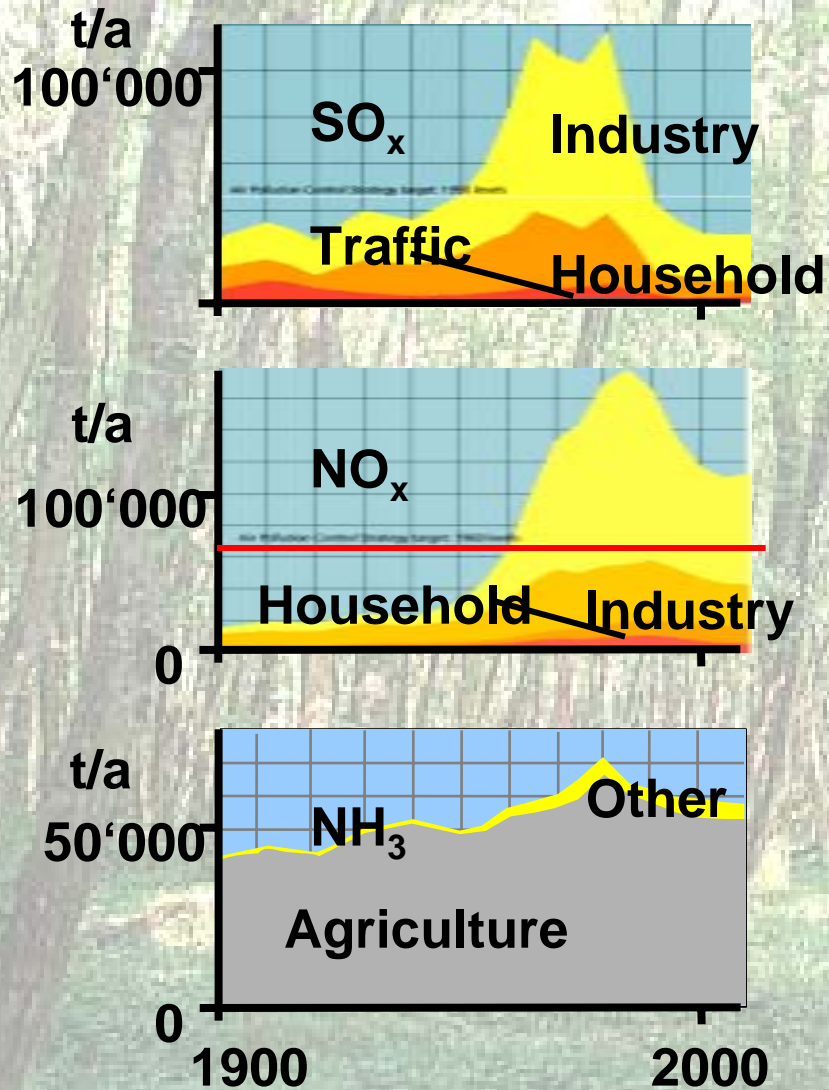


# Nitrogen cycle of selected Swiss ICP Forests level II plots

**Peter Waldner, Elisabeth Graf Pannatier, Maria Schmitt,  
Anne Thimonier, Lorenz Walthert**  
Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf

