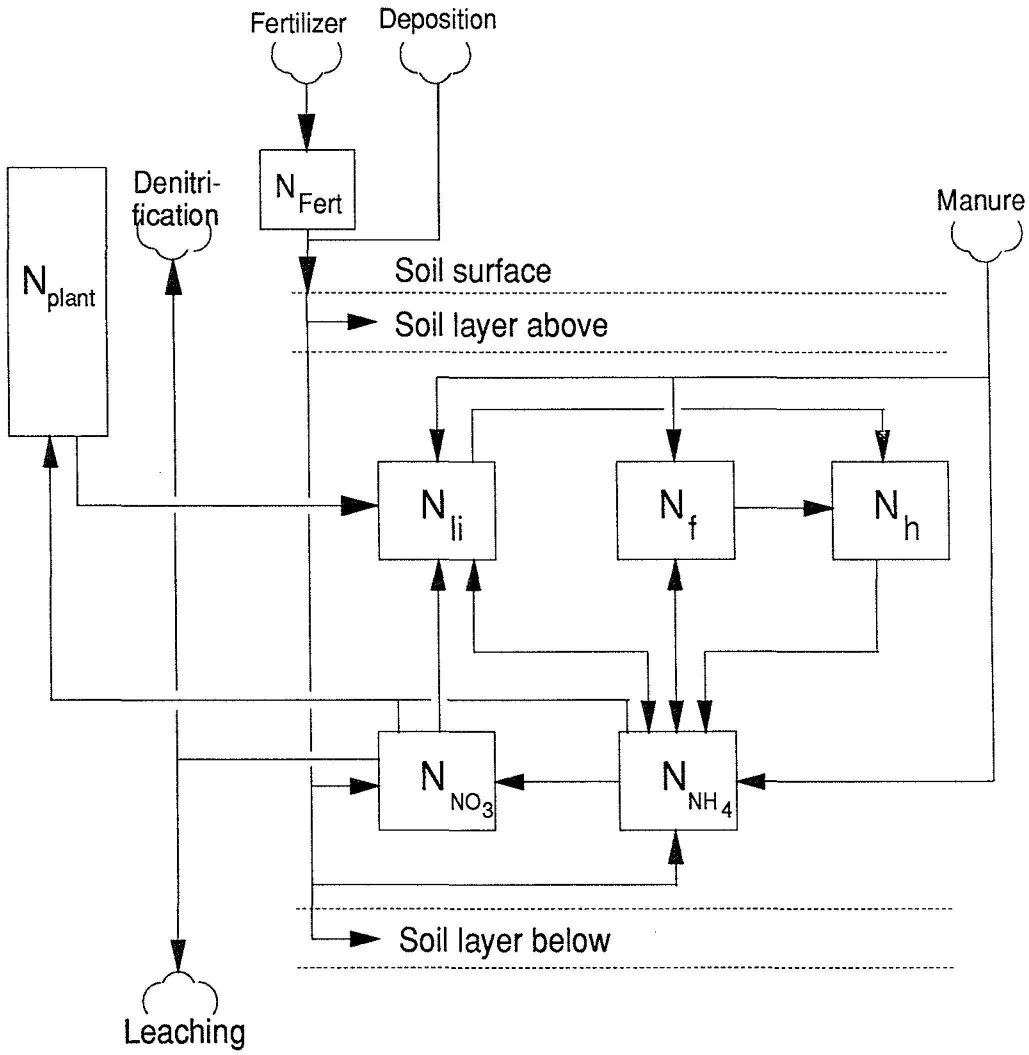


Figure 1. An approximate schematic description of the nitrogen flows and states of the soil part of the SOILN model. N denotes nitrogen and subscripts are as follows: f = faeces, Fert = fertilizer, h = humus, li = litter, NH_4 = ammonium an NO_3 = nitrate.

SOILN has been extended with a crop growth submodel (named CROP; Eckersten & Jansson, 1991), describing plant growth and nitrogen uptake demand as a function of meteorological variables. The submodel can be used as a substitute to the time-dependent empirical plant uptake function of the soil submodel (Fig. 2).

Futhermore, a growth submodel for short-rotation forests (named FORESTSR) is available in the same manner as is the crop growth submodel. The submodel originates from another model for willow growth named WIGO which is described by Eckersten (1991a) and Eckersten & Slapokas (1990). The formulas related to the plant in those descriptions are valid also for the FORESTSR submodel (Fig. 3).

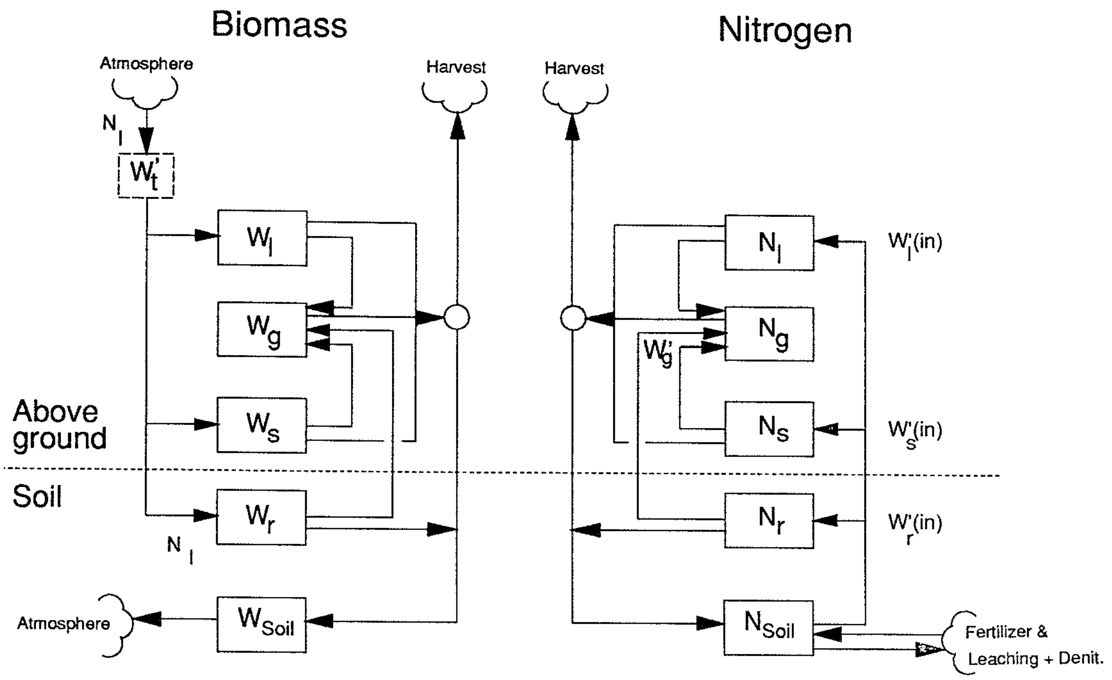


Figure 2. An approximate schematic description of the biomass and nitrogen flows and states of the CROP-submodel of SOILN model. W and N denote biomass and nitrogen. Subscriptes are as follows: l = leaf, g = grain, r = root, s = stem and t = total. The symbols outside boxes indicate how the biomass and nitrogen dynamics interact. Prime sign denotes a daily change.

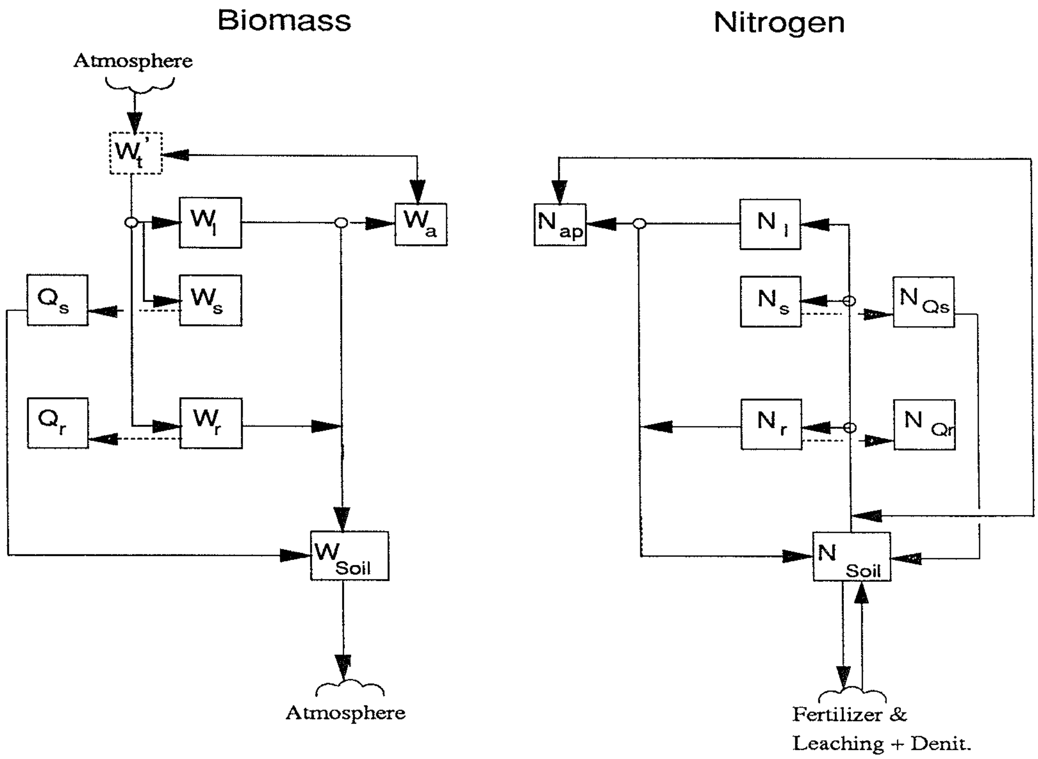


Figure 3. An approximate schematic description of the biomass and nitrogen flows and states of the FORESTSR-submodel of SOILN model. W, Q and N denote young biomass, old biomass and nitrogen, respectively. Subscriptes are as follows: a = available, l = leaf, r = root, s = stem and t = total. Dotted lines represent annual flows.

The SOILN model requires driving variables on soil heat and water conditions. These variables are simulated by the associated model named SOIL (Jansson & Halldin, 1979).

This manual is linked with the theoretical descriptions through the symbol given directly after the parameter or variable name or the equation numbers given.

2 Getting started

2.1 Installation

The model is normally distributed together with the SOIL model on a special floppy diskette for IBM/PC. Two different installation diskettes can be used depending on whether you are a previous user of the PGraph program or not.

SOIL — requires that the Pgraph program is installed on your computer.

SOILDEMO — contains a demo version of Pgraph called PGDEMO that can be used for testing and using the SOIL model with the supplied data files.

Independent of which diskette you have got you will use the same command for installation which is found on the diskette:

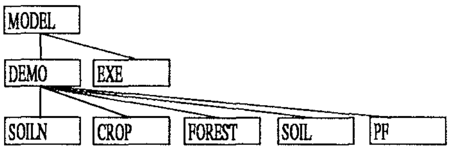
Type the command: `A:INSTALL A: C: MODEL`

This means that you have inserted the diskette into a floppy disk drive named A: and you want to install the model on your hard disk C: in the directory named MODEL. If you already have a directory with that name you should choose another name at the installation.

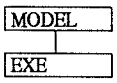
In addition to the SOILN model also files for running the SOIL model are included on the distribution diskette.

2.2 Files

The installation procedure will create one main directory below which the program files are stored in different subdirectories. The executable files are placed in the subdirectory named EXE and sample files in subdirectory DEMO.



Directory	Files	Description



Files	Description
SOILN.EXE	Executable file, SOILN model
SOILN.DEF	Definition file, SOILN model
SOILN.HLP	Help file, SOILN model
SOILN.TRA	Variable name translation file, SOILN
SOILNFOR.TRA	Variable name translation file, SOILN, special for the FORESTSR submodel
PREP.EXE	Executable file, PREP program
PGDEMO.EXE	Executable file, Pgraph program (only if the SOILDEMO diskette is used)
PG.HLP	Help file, Pgraph program (only if the SOILDEMO diskette is used)
SOIL.EXE	Executable file, SOIL model
SOIL.DEF	Definition file, SOIL model
SOIL.HLP	Help file, SOIL model
SOIL.TRA	Variable name translation file, SOIL
PLOTPF.EXE	Executable file, PLOTPF program
PLOTPF.HLP	Help file, PLOTPF program

MODEL
DEMO
SOILN

DEMO.BAT	Demo file for running the SOILN model and using the PG program for visualizing some results on the screen.
DEMO_F.INI	Initial conditions for running the SOILN model.
DEMO_F.PAR	Parameter file for simulating nitrogen dynamics of a short rotation forest.
DEMO_SOI.PAR	An extra parameter file including changes of DEMO_F.PAR so as to give outputs suitable for the soil presentations.
DEMOXXXX.PG	Input files for the PG program used in the DEMO.BAT file for showing results from the simulation.
DEMO_FF.BIN	PG-file with climatic driving variables for running the SOILN model. The same as DEMO_F.BIN but comprising a shorter period.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILP.DAT	File with soil hydraulic properties.