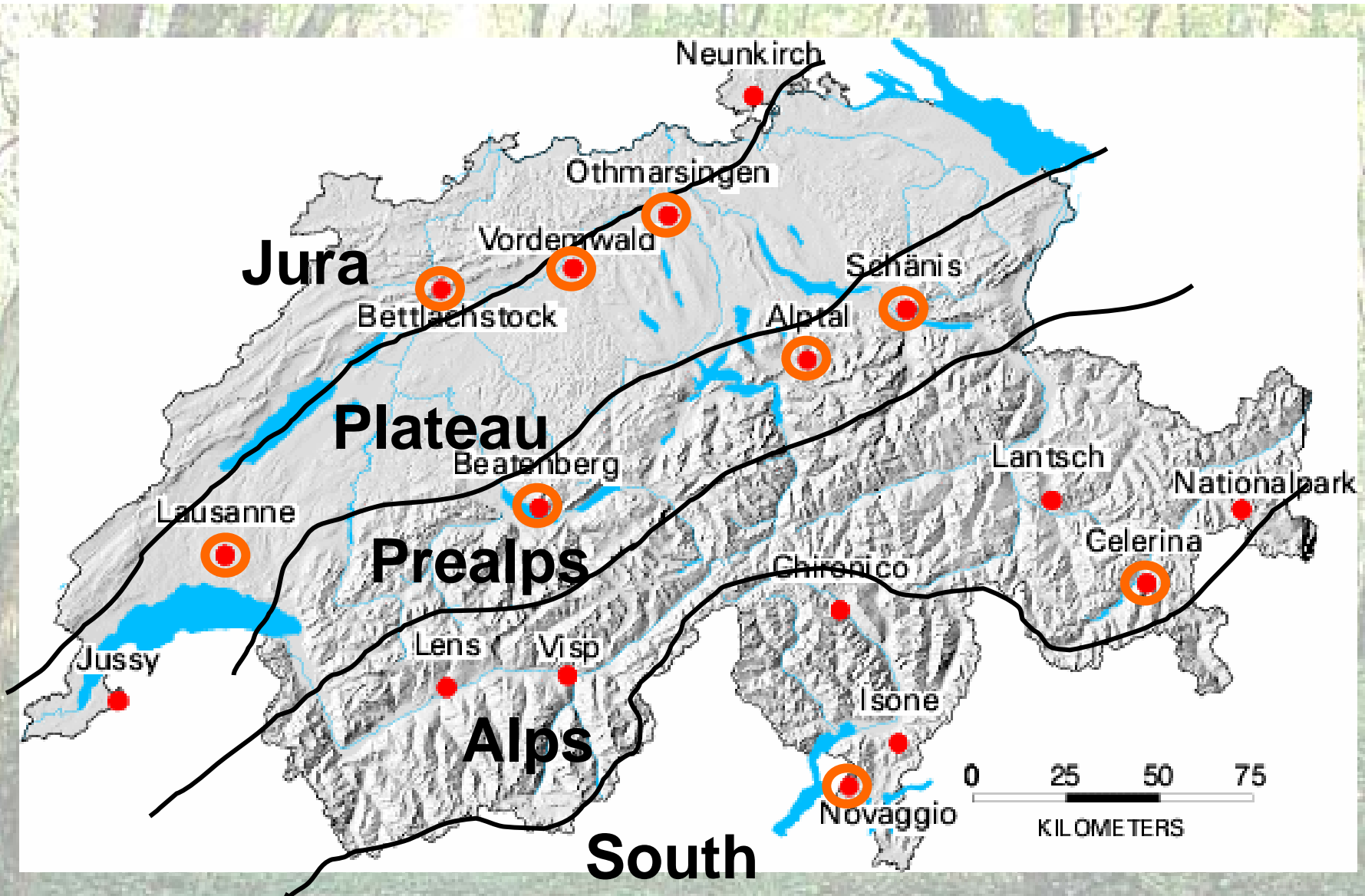


# Last century's increase



(BUWAL, 1997)

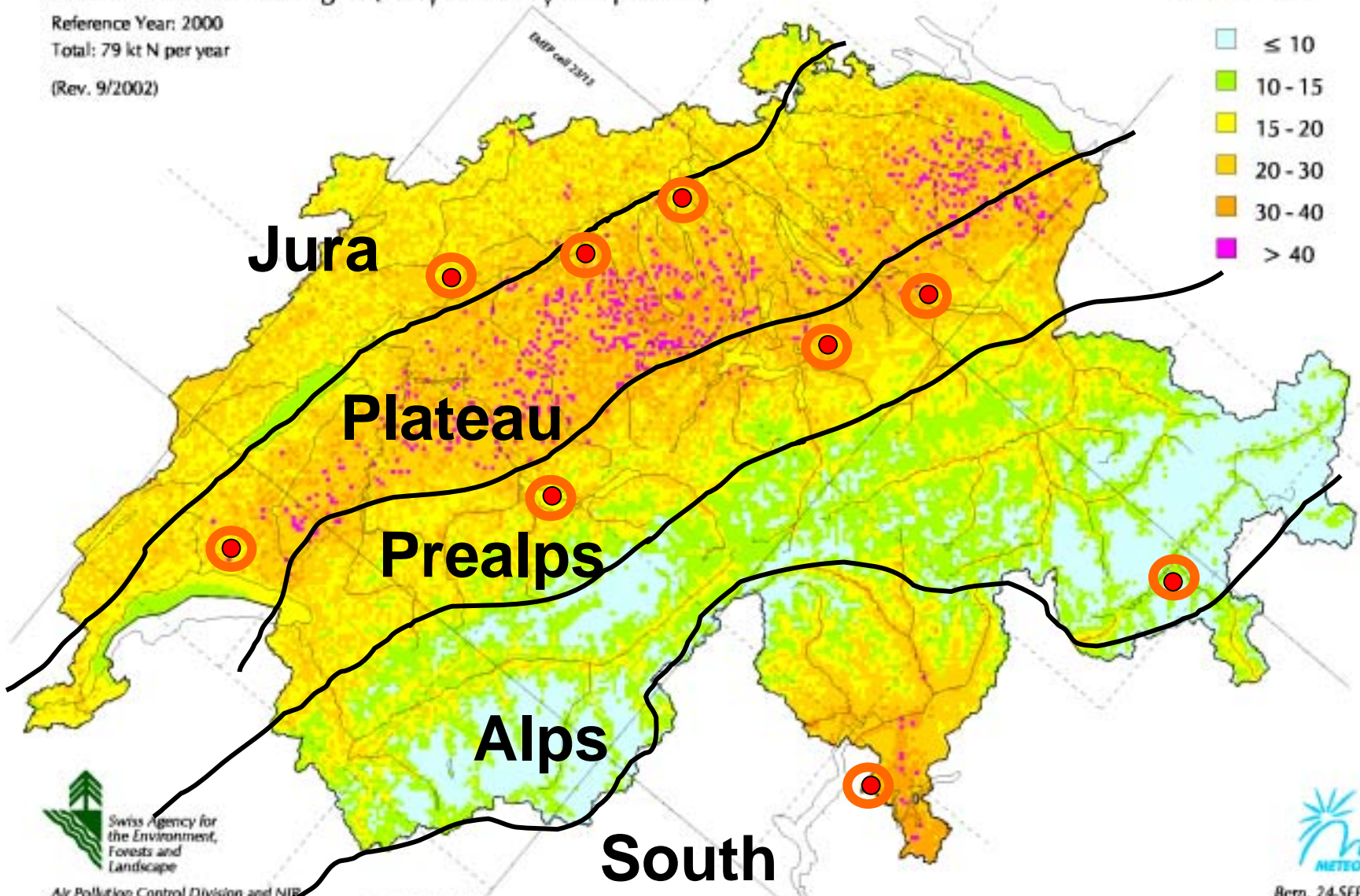
# Location of the plots



MAPPING CRITICAL LEVELS AND LOADS FOR SWITZERLAND:  
Present Loads of Nitrogen ( $\text{NH}_\gamma$  and  $\text{NO}_\gamma$  compounds)

Reference Year: 2000  
Total: 79 kt N per year  
(Rev. 9/2002)

Deposition Model  $1 \times 1 \text{ km}^2$   
Units:  $\text{kg N ha}^{-1} \text{yr}^{-1}$