MODEL
DEMO
CROP

DEMO.BAT	Demo file for running the SOILN model using the CROP submodel and with help of the PG program visualizing some results on the screen.
DEMO_C.INI	Initial conditions for running the SOILN model.
DEMO_C.PAR	Parameter file for simulating nitrogen dynamics of an agricultural crop during a growing season.
DEMO_CHA.PAR	An extra parameter file including changes of DEMO_C.PAR.
DEMOXXXX.PG	Instruction files for the PG program used in the DEMO.BAT file when showing results from the simulation.
DEMO_C.BIN	PG-file with climate data for running the SOILN model.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.
SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILP.DAT	File with soil hydraulic properties.

MODEL
DEMO
FOREST

DEMO.BAT	Demo file for running the SOILN model using the FORESTSR submodel and with help of the PG program visualizing some results on the screen.
DEMO_F.INI	Initial conditions for running the SOILN model.
DEMO_F.PAR	Parameter file for simulating nitrogen dynamics of a short-rotation forest.
DEMO_CHA.PAR	An extra parameter file including changes of DEMO_F.PAR.
DEMOXXXX.PG	Input files for the PG program used in the DEMO.BAT file for showing results from the simulation.
DEMO_F.BIN	PG-file with climatic driving variables for running the SOILN model.
DEMOZXXX.BIN	Files with modified output variables from the simulation examples aimed to be plotted on screen.

SOILNXXX.BIN SOILNXXX.SUM	Files with output variables from the simulation examples.
SOILNFOR.AUT	Annual values of accumulated flows (ASCII)
SOILP.DAT	File with soil hydraulic properties.

MODEL
DEMO
SOIL

DEMO.BAT	Demo file for running the SOIL model and using the PG program for visualizing some results on the screen.
CLIMATE.BIN	PG-file with climate data for running the model.
SOILP.DAT CLAY.DAT SAND.DAT	Files with soil hydraulic properties.
THCOEF.DAT	Files with soil thermal properties.
SITEPROF.DBA SITEPROF.DBB	Data base with soil physical properties from some selected sites. Use the PLOTPF program to investigate the soils in the data base and to create new data sets with soil physical properties.
ANASOL.PAR	Parameter file for simulating the daily variation of soil temperature in a homogeneous soil profile.
FROST.PAR	Parameter file for simulating the behaviour of a freezing and thawing of the soil.
EVAPO.PAR	Parameter file for simulating the water balance of an agricultural crop during a growing season using climate data from the CLIMATE.BIN file.
YEAR.PAR	Parameter file for simulating the annual course of water and heat flow in an agricultural soil using climate data from the CLIMATE.BIN file.
DRIVN.PAR	Parameter file for creating a driving variable file for the SOILN model.
INFSAND.PAR INFCLAY.PAR	Parameter files for simulating infiltration and redistribution of water in homogeneous soil profiles.
DEMO_S.IN PF.IN	Input files for Pgraph and PlotpF. Used in the DEMO.BAT file.

MODEL
DEMO
PF

PFPROF.DBA PFPROF.DBB	Swedish data base with soil physical properties. Use the PLOTPF program to investigate the soils in the data base and to create new data sets with soil physical properties.
MXX.PFN	Comments to the SOIL physical properties from a site XX.

2.3 Running the model

Before running the model you must make sure that the model and utility programs are correctly installed on your computer. The subdirectory called EXE created by the installation procedure may be renamed or the file may be moved to another directory but it is important that PATH is set to the directory where all the files of the EXE directory is stored. After setting this PATH (most conveniently in the AUTOEXEC.BAT file. OBS! the address to SOILNXXX.TRA file in the XXXXXX.PAR files must also be changed) you can run the model by using the sample files in the DEMO subdirectories.

The DEMO.BAT file will be a good test of the installation and it will also show a number of results without any other efforts than running the DEMO.BAT file.

For running the program interactively use commands as specified in the section on Commands.

```
PREP SOILN DEMO
```

Is an example of how you can make your own simulation based on information in the DEMO.PAR file.

2.4 Evaluating your simulation

A successful simulation will result in two different output files numbered as nnn :

SOILNnnn.SUM Contains a summary of simulation results.

SOILNnnn.BIN A binary file comprising output variables from the simulation. You start the Pgraph program by typing:

```
PG SOILNnnn   or   PGDEMO SOILNnnn
```

For details on how to use Pgraph see the Pgraph manual or use the help utility in the program (F1 key).

Another file created by the PREP program the first time you run the model in a certain directory is:

SOIL.STA which includes information about your run number. This file could not be listed but the numbering of a run can be modified by the PREP program (see section 8 Run options)

3 Program structure

The preparation of the model prior to a run follows an interactive dialogue where the user has the possibility to design the run according to the present purpose.

The different menus can be reached in any order after moving the cursor to the subject using arrow keys and pressing "return" at the chosen subject. "Return" takes the cursor down in the menus and "Esc" moves the cursor up one level. Normally a user will start with the subjects to the left in the main menu and move to the right. It is a good rule to modify the settings of switches and input files before moving to the other menus since the content of the other menus are influenced by the setting of the two first sub menus.

4 Input files

4.1 Driving variable file

XXXXXX.BIN: A driving variable file is always a PG-file. The variables in the PG-file can be organized in different ways depending on how different parameters are specified. The driving variables for the SOILN model is generated by the SOIL model. The file should consist of the following variables:

Variable (#)	Explantation	Name in the SOIL model	Unit
1 : N-1	Vertical water flow	WFLOW	(mm/day)
N	Infiltration to soil	INFIL	(mm/day)
N+1 : 2*N	Drainage flow	DFLOW	(mm/day)
2*N+1	Infiltration to soil	SPOOLINF	(mm/day)
2*N+2	Surface runoff	SURR	(mm/day)
2*N+3 : 3*N+2	Soil temperature	TEMP	(°C)
3*N+3 : 4*N+2	Soil water content	THETA	(vol %)
4*N+3	Actual/potential transpiration	ETR	(-)
4*N+4	Groundwater percolation	PERC	(mm/day)
4*N+5	Excess surface runoff	SURRE	(mm/day)
4*N+6	Air temperature	TA	(°C)
4*N+7	Global radiation	RIS	(Jm2/day)
4*N+8	Measured N-conc in tiles		(mg/l)

N is the number of layers in your simulation and this number must correspond to the value of the NUMLAY paramater (See soil profile)

4.2 Parameter file

XXXXXX.PAR: The parameter file is an ordinary DOS-file with ASCII- characters. All parameters with actual numerical values should be included in the file. If any parameter is missing in the file an message is displayed on the screen and a default value of zero is selected. New parameter files may be created prior the execution of the model using the WRITE command (see EXECUTION WRITE).

4.3 Translation file

SOILN.TRA: A translation file have to exist if the variables in the output PG-file should get their correct identifications. Only when the OUTFORN switch is ON this file is not necessary.

SOILNFOR.TRA: A special translation file (a modification of SOILN.TRA) which should be used when the FORESTSR switch is ON.

4.4 Initial states file

XXXXXX.INI: The file contains the initial values of all state variables.

4.5 Final states file

This file contains the final values of all state variables.

4.6 Output file

SOILNnnn.SUM: Contains a summary of all instructions used for the simulation and a summary of simulated results. The first part of this file corresponds with a parameter file. This means that you can always rename or copy this file to a file named, for example, MYRUN.PAR which could be used as parameter file for future simulations. If you do not modify the instruction by editing this file or modifying anything by using the PREP program you will reproduce your old run.

SOILNnnn.BIN: A binary file to be used by the Pgraph program for plotting results from the simulation. The file contains all the outputs that where selected in the PREP program. In case of having the ADDSIM switch ON you have to specify the name of the output file since the output file will be the same as used by a previous run with the model.

SOILNFOR.AUT: Annual sums of different flow variables. This file has to exist. Its name is fixed. Only used if FORESTSR-switch is ON (ASCII)

4.7 Validation file

A validation file is a file with variables that should be compared with simulated variables. The result of the comparison will be found in the SOILNnnn.SUM file. The first variable in the validation file will be compared with the first variable in the output PG-file, the second with the second and so wider.

4.8 Soil physical properties

SOILP.DAT: A file containing soil physical properties of the soil profile which are used for the soil water and heat simulation with the SOIL model. The file is created by the PLOTPF program and must exist on the directory where the simulation will be done. The table below include all the parameters in the file. Only the porosity (PORO) and the water content at wilting point (WILT) are used in the nitrogen simulation. A complete description of the file is found in the SOIL manual (Jansson, 1991b).

In the SOIL model, the thicknesses given for each layer in the SOILP.DAT file can be adjusted in the simulation (Parameters in the SOIL model: UDEP and LDEP, in case UTHICK = 0, otherwise see UTHICK). Check your actual layer thicknesses used in the sum file of your SOIL simulation. If necessary adjust the layer thicknesses in the SOILP.DAT file used for the SOILN simulation. The result of these adjustments can be seen in the SOILNnnn.SUM file.

4.9 External inputs - driving variable file

XXXXXX.BIN: Depending on the value of the switch DRIVEXT different variables are expected to be find in this file at time 12:00.

Value on DRIVEXT	Variable (#)	Explantation	Parameter name in model	Unit
1	1	Fertilizer (NO_3)	FERN	gN m^{-2}
2	2	Manure NH_4	MANNH	gN m^{-2}
2	3	Manure litter or beddings	MANNL	gN m^{-2}
2	4	C-N ratio of beddings	CNBED	(-)
2	5	Manure faeces	MANFN	gN m^{-2}
2	6	C-N ratio of faeces	CNFEC	(-)
2	7	Mixing depth of manure	MANDEPTH	(m)
3	8	Concentration of min-N in precipitation	DEPWC	(mgN l^{-1})
3	9	Dry deposition rate of min-N	DEPWC	(gN $m^{-2}day^{-1}$)

4.10 Crop - driving variable file

XXXXXX.BIN: A file used only if the GROWTH switch is OFF.

Value on DRIVCROP	Variable (#)	Explantation	Parameter name in model	Unit
1	1	Root depth	ROOTDEP	(m)
2	2	Potential nitrogen uptake	(UPA,UPB..)	(gN $m^{-2}day^{-1}$)

4.11 Management - driving variable file

XXXXXX.BIN:

Value on DRIVMANA	Variable (#)	Explantation	Parameter name in model	Unit
1	1	Ploughing depth	PLOUGHDEP	(m)
2	2	Harvest fraction of total plant-N	HARHP	(-)
2	3	Above ground residue fraction of total plant-N	HARAR	(-)
2	4	Live root fraction of total plant-N	HARLR	(-)
2	5	C-N ratio of above ground residues	CNARES	(-)
2	6	C-N ratio of roots	CNROOT	(-)

5 SWITCHES

The purpose of switches is to choose the simulation mode. Switches can be OFF or ON or have a numerical value. To toggle the status of a switch put the cursor at the switch an press the return key. The switch will then change its value. Switches may be hidden if some other switches make them irrelevant. After you have modified a switch the modification is activated by escaping [ESC] the menu. By entering the menu again, immediately after the escape, you see whether some more switches have become visible because of the previous change.

5.1 Technical

ADDSIM

OFF *Default*	The simulation results will be stored in a separate result file with a name according to the run number.
ON	The simulation results are automatically added to the result file of a previous simulation, run for an earlier time period. Note that the selected output variables must be exactly the same for the present and the previous simulation. The name of the former result file is given by the user as the "output file" name. By default the start date of the present simulation is put identical to the terminate date of the previous simulation. The final values of state variables from the previous simulation must be selected as the initial values of state variables for the present run (see INSTATE and OUTSTATE switches). Note that the OUTSTATE switch must be ON for any simulation to which results of a later simulation will be added. No new result file ".BIN" will be created but a separate summary file ".SUM" will be created just like for an ordinary simulation.