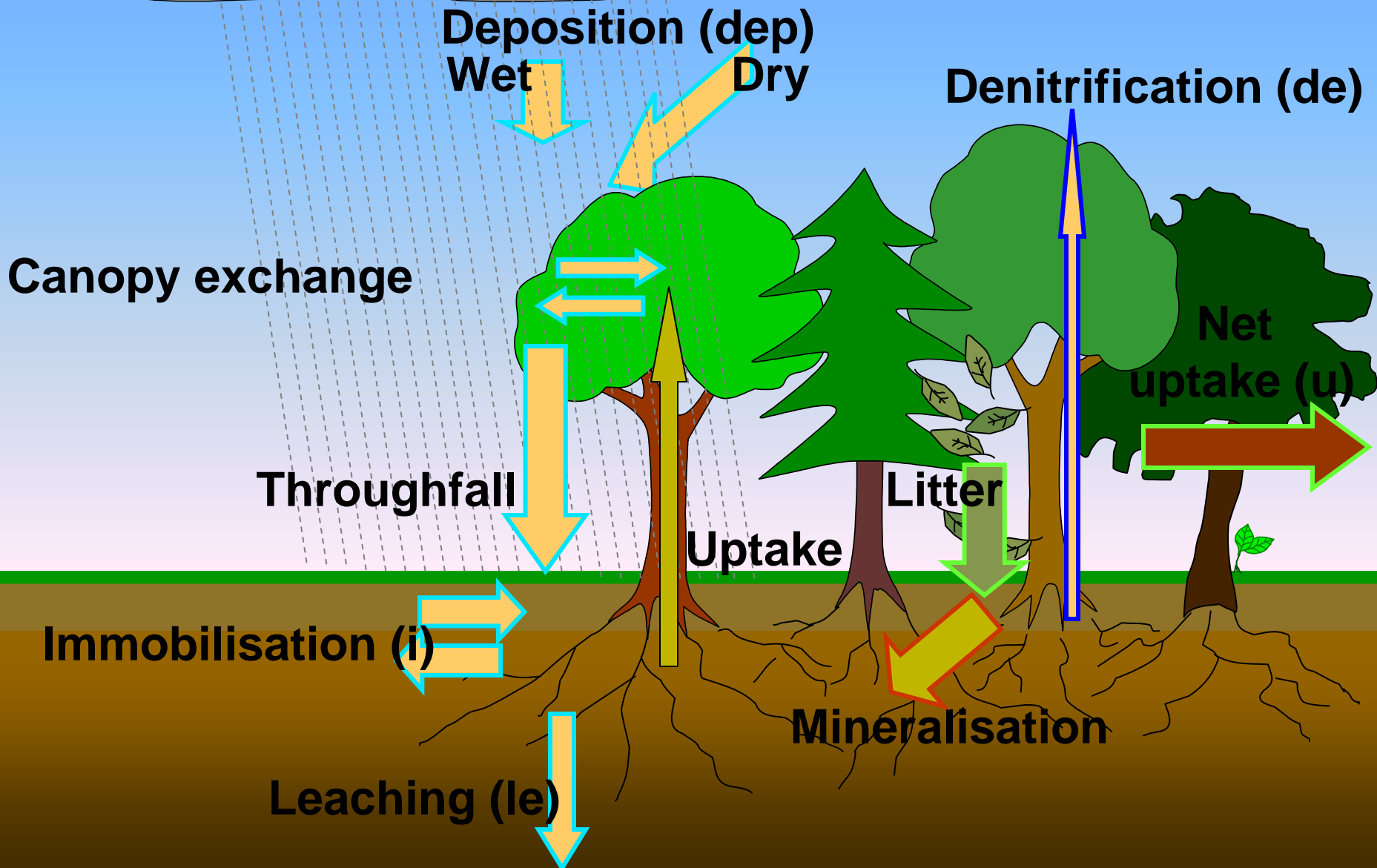
Air Pollution Control Division and NIP

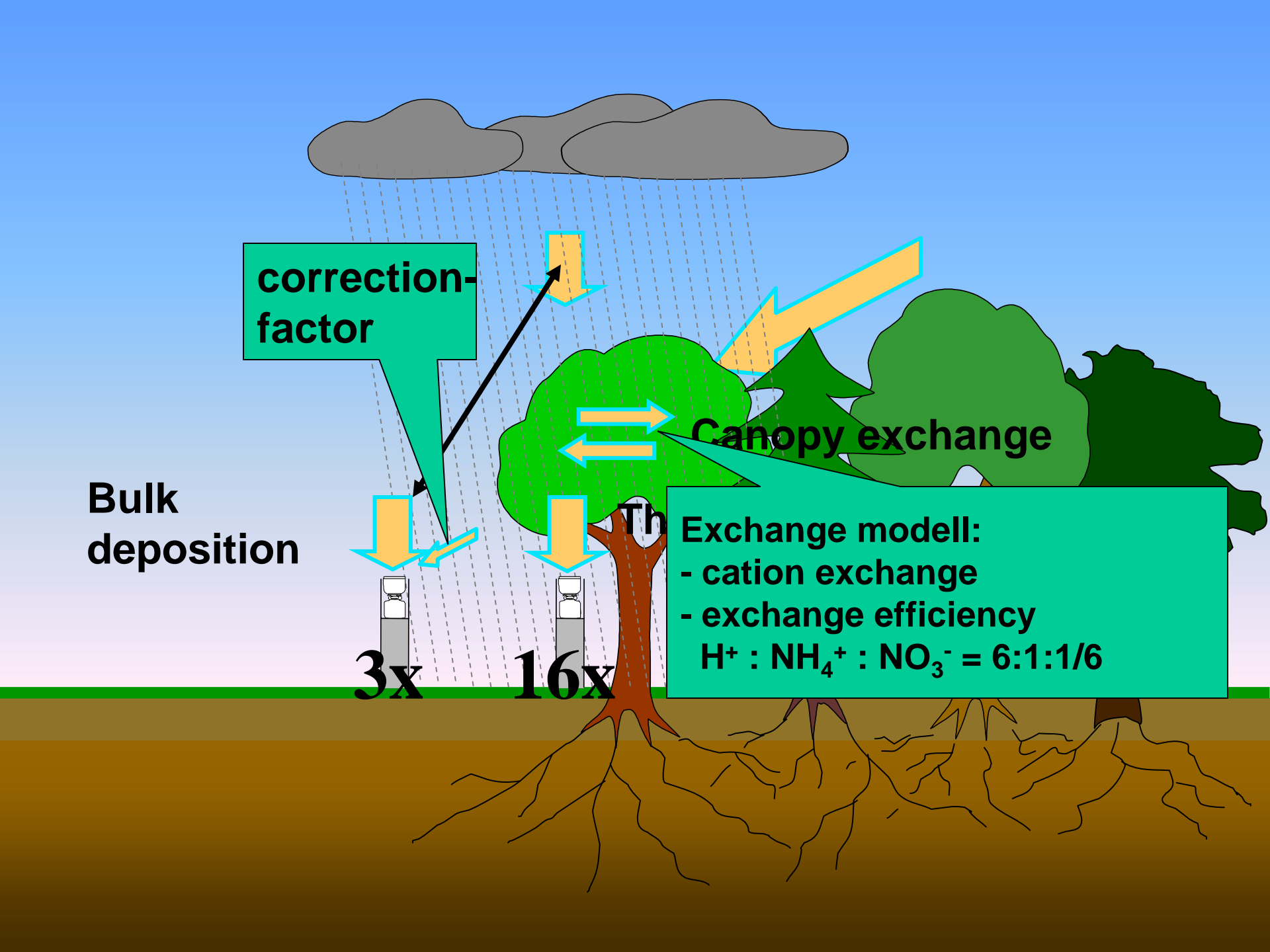
Land use: BFMGEOSTAT



Bern, 24-SEP-2002

# Nitrogen cycle





correction-factor

Bulk deposition

3x

16x

Exchange modell:  
- cation exchange  
- exchange efficiency  
 $H^+ : NH_4^+ : NO_3^- = 6:1:1/6$