AVERAGED

OFF	All requested driving (=D) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval. Otherwise the date is the middle of each output intervals.
ON *Default*	All requested driving (=D) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGEG

OFF	All requested auxiliary (=G) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval. Otherwise the date is the middle of each output intervals.
ON *Default*	All requested auxiliary (=G) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGET

OFF	All requested flow (=T) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval. Otherwise the date is the middle of each output intervals.
ON *Default*	All requested flow (=T) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

AVERAGEX

OFF	All requested state (=X) variables will be the current simulated values at the end of each output interval. If all switches AVERAGE_ are OFF the date given in the PG-file is also at the end of the interval. Otherwise the date is the middle of each output intervals.
ON *Default*	All requested state (=X) variables will be mean values representing the whole output interval (see section on Output interval). The output interval is represented with the date in the middle of each period.

CHAPAR

OFF *Default*	Parameter values are constants for the whole simulation period.
ON	Parameter values may be changed at different dates during the simulation period. The new parameter values and the dates from which they should be valid are specified after the other parameter values (which are valid from the start of the simulation). A maximum of 20 dates can be specified.

DRIVPG

0	No function
1 *Default*	Driving variables will be read from a Pgraph file. The name of the file is specified by the user. Model parameters are used to define the arrangement of variables in the file (see parameters in the group under the heading DRIVING VARIABLES).

INSTATE

OFF	No function.
ON *Default*	initial values of state variables will be read from a file. The name of the file is specified by the user, the format should be exactly the same as in the file for final values of state variables, created by the model when the OUTSTATE switch is ON.

LISALLV

OFF	only the subset of output variables selected by the user will be found in the summary file.
ON *Default*	all output variables will be found in the summary file after the simulation.

OUTFORN

OFF *Default*	the variables will be named according to the information stored in the file SOILN.TRA (or SOILNFOR.TRA).
ON	all variables in the output Pgraph-file will be named according to their FORTRAN names.

OUTSTATE

OFF *Default*	no action.
ON	final values of state variables will be written on a file at the end of a simulation. The name of the file is specified by the user and the format is the same as used in the file for initial state variables (see the INSTATE switch).

VALIDPG

OFF *Default*	No validation.
ON	Validation variables will be read from a Pgraph file. The name of the file is specified by the user. The values in the validation file will be compared with variables from the output file.

5.2 Model Specific

CROP

OFF *Default*	No action
ON	The growth and nitrogen uptake of the crop is simulated with CROP submodel (see the additional parameter sections on Crop Biomass and Crop Nitrogen). GROWTH-switch must be ON and FORESTSR-switch must be OFF.

DENDIST

0 *Default*	Denitrification rate distribution from parameter values, separate fractions are given for each soil layer (see DFRAC).
1	A linear decrease of denitrification rate from soil surface to the depth specified by the parameter DENDEPTH.
2	A constant denitrification rate from soil surface to the depth specified by the parameter DENDEPTH.
3	A exponential decrease of denitrification rate from soil surface to the depth specified by the parameter DENDEPTH. The deepest depth for denitrifiction is defined as the depth where a fraction given by the parameter DFRACLOW remains of the total denitrification capacity. The remaining fraction DFRACLOW is distributed at layers above the denitrification depth to make the total denitrification capacity to unity.

DRIVCROP

0 *Default*	Crop developement is specified by parameter values or simulated (i.e. the GROWTH switch is ON).
1	The root depth is read from a driving variable file.
2	Also the potential N-uptake rate is read from the same file.

DRIVEXT

0 *Default*	External inputs of nitrogen to the model is specified by parameter values.
1	N-ferlization rate is in a driving variable file.
2	Also the application of manure is specified in the driving variable file.
3	Also variables for wet and dry deposition are specified in the driving variable file.

DRIVMANA

0 *Default*	Management operations are specified by parameter values.
1	Ploughing depth is read from a driving variable file.
2	Also harvest and recirculation of crop residues are specified by variables in a driving variable file.

FORDRIV

OFF	All driving variables are available in the input file.
ON *Default*	FIXED to this value! Some of the driving variables in the input file are not available or wanted to be modified. This option gives access to simple substitution functions of driving variables. OBS! Be careful, this switch does not influence the calculations.

FORESTSR

OFF *Default*	No action
ON	The growth and nitrogen uptake of a short rotation forest is simulated with the FORESTSR submodel (see the additional parameter sections on Forest Growth, Forest Biomass, Forest Nitrogen and Forest Harvest). GROWTH-switch must be ON and CROP-switch must be OFF.

FORHARVEST

OFF *Default*	No action
ON	It is possible to harvest at a certain day. The daynumber is given by the ZSTHAR parameter (Forest Harvest group). FORESTSR-switch must be ON.

FORLEAF

OFF	The areal leaf weight is a driving variable in the input file.
ON *Default*	FIXED to this value! The areal leaf wight (leaf "thickness") can be put constant.

FORRAD

1	The daily radiation driving variable RIS is: the relative duration of sunshine (D).
2	the duration of sunshine (t_{Sun} (h d^{-1})).
3	the ratio between actual and clear sky global radiation (S_s/S_{Cls}).
4	the actual global radiation (S_s (MJ m^{-2} d^{-1})).
5	the fractional cloudiness during daytime (O_v).

FORWATER

OFF	Growth is assumed not to be limited by plant water conditions.
ON *Default*	Water growth factor is given as a driving variable (ETR). Only available if FORESTSR-switch and SPECIAL-switch are ON.

GROWTH

OFF *Default*	The plant N-uptake is a function of time and root depth is input (see parameter sections on Plant N-uptake and management and Plant root development).
ON	The plant growth and nitrogen uptake is simulated for either a crop (see CROP-switch) or a short rotation forest (see FORESTSR-switch).

GROWTHR

Determining the calculation of the growth response function (f_{Tot}). Only used if the CROP-switch and SPECIAL-switch is ON.

0	$f_{Tot} = Min(f_T, f_N, f_W)$
1 *Default*	$f_{Tot} = f_T * f_N * f_W$
2	$f_{Tot} = (f_T + f_N + f_W)/3$

GWFLOW

OFF	The PERC driving variable is considered as deep percolation to ground water. This means that the whole simulated soil profile is unsaturated and that the GWFLOW was OFF when running the SOIL model.
ON *Default*	The PERC driving variable is considered as a net horizontal ground water flow. This means that GWFLOW was ON when running the SOIL model.

MANURE

OFF *Default*	Aplication of manure and transformation of faeces is not considered.
ON	Aplication of manure and transformation of faeces is considered.

ROOTDIST

0 *Default*	Root distribution from parameter values, separate fractions are given for each soil layer.
1	A linear decrease of root density from soil surface to the root depth.
2	A constant root density from soil surface to the root depth.
3	An exponential decrease of the root density from soil surface to the root depth. The root depth is defined as the depth where a fraction given by the parameter RFRACLOW remains of the total uptake capacity. The remaining fraction RFRACLOW is distributed at layers above the root depth to make the total uptake capacity equal to unity.

TEMPR

0 *Default*	The temperature response function for soil biological processes is calculated from the Q_{10} expression in the whole range.
1	The temperature response function for soil biological processes is calculated from the Q_{10} expression when the temperature is above 5 °C. Below that a linear decrease is assumed towards 0 °C where the response diminish.

SPECIAL

OFF *Default*	No action.
ON	Gives access to the parameters in the group named SPECIAL and to certain switches. Then special functions are available. OBS! Be careful, this switch does not influence the calculations. The parameters do. This switch also cancels the FORLEAF switch direct effect on the calculations.

6 PARAMETERS

All parameter values may be modified by pressing the return key when the cursor is located at a certain parameter. A new numerical value may then be specified.

Equation numbers given in the text refers to Johnsson et al. (1987) and symbols given in brackets refer to Eckersten (1991a) and Eckersten & Jansson (1991).

Beneath the unit to the right in the text a default value for each parameter is often given.

6.1 External inputs

Dry and wet deposition to the soil is determined by a dry deposition rate (DEPDRY) and the water infiltration rate (driving variable) combined with a total concentration of nitrogen (DEPWC) in precipitation. Commercial fertilizer N (FERN) can be applied at a day (FERDAY) and is made available at a constant rate (FERK). Under conditions of a water source flow to the soil, this flow can also be a source of nitrogen (see GWCONC).

DEPDRY

Dry deposition of mineral N — (gN m^{-2} d^{-1}) *0.001*

A value of 0.001 correspond to 3.65 kg N/ha/year. Normal range for an open field in southern Sweden 0.0005 - 0.002 gN m^{-2} d^{-1}.

DEPWC

Concentration of mineral N in precipitation. — (mg l^{-1}) *0.8*

During a year with 800 mm infiltration a value of 0.8 corresponds to a wet deposition of 6.4 kg N/ha/year. Normal range for southern Sweden 0.8 - 1.8 mg/l and for central Sweden 0.4 - 1.0.

FERDAY

Fertilization date (commercial fertilizer). — (day number) *140.*

FERK

Specific dissolution rate of commerical fertilizer — (d^{-1}) *0.15*

A value of 0.15 corresponds to half time of 5 days and that 90% of the fertilizer is dissolved within 15 days. A higher value results in faster dissolution. Dependent on fertilizer type and moisture conditions. Normal range 0.05 - 0.5.

FERN

N-fertilization (commercial fertilizer) — (gN m^{-2}) *8*

1 gN m^{-2} = 10 kgN/ha. Normal range 0 - 30 gN m^{-2}.

GWCONC

Concentration of nitrate in deeper groundwater — (mgN l^{-1}) *0.3*

Depends on the local conditions. Normal range 0.1 - 5.

6.2 Manure application

Manure can be applied during three different periods according to day numbers assigned to MANST and MANET. The manure-N is split up between inorganic forms as ammonia (MANNH), organic forms as faeces-N (MANFN) and litter-N (MANLN). The organic forms of manure are described by carbon-nitrogen ratios CNBED and CNFEC for litter and faeces respectively. Applied manure is mixed into the soil down to a depth given by the MANDEPTH parameter.

CNBED
C-N ratio of bedding in manure (-)
(index= applic. period 1, 2 or 3) *30.*
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range from 20 to 80. Default value 30.

CNFEC
C-N ratio of faeces in manure (-)
(index= applic. period 1, 2 or 3) *20.*
Only used when the MANURE switch is ON and DRIVEXT < 2
Depend on type of animals. Normal range 10 - 30. Default value 20.

MANDEPTH
Depth to which the applied manure is uniformly mixed into the soil (m)
(Index= application period 1, 2 or 3). *0.1*
Only used when the MANURE switch is ON and DRIVEXT < 2
Maximum depth = depth of layer 1+2. Normal range 0.5 - 0.25 m. Default value 0.10 m.

MANET
Last date of manure application (day number)
(index= applic. period 1, 2 or 3) *100.*
Only used when the MANURE switch is ON and DRIVEXT < 2
If MANET is given the same value as MANST the application of manure is made during one day.

MANFN
Nitrogen in faeces in manure (gN m^{-2})
(index= applic. period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 30 gN m^{-2}.

MANLN
Nitrogen in bedding in manure (gN m^{-2})
(index= applic. period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 5 gN m^{-2}.

MANNH
Nitrogen in ammonium in manure (gN m^{-2})
(index= applic. period 1, 2 or 3).
Only used when the MANURE switch is ON and DRIVEXT < 2
Normal range 0 - 30 gN m^{-2}.

MANST
First date of manure application (day number)
(Index= applic. period 1, 2 or 3) *100.*
Only used when the MANURE switch is ON and DRIVEXT < 2

6.3 Mineralisation and immobilisation

The turnover of faeces and litter is treated in a similar way. Rate coefficients for litter and faeces C decomposition are given by the parameters LITK and FECK, respectively. Efficiency constants (FECEFF, LITEFF) determines the fraction of organic C that after respiration remains as organic C. A constant carbon-nitrogen ratio (CNORG) and a humification fraction (FECHF, LITHF) determines the corresponding synthesis of N in faeces, litter and humus pools. Humus N mineralization is given by the specific rate constant HUMK. Depending on the efficiency constants and the actual carbon-nitrogen ratios, litter and faeces may either demand nitrogen (= immobilization) or release nitrogen as ammonium (= mineralisation). The critical carbon-nitrogen ratio for the shift from immobilization to mineralisation is determined by the ratio between CNORG and FACEFF or LITEFF. Transformation of ammonium to nitrate (=nitrification) will occur if the ratio nitrate-ammonium is lower than NITR, with a rate controlled by NITK.

CNORG

C-N ratio of microorganisms and humified products (r_o in eq. 8) (-)
Increasing the value results in larger litter N mineralization rates and increased C-N ratio of litter at which the shift between mineralization and immobilization occur. Normal range from 5 to 15. *10.*

FECEFF

Efficiency of the internal synthesis of microbial biomass and metabolites in faeces (-) *0.5*
Only used when the MANURE switch is on.
Normal range the same as for LITEFF (0.2 - 0.7).

FECHF

Faeces carbon humification fraction (-)
Only used when the MANURE switch is on. *0.2*
See LITHF for normal range.

FECK

Faeces specific decomposition rate (d^{-1})
Only used when the MANURE switch is on. *0.035*
Of the same order of magnitude as LITK. Dependent on the type of manure.

HUMK

Humus specific mineralisation rate (k_h in eq. 3) (d^{-1})
A value of 5.0E-5 corresponds to a half time of 38 years under optimal water and temperature conditions. Thus, the effective half time is much longer. Values between 1.0E-5 and 20E-5 have been used. This parameter is also dependent on the definition of the turnover of litter and humus pools according to the assumed humification fraction (see LITHF). If a major part of the residues incorporated into the litter pool is assumed to be remineralized ("fast" litter N mineralization), it is reasonable to assume a lower value than if the reverse ("slow" litter N mineralization) is assumed (see LITHF). *5.0E-5*

LITEFF

Efficiency of the internal synthesis of microbial biomass and metabolites in litter (f_e in eq. 5). (-) *0.5*
Normal range 0.2 - 0.7 based on literature values of microbial growth yield. Increasing the value results in increased litter N mineralization rates and a decreased C-N ratio at which the shift between litter mineralization and immobilization occur.

LITHF

Litter carbon humification fraction (f_h in eq. 6). (-)
Low values, 0.1 - 0.3 (Defining litter turnover as "fast"), results in that a major part of the residues incorporated into the litter-N pool is remineralized while a minor part is humified. High values 0.6 - 0.9 ("slow" litter turnover), results in the reverse. High values give the humus pool a more active role for the total mineralization of nitrogen. A fast litter turnover has been assumed in most applications. *0.2*

LITK

Litter specific decomposition rate (k_l in eq. 4) (d^{-1})
A value of 0.035 corresponds to a half time of 20 days under optimal water and temperature conditions. Thus, the effective half time is much longer. Increasing the value results in an increased litter decomposition rate. *0.035*

NITK

Specific nitrification rate (k_n in eq. 9). (d^{-1})
0.2

NITR

Nitrate-ammonium ratio in nitrification function (n_q in eq. 9) (-)
Normal range for agricultural soils 1 - 15. *8.*

6.4 Soil moisture response

A Common soil moisture response function is used for mineralisation, immobilization and nitrification. The activity is zero below the wilting point (defined in the SOILP.DAT file or by parameter WILT) and increases to unity in a soil moisture interval given by MOS(1). Near saturation, the activity decreases down to a saturation activity (MOSSA) in and interval given by MOS(2). Soil porosity (saturation water content) is defined in the SOILP.DAT file or by parameter PORO. The shape of the response curve in the intervals MOS(1) and MOS(2) can be varied according to the MOSM parameter.

MOS

Water content intervals in the soil moisture response function defining ranges for increasing and decreasing biological activity ($d0_1$ and $d0_2$ in eq. 12). (%)

MOS(1): Water content interval defining increasing activity from 0 (no activity) at wilting point to unity (optimum activity) at MOS(1) + wilting point. Normal range 8 - 15 vol %, depending on soil type. *13*

MOS(2): Water content interval defining decreasing activity from 1 (optimum activity) at porosity - MOS(2) to the activity given by parameter MOSSA at porosity. Normal range 1 - 10 vol %, depending on soil type. Default value 8 % *8*

MOSM

Coefficient in soil moisture function (m in eq. 11) (-)
A linear response correspond to the value 1.0. Values between 0 and 1 results in a convex response and values larger than 1 in a concave response. *1*

MOSSA

Saturation activity in soil moisture response function (e_s in eq. 11). (-)
A value of 1 corresponds to optimum activity at saturation and 0 no activity. Normal range 0 - 1. *0.6*

6.5 Soil temperature response

A common temperature response function is used for mineralisation, immobilization, nitrification and denitrification. The function is based on a Q10 relation, with a temperature base (TEMBAS) at which the value of the function is one (Optimum activity).

TEMBAS

Base temperature at which temperature effect = 1 (t_b in eq. 10) (°C)
20

TEMQ10

Response to a 10 °C soil temperature change (Q_{10} in eq. 10) (-)
A value of 2 results in a doubled activitity with a 10 °C increase in temperature. Normal range between 1.5 and 4. *3*

6.6 Denitrification

Denitrification (=loss of nitrate from soil to the atmosphere) is calculated according to a potential rate (DENPOT), the nitrate concentration in soil solution and response functions for temperature and moisture. The temperature response is the same as for the other biological processes. The distribution of the potential rate of denitrification in the soil profile can be given separately for each layer (DFRAC) or according to distribution functions (see switch DENDIST). Denitrification increases with increasing water content in an interval MOSDEN below saturation water content (PORO). The shape of the response curve may be varied according to DEND. Denitrification is reduced when the nitrate concentration decreases in soil water solution according to a michaelis-menten type function (DENHS).

DEND
Coefficient in function for soil moisture/aeration effect on denitrification (d in eq. 15) (-) *2*
A linear response correspond to a value of 1 whereas higher values results in a concave non-linear response.

DENDEPTH
The depth where the denitification capacity ceases. (m)
Only used when the DENDIST switch is set to 1,2 or 3.

DENHS
Half saturation constant in function for nitrate concentration effect on denitrification (c_s in eq. 16) ($mgN\ l^{-1}$) *10*
Nitrate concentration at which the activity is half of the activity at optimal nitrate concentrations. Normal range 5 - 15.

DENPOT
Potential rate of denitrification (k_d in eq. 16) ($gN\ m^{-2}\ d^{-1}$) *0.04*
Dependent on type of cropping system and soil. Typical value for a barley crop on a loam soil 0.04 and for a grass ley 0.2.

DFRAC
Fraction of potential denitrification in layers (-)
(Index= layer. 1 to minimum of 10 and NUMLAY)
Only used when the DENDIST switch is set to 0
The vertical distribution is dependent on soil organic matter content as source for the activity of denitrifiers in the different layers. A first assumption may be to assume similar distribution as the root distribution or the distribution of soil organic matter.

DFRACLOW
Fraction of the exponential function remaining below the depth where the denitrification activity ceases (DENDEPTH), used when the DENDIST switch is set to 3 (-) *0.05*

The activity (f_r) that are found above a depth z is given by:

$$f_r = \frac{(1-\exp(-kextd(z/z_r))}{(1-DFRACLOW)}$$

where (z_r) is the root depth and kextd is an extinction coefficient.
DFRACLOW=exp(-kextd)
and
kextd=-ln(DFRACLOW)

Normal range of kextd 2.5 - 4.5 corresponds to values from 0.08 to 0.01 of DFRACLOW.

MOSDEN
Water content range in function for soil moisture/aeration effect on denitrification (vol %) *17.*
Water content interval defining increasing activity from 0 (no activity) at saturation water content - MOSDEN, to 1 (optimum activity) at saturation water content.

6.7 Soil Profile

The division of the soil profile into a number of layers (NUMLAY) with different thickness (THICK) should be done in a way which corresponds to the driving variables simulated with the SOIL model.

NUMLAY
Number of layers (maximum 22) in the soil profile used in the simulation

THICK
Thickness of soil layers (m)
Use values from the soil water and heat simulation.

UNUM
Replicate number of soil parameters in SOILP.DAT. The replicate number is also used in the PLOTPF program.

UPROF
Profile number as specified in SOILP.DAT. The profile number is also used in the PLOTPF program

VC
NOT USED! Multiplicative factor for all layers thicknesses (THICK).
Use value from the soil water and heat simulation.

6.8 Stream water

These parameters are used to account for the consumption of nitrogen in a stream.

CONCRI
Half saturation constant in calculation of nitrate consumption in stream water (-)

CONPOT
Potential rate of nitrate consumption in stream water. ($gN\ m^{-2}\ d^{-1}$)
Note that the area correspond to the total watershed area simulated. Value dependent on the total stream length in the watershed as well as on the biological factors in the stream. Default value 0, i.e. no consumption assumed.

CONTEM
Lower temperature limit for nitrate consumption in stream water (°C)

6.9 Soil management

PLOUGHDAY
Date of ploughing or soil cultivation (day number)

PLOUGHDEP
Depth of ploughing or soil cultivation (m)
Normal range 0.05 - 0.30 m. *0.25*

6.10 Plant N uptake and management

Plant uptake of inorganic nitrogen from the soil (both nitrate and ammonium) is controlled by a logistic uptake function defining the potential demand (UPA, UPB and UPC) during different periods (UPST and UPET). The demand for nitrogen uptake is distributed in the soil profile according to the distribution of roots (see switch ROOTDIST and section 6.7: Root development). The maximum amount of mineral N available for uptake from a soil layer is controlled by the UPMA parameter. In cases when actual uptake from one layer is below the potential uptake, reallocation of the uptake demand may occur (UPMOV).
Harvest of plant can take place at three different dates (UPET). At these dates the total plant biomass-N is split into a harvest fraction (HARHP), a fraction of plant residues above ground (HARAR) and a fraction of remaining living biomass-N (HARLR). The residual (1-HARHP-HARAR-HARLR) is considered as dead root biomass-N. The dead root biomass-N is included into the litter-N pool at the day of harvest and split between different soil horizons according to the depth distribution of roots (see ROOT). The dead root biomass-C is included into the litter-C pool according to a carbon-nitrogen ratio of roots (CNROOT). At the day of ploughing (PLODAY) all remaining biomass-N (i.e., above-ground residues and remaining living plant) is included into the litter-N pool down to a depth given by PLOUGHDEP. Remaining biomass-C is included according to a carbon-nitrogen ratio of above-ground residues (CNARES).

CNARES
C-N ratio of above ground residues (-)
Only used when the GROWTH switch is off and DRIVMANA < 2 *50.*
Normal range 20-100. Default value represents a grain crop.

CNROOT
C-N ratio of roots (-)
Only used when the GROWTH switch is off and DRIVMANA < 2 *25.*
Normal range 20-30.

HARAR
Above ground residue fraction of plant N at harvest (f_{ar} in eq. 1) (-)
(index= growth period 1, 2 or 3) *0.1*
Only used when the GROWTH switch is off and DRIVMANA < 2
Normal range 0.05 - 0.3. Default value represents a grain crop.

HARHP
Harvested fraction of plant N (f_{hp} in eq. 1) (-)
(index = growth period 1-3) *0.5*
Only used when the GROWTH switch is off and DRIVMANA < 2
Depend on crop type and the specific site and application considered. Normal values from 0.3 to 0.6. Default value represents a grain crop.

HARLR
Fraction of living plant N remaining after harvest (f_{lr} in eq. 1) (-)
(index= growth period 1, 2 or 3) *0.*
Only used when the GROWTH switch is off and DRIVMANA < 2
Normal range 0 - 0.6. Default represents a grain crop.

UPA
Potential nitrogen uptake (u_c in eq. 13) (gN m^{-2} yr^{-1})
(index= growth period 1, 2 or 3) *20.*
Only used when the GROWTH-switch is OFF
Typical values may be around 20 gN m^{-2} yr^{-1} for a grain crop and 40 gN m^{-2} yr^{-1} for a grass ley in south and central Sweden.

UPB

Coefficient in plant uptake function (u_b in eq. 13) (-)
Only used when the GROWTH-switch is OFF *1.*
In case of an annual crop, UPB is the initial plant N content (gN m^{-2} yr^{-1}) at the start of the plant uptake period, i.e., the N-content of seed. A normal variation of UPB is 0.1 - 1.5. n.b! In older versions of the SoilN model the UPB parameter was defined slightly different, corresponding to (UPA-u_b)/u_b. Thus, a value of UPB of 0.95 and UPA of 20 in the present version of the model corresponds to a value of 20 in older simulations.

UPC

Coefficient in plant uptake function (u_c in eq. 13) (d^{-1})
Only used when the GROWTH-switch is OFF *0.12*
=relative uptake rate. Determines the plant development rate. Increasing UPC results in that the peek uptake occurs faster and at a higher rate. Typical values for rapid developing grain crops is around 0.12 and for slower developing crops like sugerbeats 0.04. Normal values 0.02 - 0.14.