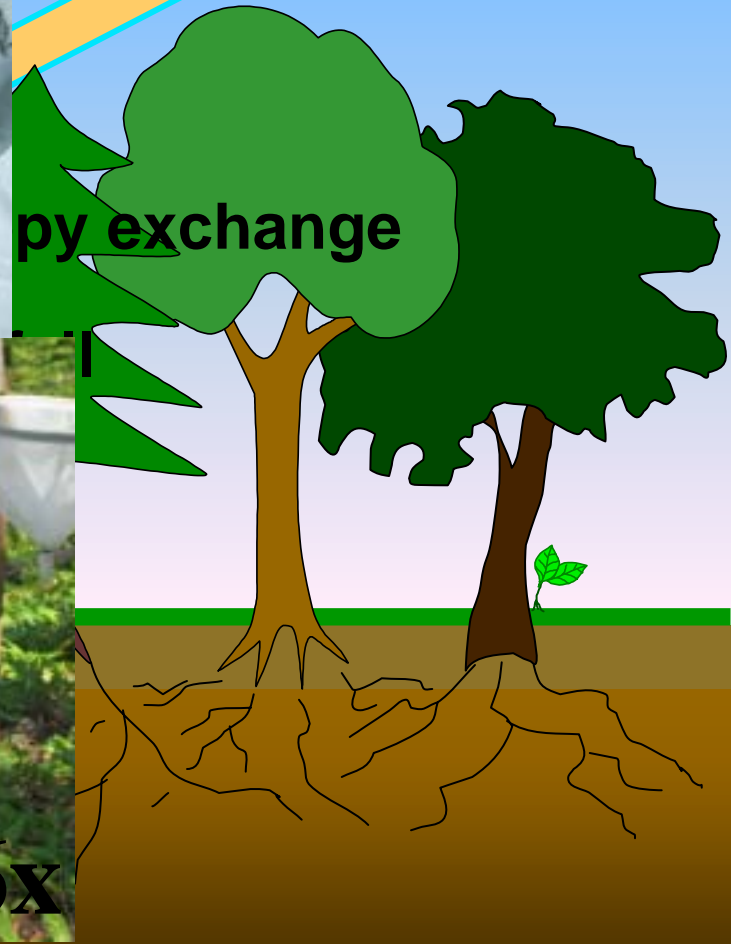
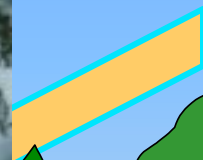
Canopy exchange



Winter:

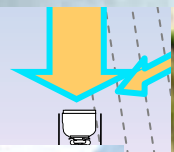
1x

4x



py exchange

deposition

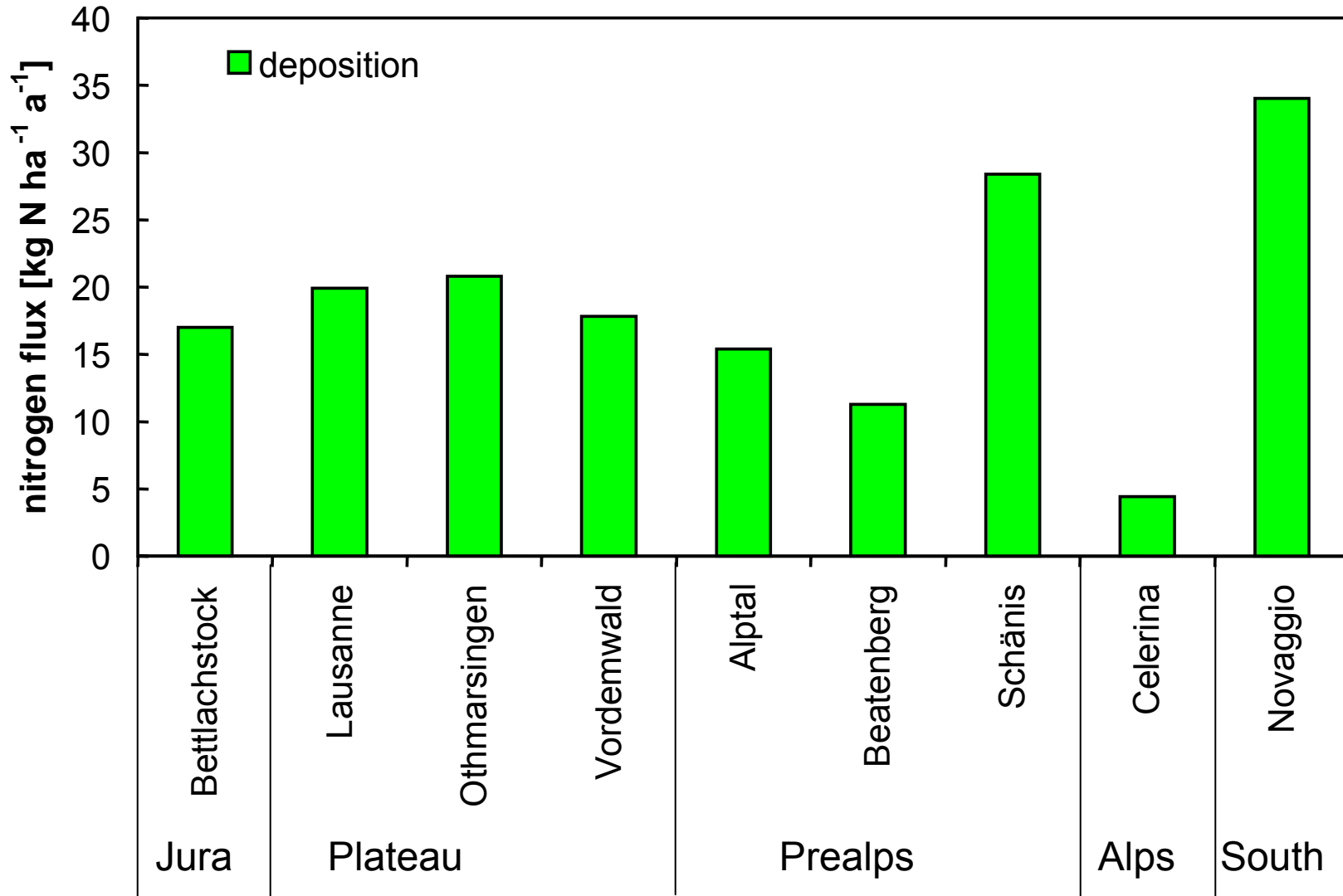


3x



16x

# Atmospheric Deposition of Nitrogen ( $N_{\text{dep}}$ )



# Nitrogen cycle: balance



$$N_{\text{dep}} = N_{\text{u}} + N_{\text{i}} + N_{\text{de}} + N_{\text{le}}$$

$N_{\text{dep}}$ : Deposition

$N_{\text{u}}$ : Uptake

$N_{\text{i}}$ : Immobilisation

$N_{\text{de}}$ : Denitrification

$N_{\text{le}}$ : Leaching

**(e.g. Manual, ICP Mapping and Modelling)**

# Critical Loads: **steady-state** mass balance

$$N_{\text{dep}} < CL_N = N_u + N_i + N_{\text{de}} + N_{\text{le acc}}$$

$N_{\text{dep}}$ : Deposition (measured)

$N_u$ : **Net** uptake (average harvest rate)