UPET

(t_e) End of plant uptake period and harvest date (day number)
(index= growth period 1, 2, or 3) *240.*
If the CROP-switch is ON:
UPET(i)=367 implies the current growth period is not ended until the simulation is ended.
UPET(i)>367 implies that the growing period (i) is stoped at day UPET(i)-365.
Should be: UPST(i)<UPET(i)<UPST(i+1)
Not used if the FORESTSR-switch is ON.

UPMA

(c_u) Fraction of available mineral N for immobilization and fraction of available mineral N for plant uptake (f_{ma} in eq. 14). (d^{-1}) *0.08*
A value of 0.1 is equivalent to that 10% of the total mineral-N pool is available at one time-step. Normal range 0.05 - 0.12.

UPMOV

(c_{um}) Fraction of compensatory increase in uptake demand (-)
A value of 1 results in the most efficient compensation (i.e., where all the differences between potential and actual uptake occuring in layers with mineral N deficiency is added to the uptake demand in layers where no deficiency occurred according to the root distribution). A value of 0 represent a crop where no reallocation of the uptake demand in the soil profile occurs. *0.5*

UPST

(t_o) Start of plant uptake period (day number)
(index= growth period 1, 2 or 3) *120*
If the GROWTH-switch is OFF: Annual crops: about 2 weeks after sowing. Perennial crops: start of the growing season.
If the CROP-switch is ON: The parameter equals the earliest day for start of plant development. The temperature may delay the start of growth from this date.
Should be UPST(1)<UPST(2)<UPST(3)<366.
UPST(i)=0 implies the period (i) is cancelled (OBS! This parameter is related to UPET (this parameter group) and TOTW (Crop Biomass group)).
Not used if the FORESTSR-switch is ON.

6.11 Plant root development

The development of the root depth is given by parameters ROOTT and ROOTDEP. The distribution of plant N uptake demand and root biomass in the soil profile can be given separately for each layer (ROOTF) or according to distribution functions (see switch ROOTDIST). If the GROWTH switch is ON then ROOTT and ROOTDEP are not active. Instead ROOTDINC, ROOTDMAX and ROOTDMIN determine the root depth development.

RFRACLOW
(Δa_r) Fraction of the exponential function remaining below the root depth, used when the ROOTDIST switch is set to 3 — (-) *0.05*

The fraction of roots (a_r) that are found above a depth z is given by:

$$a_r = \frac{(1-\exp(-k_r(z/z_r))}{(1-\Delta a_r)}$$

where (z_r) is the root depth and (k_r) is an root extinction coefficient.

$$\Delta a_r = \exp(-k_r)$$

and

$$k_r = -\ln(\Delta a_r)$$

Normal range of kext 2.5 - 4.5 corresponds to values from 0.08 to 0.01 of RFRACLOW.

ROOTDEP
Root depth at days given of ROOTT(I) — (m)
(Index= 1 to 5)
Only used when the DRIVCROP switch is set to 0.

ROOTDINC
(a_{rz}) Root depth as proportional to root biomass (OBS! <0) — (m (gDW $m^{-2})^{-1}$)
Only used when the GROWTH switch is set ON.

ROOTDMAX
(z_{rMax}) Smallest root depth (OBS! <=0) — (m)
Only used when the GROWTH switch is set ON.

ROOTDMIN
(z_{rMin}) Largest root depth (OBS! <ROOTDMAX) — (m)
Only used when the GROWTH switch is set ON.

ROOTF
Fraction of roots in layers (when fully developed) — (-)
(Index= layer 1 to min(10, NUMLAY))
Only used when the ROOTDIST switch is set to 0.

ROOTT
Day number for deepest root depth given of ROOTDEP(I) — (day number)
(Index = 1 to 5)
Day number for deepest root depth given of ROOTDEP(1) (Index=6)
Only used when the DRIVCROP switch is set to 0.

6.12 Crop biomass

These parameters are activated by the CROP-switch.

At start of growth (see Plant N uptake and management parameters) or simulation a certain amount of plant biomass exists on the field (TOTW(i); i=1-3 depending on which cultivation of the year is concerned). The solar radiation is absorbed by the canopy according to the radiation extinction coefficient (EXTCOEFF) and converted into potential growth (PHOEFF). The potential growth is reduced according to temperature (PHOTMIN, PHOTMAX) and nitrogen (see Crop nitrogen parameters NLEAFN and NLEAFX).

Growth and assimilates are allocated between roots (AROOTN, AROOTWA-B), leaves and stems (ALEAF0-1), grain (AGRAIN) and litter (ALITTER). The leaf biomass and leaf area are related through the specific leaf weight (WLAI). The grain development starts when a temperature and daylength index becomes unity (DEVALFA, DEVDAYL, DEVTA).

AGRAIN
(b_g) Fraction of assimilates in other tissues transferred to grain. (d^{-1})

ALEAF0
(b_{io}) Leaf area to shoot biomass ratio at unity shoot biomass. ($m^2\ gDW^{-1}$)

ALEAF1
(b_{i1}) Parameter determining the decrease in leaf area to shoot biomass ratio as shoot biomass increases. ($m^2\ gDW^{-1}$)

ALITTER
(b_{li}) Fraction of assimilates in leaf, stem and root lost through litter. (d^{-1})

AROOTN
(b_{rMin}) Minimal fraction of daily total growth allocated to roots. (-)

AROOTWA
(c_{bo}) Coefficient determining the relative allocation of total growth to roots as function of total plant biomass. (-)

AROOTWB
(c_{b1}) Coefficient determining the relative allocation of total growth to roots as function of total plant biomass. ($m^2\ (gDW)^{-1}$)

DEVALFA
(c_o) The asymptote of the development rate curve. The inverse of ALFA gives the shortest possible duration of the phase in days and is therefore related to the basal vegetative period. (d^{-1})

DEVDAYL
(c_1) Index 1 regulates the shape of the development-photoperiod (daylength) function. (h^{-1})

(c_2) Index 2 is the critical photoperiod (threshold) for the development (h)

DEVTA
(c_3) Index 1 regulates the shape of the development - temperature function ($°C^{-1}$)

(c_4) Index 2 is the Threshold temperature (°C)

EXTCOEF
(k) Radiation extinction coefficient for the canopy. (-)

LAT
Latitude of the field. (°)

PHOEFF
(ε) Radiation use efficiency at optimal temperature, water and nitrogen conditions. ($gDW\ MJ^{-1}$)

PHOTMAX
(T_{Max}) Daily mean air temperature for optimal growth. (°C)

PHOTMIN
(T_{Min}) Minimal daily mean air temperature for growth. (°C)

TOTW
($W_t(t_o)$) Total plant biomass at start of growth. ($gDW\ m^{-2}$)
(index= growth period 1, 2 or 3)

WLAI
(a_{ls}) Specific leaf weight ($gDW\ m^{-2}$)

6.13 Crop nitrogen

These parameters are activated by the CROP-switch and related to plant nitrogen uptake and allocation.

The allocation of nitrogen follows the allocation of assimilates however also depending on maximal concentrations of the tissues concerned.

NLEAFN
(n_{lMin}) Minimal nitrogen concentration of leaf biomass. (-)

NLEAFX
(n_{lMax}) Maximum nitrogen concentration in leaf. (-)

NROOTX
(n_{rMax}) Maximal nitrogen concentration of root biomass. (-)

NSTEMX
(n_{sMax}) Maximal nitrogen concentration of stem biomass. (-)

6.14 Forest Harvest

These parameters are activated by the FORESTSR-switch and the FORHARVEST-switch and related to harvest or sudden death of biomass.

Harvest of plant can take place at day ZSTHAR. If you simulate over several years the program harvest every year at this day. However by using the CHAPAR-switch you can change the value of ZSTHAR to zero after a harvest and then no more harvest will take place. In this way new harvest days can be chosen as well. The degree of harvest can range between 0 and 100%. You can choose the fraction of tissues that are taken out of growth ("destroyed") with ZSTHDL, ZSTHDS and ZSTHDQ. Of this amount a certain fraction can be removed from the forest (ZSTHHL, ZSTHHS and ZSTHHQ) whereas the rest is incorporated in the litter pool.

ZSTHAR
(t_h) Day-number for harvest counted from Jan 1; (d)
=0 --> no harvest. *0*

ZSTHDL
(d_l) Fraction of the leaf biomass that is destroyed. OBS! Must be <1. (-)
0.999

ZSTHDQ
(d_Q) Fraction of the old stem biomass that is destroyed. If you are giving the fraction a negative value the old root biomass is destroyed in the same proportion as the stem. (-) *0.999*

ZSTHDS
(d_s) Fraction of the stem biomass of the current year that is destroyed. If you are giving the fraction a negative value the old root biomass is destroyed in the same proportion as the stem. OBS! Must be >-1 and <1. (-) *0.999*

ZSTHHL
(h_l) Fraction of the destroyed leaf biomass that is harvested (the rest goes to litter). (-) *0*

ZSTHHQ
(h_Q) Fraction of the destroyed old stem biomass that is harvested (the rest goes to litter). (-) *1*

ZSTHHS
(h_s) Fraction of the destroyed young stem biomass that is harvested (the rest goes to litter). (-) *1*

6.15 Forest Growth

The parameters are activated by the FORESTSR-switch and related to the daily growth which is based on canopy photosynthesis.

Flushing occurs at a certain temperature sum (ZDAYTA, ZTACC). Growth then depends on temperature (PT1-3). Firstly, radiation for a typical clear and overcast sky, respectively, is calculated (PGS, PGI, PGO). The light extinction coefficient (PK0-2) and photosynthesis light response (PPM0-1, PPI) then gives the corresponding canopy photosynthesis. The actual cloudy conditions gives an intermediate photosynthesis (PM0-2).

PSTRLA
Latitude for the radiation data ; Only used when FORRAD-switch = 2. (°)

PCLOU1
(a) in: $D=a+bO_v$; (see PCLOU2) (-)

PCLOU2
(b) in: $D=a+bO_v$; (-)

Coefficients for determining the radiation factor (D is the relative duration of sunshine) as function of the fractional cloudiness (O_v)).
(only used if FORRAD-switch = 5)

PGH
(g_h) Daily time fraction for which suntrack is not obscured by horizon. Only used if FORRAD-switch = 2 (-)

PGI
(g_I) PAR-quanta incident above canopy devided by the corresponding global radiation (=Icl/Scl) (μE J^{-1})

PGO
(g_o) PAR-quanta incident above canopy during an overcast day devided by the corresponding value for clear sky conditions (=Iov/Icl) (-)

PGS
(g_s) Parameter related to air turbidity. Used for calculating global radiation (-)

PK0
(a) in: $k=a+b*A_i+c*A_i^2$ (see PK2) (-)

PK1
(b) in: $k=a+b*A_i+c*A_i^2$ (see PK2) (-)

PK2
(c) in: $k=a+b*A_i+c*A_i^2$ (-)

Coefficients for estimating the light extinction coefficient (k) as a function of the accumulated leaf area index from the canopy top (A_i).

PM0
(a) in: $M=a+b*t_{Sun}+c*t_{Sun}^2$ (see PM2) (-)

PM1
(b) in: $M=a+b*t_{Sun}+c*t_{Sun}^2$ (see PM2) (-)

PM2
(c) in: $M=a+b*t_{Sun}+c*t_{Sun}^2$ (-)

Actual photosynthesis as a function (M) of photosynthesis at overcast and clear sky conditions. t_{Sun} is the relative duration of bright sunshine.

PPI
(p_I) Parameter for the photosynthetic light response (equal to the light (PAR) that gives $P=P_m/2$) ($\mu E\ m^{-2}\ s^{-1}$)

PPM0
(p_1) in: $P_m=p_1+p_2n_l$ (see PPM1) ($mgCO_2\ gDW^{-1}\ h^{-1}$)

PPM1
(p_2) in: $P_m=p_1+p_2n_l$ ($mgCO_2\ gDW^{-1}\ h^{-1}$)

Photosynthesis per unit leaf weight at optimal light (PAR), temperature and water conditions as a function of leaf nitrogen concentration (n_l)

PSTSLA
Latitude for the growth simulation site ; OBS! Latitudes are given in degree units with minutes converted to decimals. (°)

PT1
(T_1) Lower temperature limit for growth (see T_f) (°C)

PT2
(T_2) Lower temperature limit for optimal growth (see T_f) (°C)

PT3
(T_3) Upper temperature limit for optimal growth (see T_f) (°C)

ZDALI
(δ_A) A_{li} of internal canopy layers used for calculating the light (PAR) interception. (-)

ZDAYTA
(t_{Acc}) Day number at which the calculation of T_{aAcc} starts (d)

ZID
(I_d) Light (PAR) level below which leaf-shedding starts. ($\mu E\ m^{-2}\ s^{-1}$)

ZRG
(r_g) Fractional respiration of total daily growth (W_t'). (-)

ZTAACC
(T_5) Minimum value of the temperature sum (T_{aAcc}) at which growth starts. (°C)

6.16 Forest Biomass

These parameters are activated by the FORESTSR-switch and related to the allocation of biomass within the plant and litter fall.

Growth and assimilates are allocated between roots (ZBR0), leaves and stems (ZBI0-1), and the available pool (ZWAI, ZDWAX, ZWSL). The leaf biomass and leaf area are related through the leaf "thickness" (ZSTBAC, ZBAY, ZBAX). Rate of leaf fall depends on time of season (ZTDA, ZKM0-1) and canopy size (see ZID in Forest Growth group). A certain fraction of the leaf biomass is withdrawn to plant (QBW) before abscission. Of the leaves reaching soil surface a fraction is directly leached (QWLFL).

QBW
(b_w) Fractional withdrawal of dry weight in leaves before abscission (OBS! Must be greater than 0). (-)

QMR
(m_r) Mortality of roots as a fraction of the daily root growth. ()

QMS
(m_s) Daily relative mortality rate for stems older than one year. (d^{-1})

QWLFL
(a_l) Fraction of the dry weight in the leaf fall that is leached before entering the litter pool. (-)

ZBAX
(b_{Ax}) Maximal areal leaf weight ($gDW\ m^{-2}$)

ZBAY
(a) in: $b_A=b_{Ao}(1+a*shootage)$; Annual relative increase of the areal leaf weight (both if it is given as a driving variable or if it is assumed to be constant (see ZSTBAD and ZSTBAC)). (-)

ZBI0
(b_{io}) The leaf area to shoot biomass ratio at unity shoot biomass. ($ha\ ton^{-1}$)

ZBI1
(b_{i1}) Parameter related to the decrease in the leaf area to shoot biomass ratio as the shoot biomass increases. ($ha\ ton^{-1}$)

ZBR0
(b_{ro}) Minimal fraction of the total daily growth that is allocated to roots. (-)

ZDWAX
(dW_{aMax}) Maximal daily release rate of assimilates in the available pool. ($kgDW\ ha^{-1}\ d^{-1}$)

ZKM0
(k_{mo}) Coefficient for the leaf abscission function (m_A) (-)

ZKM1
(k_{m1}) Coefficient for the leaf abscission function (m_A) (d^{-1})

ZRM
(r_m) Daily fractional maintain respiration of root and stem biomass of all ages. (d^{-1})

ZSTBAC
(b_A) [x] ; =x implies that the areal leaf weight is constant equal to x during the season. OBS! Then ZSTBAD should be 0. FORLEAF-switch must be ON. ($gDW\ m^{-2}$)

ZTDA
(d_a) Length of the day (after midsummer) when leaf abscission starts. (h)

ZWSL
(w_{as}) Stem biomass for which δW_{aMax} is doubled. (kgDW ha^{-1})

6.17 Forest Nitrogen

These parameters are activated by the FORESTSR-switch and related to plant nitrogen uptake and allocation.

The allocation of nitrogen follows the allocation of assimilates however also depending on maximal concentrations of the tissues concerned.

QNLFL
(a_{ln}) Fraction of nitrogen in the falling leaves that are leached before the litter enters the litter pool. (-)

QAW
(a_w) Fractional withdrawal of nitrogen in leaves before abscission. (-)

QNLO
(n_{lOpt}) Optimal canopy nitrogen concentration (for allocation of biomass to roots) (%gN gDW^{-1})

QNLX
(n_{lMax}) Maximal leaf nitrogen concentration (for N uptake) (%gN gDW^{-1})

QNRX
(n_{rMax}) Maximal root nitrogen concentration (%gN gDW^{-1})

QNSX
(n_{sMax}) Maximal stem nitrogen concentration (%gN gDW^{-1})

6.18 Plotting on line

These parameters activates a display of outputs on the screen during the simulation.

STPMAX
The expected maximal value among the variables selected by STXTGD. (-)

STXTGD
Numbers of output variables to be presented on the screen during the simulation. (-)
For instance, 4200 means 4 X-, 2 T-, zero G- and zero D variables. X= state, T= flow, G= auxiliary and D= driving variables. It is the first variables (of those selected as output) in each array that are plotted.

6.19 Special

These parameters are available only if the SPECIAL-switch is ON. They activates special routines not used, or kept fixed, in the original model.

These parameters are used for sensitivity tests and to select some special options. The value for no test is given in brackets []. The subscript (o) denotes the original value.
Where both the relative and the absolute value are possible to change a constant value of the variable concerned can be chosen by setting the relative change to 0.
The supply of nitrogen to leaves at growth start can be set optimal or taken as a function of the available nitrogen in the soil (QSNLTO).

NMAXG
NOT USED! Maximal nitrogen concentration of grain biomass. (-)

PSSBD
(t_{Sun}-t_{Suno}) Absolute change of sunshine factor (-)
0

PSSBR
(t_{Sun}/t_{Suno}) Relative change of sunshine factor (-)
1

PSTFD
(T_f-T_{fo}) Absolute change of temp. function (-)
0

PSTFR
(T_f/T_{fo}) Relative change of temp. function (-)
1

QSBRR
(b_r/b_{ro}) Relative change of root allocation (-)
1

QSNA
(N_{aDem}) The N-fertilization corresponding to the demand by the plant which equals the deficit in the available pool from a certain value (N_{aDem}) that is enough to meet the maximal daily plant demand. Only used if QSNDEM>0. (QSNA works on N_a). OBS! This value is inversely related to c_u (see QUPMAX). (kgN ha^{-1})
100

QSNDEM
QSNDEM= 1 and QSNF= 0 implies that N_f' is taken equal to the demand by the plant. 0< QSNDEM <1 implies that N_f' is a certain fraction of the demand. (-)
0

QSNLD
(n_l-n_{lo}) Absolute change of leaf N-conc. (-)
0

QSNLDE
(N_{lDem}'/N_{lDemo}') Relative change in the demand of N by leaves. (-)
1

QSNLR
(n_l/n_{lo}) Relative change of leaf N-conc. (-)
1

QSNLT0
switch for supply of leaf nitrogen at start [0] ; Determines wether the leaves are supplied by optimal nitrogen content at start of growth (=0 --> $N_l(t_o)=n_{lMax}W_l(t_o)$) or by the nitrogen available in the pool (=1 --> $N_l(t_o)=(N_{lo}$ MIN $N_a)$) (-)
0

QSUD
(u-u_o) Absolute change in microbial growth rate (d^{-1})
0

QSUR
(u/u_o) Relative change in microbial growth rate (-)
1

RESPK
Respiration coefficient accounts for carbon losses due to maintenance (at 10°C) . (Not used if RESPK=0) (gDW gDW^{-1}d^{-1})
0

ZDAYE

(t_e) Day number at the end of seasonal growth (≤365) (d)

365

ZSALIR

(A_{li}'/A_{lio}') Relative change of leaf area growth (-)

1

ZSTBAD

(Switch) 0 or 1; =1 implies that the areal leaf weight is given as a driving variable (DBA). OBS! Then ZSTBAC should be 0. FORLEAF-switch must be ON. (-)

0

ZSWLR

(W_l'/W_{lo}') Relative change of leaf growth (-)

1

7 OUTPUTS

Output variables are stored in a PG-structured file named SOILNnnn.BIN where nnn is the current run number. Also, a list of output variables are found in the summary file named SOILNnnn.SUM. The variables to be stored in the summary file can be selected by the switch LISALLV.

The output variables are divided into four categories:
states (=X), flows (=T), auxiliaries (=G) and drivings (=D).
Asterix (*) means that the variable have different meaning depending on if the CROP-switch or FORESTSR-switch is put ON.

Symbols given in brackets refer to Eckersten (1991a) and Eckersten & Jansson (1991).

7.1 States

Variable	(Symbol) Explanation	Unit
CF	Carbon state: Faeces-C (Index= layer 1 to 2)	(gC m^{-2})
CL	Carbon state: Litter-C (Index=layer 1 to min(NUMLAY,10))	(gC m^{-2})
DENIT	Nitrogen state: Accumulated denitrification of NO3-N	(gN m^{-2})
DLOSST	Nitrogen state: Accumulated leaching of NO3-N	(gN m^{-2})
FERT	Nitrogen state: Solid fertilizer-N (undissolved)	(gN m^{-2})
GRAINW	(W_g) Biomass state: Grain dry weight	(gDW m^{-2})
GRAINN	(N_g) Nitrogen state : Grain-N	(gN m^{-2})
LEAFW	(W_l) Biomass state: Leaf dry weight	(gDW m^{-2})
LEAFN	(N_l) Nitrogen state : Leaf-N	(gN m^{-2})
LITABOVE	Nitrogen state: Harvest residue-N above ground	(gN m^{-2})
NF	Nitrogen state: Faeces-N (Index= layer 1 to 2)	(gN m^{-2})
NH	Nitrogen state: Humus-N (Index=layer 1 to min(NUMLAY,10))	(gN m^{-2})
NH4	Nitrogen state: ($N_{NH4}(i)$) NH4-N (Index= layer 1 to min(NUMLAY,10))	(gN m^{-2})
NLIT	Nitrogen state: Litter-N (Index=layer 1 to min(NUMLAY,10))	(gN m^{-2})
NO3	Nitrogen state: ($N_{NO3}(i)$) NO3-N (Index= layer 1 to NUMLAY)	(gN m^{-2})
PLANT	Nitrogen state: Plant-N (including roots)	(gN m^{-2})
ROOTW	(W_r) Biomass state: Root dry weight	(gDW m^{-2})
ROOTN	(N_r) Nitrogen state : Root-N	(gN m^{-2})
STEMW	(W_s) Biomass state: Stem dry weight	(gDW m^{-2})

STEMN	(N_s) Nitrogen state : Stem-N	($gN\ m^{-2}$)
XNAP	(N_{ap}) N in plant available for re-translocation (FORESTSR)	($gN\ m^{-2}$)
XNL	(N_l) N in leaves (FORESTSR)	($gN\ m^{-2}$)
XNQR	(N_{Qr}) N in roots older than one year (FORESTSR)	($gN\ m^{-2}$)
XNQS	(N_{Qs}) N in stems older than one year (FORESTSR)	($gN\ m^{-2}$)
XNR	(N_r) N in roots (FORESTSR)	($gN\ m^{-2}$)
XNS	(N_s) N in stem (FORESTSR)	($gN\ m^{-2}$)
XQR	(Q) Accumulated root growth since planting (or harvest) except the growth of the current year (FORESTSR)	($gDW\ m^{-2}$)
XQS	(Q_s) Accumulated stem growth since planting (or harvest), except the growth of the current year (FORESTSR)	($gDW\ m^{-2}$)
XWA	(W_a) Assimilates in plant available for flushing (FORESTSR)	($gDW\ m^{-2}$)
XWL	(W_l) Accumulated leaf growth of the current year (FORESTSR)	($gDW\ m^{-2}$)
XWR	(W_r) Accumulated root growth of the current year (FORESTSR)	($gDW\ m^{-2}$)
XWS	(W_s) Accumulated stem growth of the current year (FORESTSR)	($gDW\ m^{-2}$)

7.2 Flows

Variable	(Symbol) Explanation	Unit
ALEAFGW	Biomass flow : From leaf to grain * OBS! If FORESTSR-switch is ON then: (W_l') Leaf net growth	($gDW\ m^{-2}\ d^{-1}$)
ALEAFGN	Nitrogen flow : From leaves to grains * OBS! If FORESTSR-switch is ON then: (N_l'(in)) Nitrogen uptake to leaf growth.	($gN\ m^{-2}\ d^{-1}$)
APHOTLW	(W_r') Daily net root growth (FORESTSR)	($gDW\ m^{-2}\ d^{-1}$)
APHOTRW	(W_r'(in)) Daily gross root growth (FORESTSR)	($gDW\ m^{-2}\ d^{-1}$)
APHOTSW	(W_s'(in)) Daily gross stem growth (FORESTSR)	($gDW\ m^{-2}\ d^{-1}$)
AROOTGN	Nitrogen flow : from root to grain * OBS! If FORESTSR-switch is ON then: (N_r'(in)) Nitrogen uptake to root growth.	($gN\ m^{-2}\ d^{-1}$)
ASTEMGW	Biomass flow : From stem to grain * OBS! If FORESTSR-switch is ON then: (W_l'(ut)) Leaf fall rate	($gDW\ m^{-2}\ d^{-1}$)

ASTEMGN Nitogen flow : From stem to grains ($gN\ m^{-2}\ d^{-1}$)

* OBS! If FORESTSR-switch is ON then:
(N_s'(in)) Nitrogen uptake to stem growth.

CFLOSS Carbon flow: Faeces-C loss (mineralisation + humification) (Index= layer 1 to 2) ($gC\ m^{-2}\ d^{-1}$)

CLLOSS Carbon flow: Litter-C loss (mineralisation + humification) (Index= layer 1 to min(NUMLAY,10)) ($gC\ m^{-2}\ d^{-1}$)

DECALIT Nitrogen flow: Above-ground residue-N to litter-N (Index= layer 1 to 5) ($gN\ m^{-2}\ d^{-1}$)

DENI Nitrogen flow: Denitrification of NO3-N (Index= layer 1 to min(NUMLAY,10)) ($gN\ m^{-2}\ d^{-1}$)

DEP Nitrogen flow: Deposition (wet and dry) of mineral nitrogen to NO3-N layer 1 ($gN\ m^{-2}\ d^{-1}$)

DLOSS Nitrogen flow: NO3-N leaching to tiles (Index= layer 1 to NUMLAY) ($gN\ m^{-2}\ d^{-1}$)

FINCB Carbon flow: Carbon in faeces in manure to faeces-C (Index= layer 1 to 2) ($gC\ m^{-2}\ d^{-1}$)

FINNA Nitrogen flow: Nitrogen in bedding in manure to litter-N (Index= layer 1 to 2) ($gN\ m^{-2}\ d^{-1}$)

FINNB Nitrogen flow: Nitrogen in faeces in manure to faeces-N (Index= layer 1 to 2) ($gN\ m^{-2}\ d^{-1}$)

FINNH Nitrogen flow: Nitrogen in NH4 in manure to NH4-N (Index= layer 1 to 2) ($gN\ m^{-2}\ d^{-1}$)

FNIT Nitrogen flow: Nitrification of NH4-N to NO3-N (Index= layer 1 to min(NUMLAY,10)) ($gN\ m^{-2}\ d^{-1}$)

HARVGW Biomass flow : harvest of grain ($gDW\ m^{-2}$ veg.per.$^{-1}$)

* OBS! If FORESTSR-switch is ON then:
(W_a') Change of assimilates in plant available for flushing ($gDW\ m^{-2}\ d^{-1}$)

HARVGN Nitrogen flow : harvest of grains ($gN\ m^{-2}$ veg.per.$^{-1}$)

* OBS! If FORESTSR-switch is ON then:
(N_{ap}') Change of nitrogen in plant available for flushing ($gN\ m^{-2}\ d^{-1}$)

HARVLW Biomass flow : harvest of leaves ($gDW\ m^{-2}$ veg.per.$^{-1}$)

HARVLN Nitrogen flow : harvest of leaves ($gN\ m^{-2}$ veg.per.$^{-1}$)

HARVSW Biomass flow : harvest of straw ($gDW\ m^{-2}$ veg.per.$^{-1}$)

HARVSN Nitrogen flow : harvest of straw ($gN\ m^{-2}$ veg.per.$^{-1}$)

INCALIT Nitrogen flow: Plant-N to above-ground residue-N ($gN\ m^{-2}\ d^{-1}$)

NEWCL	Carbon flow: Incorporation of plant carbon or above-ground residues to litter-C (Index= layer 1 to min(NUMLAY,10))	($gC\ m^{-2}\ d^{-1}$)
NEWNL	Nitrogen flow: Plant-N to litter-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)
NFERT	Nitrogen flow: Solid fertilizer-N dissolved to NO3-N in layer 1	($gN\ m^{-2}\ d^{-1}$)
NFHUM	Nitrogen flow: Humification of faeces-N to humus-N (Index= layer 1 to 2)	($gN\ m^{-2}\ d^{-1}$)
NFLOW	Nitrogen flow: NO3-N flow between layers (Index= layer 1 to NUMLAY-1)	($gN\ m^{-2}\ d^{-1}$)
NFMIN	Nitrogen flow: Mineralisation of faeces-N to NH4-N (Index= layer 1 to 2)	($gN\ m^{-2}\ d^{-1}$)
NHARV	Nitrogen flow: Harvest export of plant-N	($gN\ m^{-2}\ d^{-1}$)
NHMIN	Nitrogen flow: Mineralisation of humus-N to NH4-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)
NLHUM	Nitrogen flow: Humification of litter-N to humus-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)
NLMIN	Nitrogen flow: Mineralization/immobilization of litter-N to NH4-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)
PHOS	(W_t') Biomass flow : Assimilation rate	($gDW\ m^{-2}\ d^{-1}$)
RESPGW	Biomass flow : respiration rate of grains (not used when RESPK=0)	($gDW\ m^{-2}\ d^{-1}$)
RESPLW	Biomass flow : respiration rate of leaves (not used when RESPK=0)	($gDWm^{-2}\ d^{-1}$)
RESPRW	Biomass flow : respiration rate of roots (not used when RESPK=0)	($gDW\ m^{-2}\ d^{-1}$)
RESPSW	Biomass flow : respiration rate of straw (not used when RESPK=0)	($gDWm^{-2}\ d^{-1}$)
UPPNH4	($X_{NH4u}(i)$) Nitrogen flow: Plant uptake of NH4-N to plant-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)
UPPNO3	($X_{NO3u}(i)$) Nitrogen flow: Plant uptake of NO3-N to plant-N (Index= layer 1 to min(NUMLAY,10))	($gN\ m^{-2}\ d^{-1}$)

7.3 Auxiliaries

Variable	(Symbol) Explanation	Unit
AEFF	Combined effect of soil water content and soil temperature on all biological processes except denitrification (in total profile)	(-)
AFR	(b_r) Root allocation function (=W_r'/W_t') (0-1)	(-)

ATEFF	Effect of soil temperature on the biological processes	(-)
BI	(b_i) Specific leaf area of the shoot (=A_{li}/W_{sh}).	(m^2 gDW^{-1})
CLTPROF	Litter-C in whole profile	(gC m^{-2})
LEAFDN	Nitrogen flow : leaves nitrogen demand	(gN m^{-2} d^{-1})
NCONC	Concentration of NO3-N in soil solution (Index= layer 1 to NUMLAY)	(mgN l^{-1})
NFTPROF	Faeces-N in whole profile	(gN m^{-2})
NGRAIN	(n_g) Actual nitrogen concentration of grain * OBS! If FORESTSR-switch is ON then: (P_d/v_d) Daily gross canopy photosynthesis at optimal temperature and water conditions (gDW m^{-2} d^{-1})	(-)
NH4T	NH4-N in whole profile	(gN m^{-2})
NHTPROF	Humus-N in whole profile	(gN m^{-2})
NLEAF	(n_l) Actual nitrogen concentration of leaf	(-)
NLTPROF	Litter-N in whole profile	(gN m^{-2})
NO3T	NO3-N in whole profile	(gN m^{-2})
NROOT	(n_r) Actual nitrogen concentration of root	(-)
NSTEM	(n_s) Actual nitrogen concentration of stem	(-)
ODNO3	"Partly measured" leaching of NO3-N to tile drainage system (from all layers) ,i.e., measured NO3 concentration multiplied by simulated water flows from drainage tile system.	(gN $m^{-2}d^{-1}$)
PIPEL	Leaching of NO3-N to tile drainage system (from all layers)	(gN m^{-2} d^{-1})
PIPENO3C	Concentration of NO3-N in tile drainage	(mgN l^{-1})
PIPEQ	Water flow to drainage tiles (from total profile)	(mmH_2O d^{-1})
POTUPT	(X_{Nd}) Potential plant uptake of NO3-N + NH4-N	(gN m^{-2} d^{-1})
QNO3C1	Concentration of NO3 in stream water.	(mgN l^{-1})
QNO3C2	Concentration of NO3 in stream water after N-consumption in stream.	(mgN l^{-1})
RATCNF	C-N ratio of faeces (Index = layer 1 to min(NUMLAY,10))	(-)
RATCNL	C-N ratio of litter (Index = layer 1 to min(NUMLAY,10))	(-)
ROOTDEPTH	(z_r) Root depth	(m)
ROOTDN	Nitrogen flow : roots nitrogen demand	(gN m^{-2} d^{-1})

RPTOT	(f_{Tot}) Photosynthesis response function, combined effect of soil water stress (ETR), nitrogen availability (RPN) and temperature (RPTEM) * OBS! If FORESTSR-switch is ON then: (P_{dOv}/v_d) Gross canopy photosynthesis at optimal temperature and water conditions for overcast day (gDW m^{-2} d^{-1})	(-)
RPN	(f_N) Photosynthesis response function to nitrogen availability * OBS! If FORESTSR-switch is ON then: (P_{dCl}/v_d) ; Gross canopy photosynthesis at optimal temperature and water conditions for a clear day (gDW m^{-2} d^{-1})	(-)
RPTEM	(f_T) Plant growth response function to temperature	(-)
RUSENO3	NO3-N consumption in stream water	(gN m^{-2} d^{-1})
STEMDN	Nitrogen flow : stem nitrogen demand	(gN m^{-2} d^{-1})
STREAMQ	Water flow in stream	(mmH_2O d^{-1})
STREAMT	Total leaching of NO3-N to stream flow (including tile drainage, surface runoff and ground water percolation)	(gN m^{-2} d^{-1})
TOTDEN	Actual denitrification (from total profile)	(gN m^{-2} d^{-1})
TOTFI	Total leaching of NO3-N to stream flow after N-consumption in stream	(gN m^{-2} d^{-1})
TOTMAE	Flow of nitrogen in faeces in manure to faeces-N (in total profile)	(gN m^{-2} d^{-1})
TOTMAL	Flow of nitrogen in bedding in manure to litter-N (in total profile)	(gN m^{-2} d^{-1})
TOTMAN	Flow of nitrogen in NH4 in manure to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTNFMIN	Mineralization/immobilization of faeces-N to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTNHMIN	Mineralisation of humus-N to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTNIT	Nitrification of NH4-N to NO3-N (in total profile)	(gN m^{-2} d^{-1})
TOTNLMIN	Mineralization/immobilization of litter-N to NH4-N (in total profile)	(gN m^{-2} d^{-1})
TOTUPT	(X_{Nu}) Actual plant uptake of NO3-N + NH4-N, total profile	(gN m^{-2} d^{-1})
VDEV	(i_g) Index that determines the start of grain development * OBS! If FORESTSR-switch is ON then: ($P_d(1-r_g)/v_d$) Daily net canopy photosynthesis at optimal temperature and water conditions (kgDW ha^{-1} d^{-1})	(-)

7.4 Drivings

Variable	Explanation	Unit
DFLOW	Driving variables: Water flow to drainage tiles, ground water flow and surface runoff because of limited hydraulic conductivity in the soil. (Index= layer 1 to NUMLAY). DFLOW in the SOIL model.	(mmH_2O d^{-1})
ETR	Transpiration ratio (actual/potential)	(-)
INF	Driving variable: Infiltration of water into the soil surface (including infiltration from surface pool). INFIL + SPOOLINF in the SOIL model.	(mmH_2O d^{-1})
MEACONC	Measured concentration of NO3 in tile drainage.	(mgN l^{-1})
PERC	Driving variable: Ground water flow. PERC in the SOIL model.	(mmH_2O d^{-1})
RIS	(I) Solar radiation	(MJm^{-2} d^{-1})
	* OBS! If FORESTSR-switch is ON then: Radiation factor that can be (see switch FORDRIV):	
	(i) t_D ; Relative daily duration of sunshine	(-)
	(ii) t_{Sun} ; Duration of sunshine	(h d^{-1})
	(iii) ; Ratio between daily values of actual and clear sky global radiation.	(-)
	(iv) S_s ; Daily sums of global radiation (300-3000nm)	(MJ m^{-2} d^{-1})
	(v) O_v ; Mean daytime fraction of cloudiness	(-)
SURR	Driving variable: Surface runoff because of limited infiltration capacity in the soil surface. SURR in the SOIL model.	(mmH_2O d^{-1})
SURRE	Driving variable: Surface runoff because of limited hydraulic conductivity in the soil. SURRE in the SOIL model.	(mmH_2O d^{-1})
TA	(T) Air temperature	(°C)
TEMP	Driving variables: Soil temperature (Index= layer 1 to NUMLAY) TEMP in the SOIL model.	(°C)
THETA	Driving variables: Volumetric water content (Index= layer 1 to NUMLAY). THETA in the SOIL model.	(%)
WFLOW	Driving variables: Water flow between soil layers (Index= 1 to NUMLAY-1). WFLOW in the SOIL model.	(mmH_2O d^{-1})
DBA	NOT USED! (b_A) Areal leaf weight (= leaf biomass to leaf area ratio) (OBS! You should set: ZSTBAD=1 and ZSTBAC=0)	(gDW m^{-2})

7.5 Annual sums

If the FORESTSR-switch is ON then: In a special output file named SOILFOR.AUT the annual sums (in case of flow variables) of some variables (mainly those not available in the T-array) are presented in ASCII form. (in) and (ut) denote input and output, respectively. The variables are given in the following order in SOILFOR.AUT:

Shoot age		(year)
	******* Line break *******	
W_t'(in)	Total growth	(tonDW ha^{-1} y^{-1})
W_{sh}'(in) & W_{sh}'(ut)	Shoot growth	(tonDW ha^{-1} y^{-1})
W_r'(in) & W_r'(ut)	Root growth	(tonDW ha^{-1} y^{-1})
W_d'(0)(in)	Litter fall	(tonDW ha^{-1} y^{-1})
W_a	Available pool in plant	(tonDW ha^{-1})
	******* Line break *******	
N_l'(in) & N_l'(ut)	Leaf nitrogen	(kgN ha^{-1} y^{-1})
N_s'(in)	Stem nitrogen	(kgN ha^{-1} y^{-1})
N_r'(in) & N_r'(ut)	Root nitrogen	(kgN ha^{-1} y^{-1})
	******* Line break *******	
N_d(0)'(in)	Litter fall	(kgN ha^{-1} y^{-1})
N_{ap}'(in) & N_{ap}'(ut)	Available pool in plant	(kgN ha^{-1} y^{-1})
N_{ap}	Available pool in plant	(kgN ha^{-1})
N_{lfl}'(in)	Leaching from falling leaves	(kgN ha^{-1} y^{-1})
N_{Harv}	Nitrogen taken away through harvest	(kgN ha^{-1} y^{-1})
W_{Harv}	Biomass taken away through harvest	(kgN ha^{-1} y^{-1})

8 Run options

Are used to specify the timestep, the temporal representation of output variables and the period for the simulation.

8.1 Run no.:

8.2 Start date:

8.3 End date:

8.4 Output interval:

The output interval determines how frequent the output variables will be written to the output file. The actual representation of the requested output variables can either be a mean value of the whole time interval or the actual value at time of output (see the switches, AVERAGEX, T.., G.., D..). You can specify the output interval as integers with units of days or minutes.

days:

minutes:

8.5 No of iterations:

The time step of the model is one day. No other values are allowed.

8.6 Run id:

Any string of characters may be specified to facilitates the identification of your simulation in addition to the run number. The identification given will be written in the variable identification field used by the Pgraph-program. Be careful when using long strings of characters since the default information for identification of a field may be overwritten in some cases.

8.7 Comment:

9 Execute

9.1 Exit

The exit command will terminate the interactive session and quit the program without starting a simulation. If a parameter file has been created the input will be saved otherwise all information entered will be lost.

9.2 Run

The run command will terminate the interactive session and start a simulation using the instructions entered. All the instructions are also written to the .SUM-file which may be used as a parameter file if you would like to reproduce the simulation.

9.3 Write parameter file

This will create a new parameter file which includes all the instructions which are specified when the command is given. The new parameter file can be used as an input file if you would like to run the model using instructions from the new parameter file.

10 Warnings and Errors

If you specify your input files or your parameter values in a strange way you may get informations about this before you start executing the model. There are two level: Warnings and Errors.

Normally you will be informed about warning or errors after you have modify a parameter value and moved to the new submenu. Some errors are the results of combinations of different parameters values and they may not occurr before you try to run the model. In this situation a final check of all input files and all relevant parameter values are made. If the final check results in any messages you can always return to the PREP program and continue to modify your instructions so they will be within valid ranges of accepted intervals. If you do so the list of messages are found in an window under the execute menu.

In case of errors, the most servere level, there are no chance to run the model but in case of only warnings you may try to run the model without correcting your instructions.

11 Commands

You start the preparation of a simulation by pressing

```
PREP SOILN
```

on the command line of the DOS system. This will be the starting point for adding any type of new instuctions for your simulation. If a parameter file named SOILN.PAR is present at the current directory default values from that file will be used otherwise original model default values will be used.

You can also start the interactive session with values taken from parameter file by entering the name of the parameter file name on the command line:

```
PREP SOILN DEMO
```

will result in default values from the parameter file DEMO.PAR.

You run the SOILN model in batch mode, which means that you will not make use of the interactive session at all. Instead you will run the model from default values.

```
PREP -b SOILN DEMO
```

which will result in a simulation making use of information from the DEMO.PAR file. If information is missing in the DEMO.PAR file values from the original model definition file will be used. A parameter file does not need to be complete. It may be restricted to only instructions that need to be changed compared to what is found in the original model definition file. There are also a possibility to specify a number of parameter files on the command line:

```
PREP -b SOILN DEMO NEWGROWTH NEWTIME
```

This means that the PREP program will first read the intructions in the DEMO.PAR file, then the NEWGROWTH.PAR file and finally the NEWTIME.PAR file. If information for one parameter is read several times the one read last will be used. Remember that the parameter files may not be complete. They can be organized with only information about evaporation in the NEWGROWTH.PAR file information about run options like time periods in the NEWTIME.PAR file.

12 Additional information

12.1 Help

Just press the F1 key and you are transferred to the help utility.

In some situations you will get simultaneous help as you move between different items in the ordinary menues. In such a case you are fully transferred to the help by using the F2 key which may be necessary if the information from the help library is not fully within the size of the current size of the help window.

12.2 Acknowledgement

The SOILN model is the result of many years work. A number of persons have contributed with ideas and suggestions. This could easily be seen from the reference list. The present updating of the SOILN model to fit the new interface (PREP program of January 1991) was a joint effort by the authors of this report. Per-Erik Jansson has a general responsibility for the model, Henrik Eckersten is responsible for the plant growth parts and Holger Johnsson is responsible for the soil nitrogen processes. For a future successful work with the model you are welcomed with your contribution. The development of the PREP program was made by Per-Erik Jansson and Jan Clareus.

If you get problems, find bugs or just want to report an interesting phenomena please let us know about it. Write to:

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Department of Soil Science
Swedish University of Agricultural Sciences
P.O. Box 7014
S-750 07 Uppsala
Sweden

*) Present P.O. Box for Holger Johnsson is 7072.

Remember to send a copy of your input data files and the commands used when you get any problems.

12.3 References

Papers and reports published with relevance for the SOILN model and publications referred to in the text.

SOILN nitrogen model

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12.4 News

Important changes in new versions will be mentioned here.

April 88
The GWFLOW switch was introduced to make it possible to handle soils with only deep percolation and no ground water flows in the simulated soil profile.

January 1989
The GROWTH switch was introduced . The growth rate of the crop with respect to nitrogen availability can be calculated .The carbon and nitrogen, fluxes and contents for the different parts of the plant (grains, leaves, straw and roots) are computed.

The help utility has been updated. All parameter and output variables are now included in the general help utility. The specific HELP reached after typing HELP is not needed any longer. Please use the F1 key for help at all stages in the simulation dialogue when you need help.

September 1990
The GROWTH switch activates the CROP_GROWTH submodel

March 1991
The SOILN model is now adapted to a new interface and a number of new features have been introduced in connection with this adaptation. The most important are found in the Switch section and in the section of input files. Also a number of parameters have been deleted, renamed, modified or introduced.

Conceptually the UPMOV parameter and the UPB parameters works differently.

New input file SOILP.DAT is introduced and the arrangement of the driving variables in the PG-file has been modified. A number of new driving variable files have also been introduced which can opionally be used instead of parameters for specifing management operations and other time dependent conditions.

June 1991
Some changes have been made on the CROP-GROWTH submodel. (i) The root allocation function is now also a function of plant biomass. (ii) The nitrogen dependency of this function has been changed. Previously it depended on the total canopy nitrogen concentration. Now it depends on the nitrogen concentration of the newly formed leaf tissues. (iii) Rootdepth is now a function of root biomass. (iv) Litterfall is introduced. (v) Some variable names have been changed.

August 1991
A submodel (FORESTSR) for growth, nitrogen uptake and allocation of a short rotation forest has been introduced. No changes of previous functions, parameter or variables have been made. One switch has been added. The GROWTH-switch now gives you the possibility to choose between the crop simulation (CROP-switch) and the forest simulation (FORESTSR-switch). Switches related to FORESTSR are named FOR... and four new parameter groups are introduced all named Forest ..... .

October 1991
Old input files can to some extent be used when running the new version of the model. The most important change is that the command files (normally called *.in and used with the -f switch on the command line) used to run the previous version of the model in batch mode are not used any longer. The instructions previously stored in this command file will, in the new system, be found in the parameter file.

The following files from previous versions of the model can be used:

File	Name	Comments
Initial values	*.INI	No change in format
Final values	*.FIN	No change in format, can be used as initial values for state variables
Driving variables	*.BIN	No change in format
Hydraulic soil properties	SOILP.DAT	Introduced as a new input file to the SOILN model (the same as used for the SOIL model)
Parameter file	*.PAR	Can be read, but a number of old parameter names do not exist any longer and new parameters have been introduced. The PREP program will tell you about parameter names that have been deleted and you are asked to correct your parameter file. An important difference is that the old parameter file contained all parameter names but no other information. The new parameter file contains only the valid parameters that have relevance for your run but in addition to that all other type of information that is needed to design a run with the model.

The following parameters in the old parameter file are modified or deleted:

Old parameter name	Substituted with
ALFA	DEVALFA
MANF	MANDEPTH
PLODAY	PLOUGHDAY
PLOLAY	PLOUGHDEP
ROOTL	ROOTDEP
ROOT	ROOTF
PORO	Now in SOILP.DAT file
WILT	Now in SOILP.DAT file
PFREE1-4	Deleted
ZNUM	Deleted
ZVER	Deleted

Förteckning över utgivna häften i publikationsserien fr o m 1989

SVERIGES LANTBRUKSUNIVERSITET, UPPSALA. INSTITUTIONEN FÖR MARKVETENSKAP. AVDELNINGEN FÖR LANTBRUKETS HYDROTEKNIK. AVDELNINGSMEDDELANDE.

89:1 Linnér, H., Persson, R., Berglund, K. & Karlsson, S.-E. Resultat av 1988 års fältförsök avseende detaljavvattning, markvård och markförbättring samt bevattning. 70 s.

89:2 Persson, L. & Jernlås, R. Apparat för kolonnexperiment under omättade förhållanden. Manuskript.

89:3 Berglund, K. Ytsänkning på mosstorvjord. Sammanställning av material från Lidhult, Jönköpings län. 18 s.

89:4 Messing, I. Saturated hydraulic conductivity as related to macroporosity in clay soils. 21 s.

89:5 Karlsson, I. M. Markbyggnad för bostads- och rekreationsområden. Prioritering av forskningsinsatser. 17 s.

89:6 Håkansson, A. Filtermaterial för dränering. Kommentarer till en serie demonstrationsprover av grus- och sågspånsmaterial. 11 s.

89:7 Persson, R. & Wredin, A. (red.). Vattningsbehov och näringstillförsel. Föredrag presenterade vid NJF-seminarium nr 151, Landskrona 1-3 aug 1989. 275 s.

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89:9 Sandsborg, J. & Bjerketorp, A. Kompendium i elementär hydromekanik. 8: Hydraulisk likformighet samt dimensionsanalys. 30 s.

89:10 Karlsson, I. M. Effekten av jordkonditioneringsmedlet ammonium-lauretsulfat på den hydrauliska konduktiviteten i vattenmättat tillstånd i två svenska lerjordar. 16 s.

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91:2 Persson, R. & Wesström, I. Markkemiska effekter av bevattning med Östersjövatten på Öland. 23 s + 5 bil.

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91:4 Eckersten, H. SPAC-GROWTH model. User's manual. 32 s.

91:5 Stenlund, S. Rainwater harvesting - Metoder för uppsamling av regnvatten för bevattning. En litteraturöversikt. 24 s.

91:6 Jansson, P-E., Eckersten, H. & Johnsson, H. SOILN model. User's manual. 49 s.