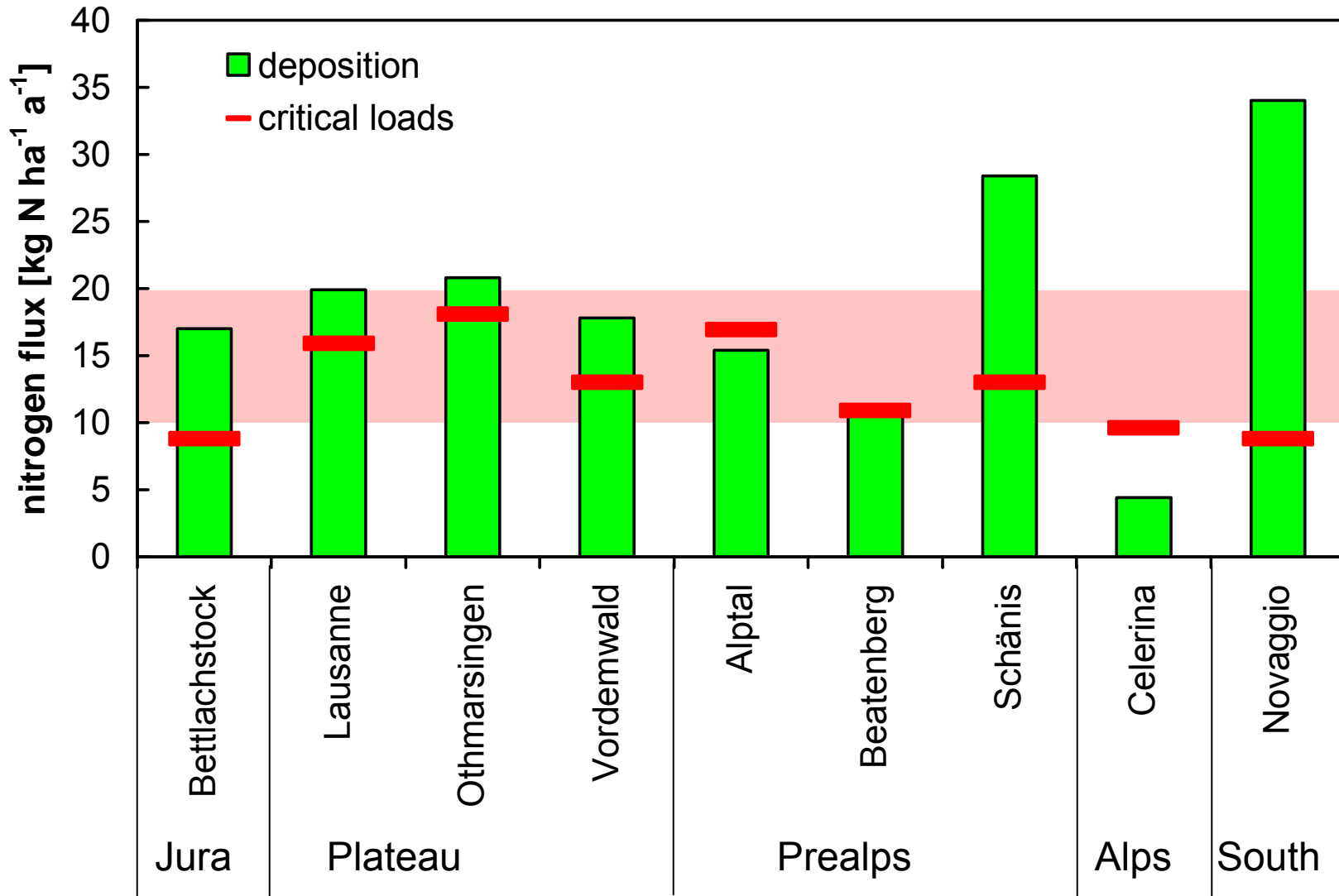
$N_i$ : **Net** immobilisation (estimate)

$N_{\text{de}}$ : Denitrification (estimate)

$N_{\text{le acc}}$  **Acceptable** Leaching (defined)

(e.g. Manual, ICP Mapping and Modelling)

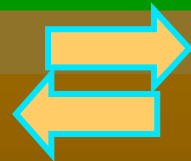
# Deposition and Critical Loads



# Nitrogen Leaching

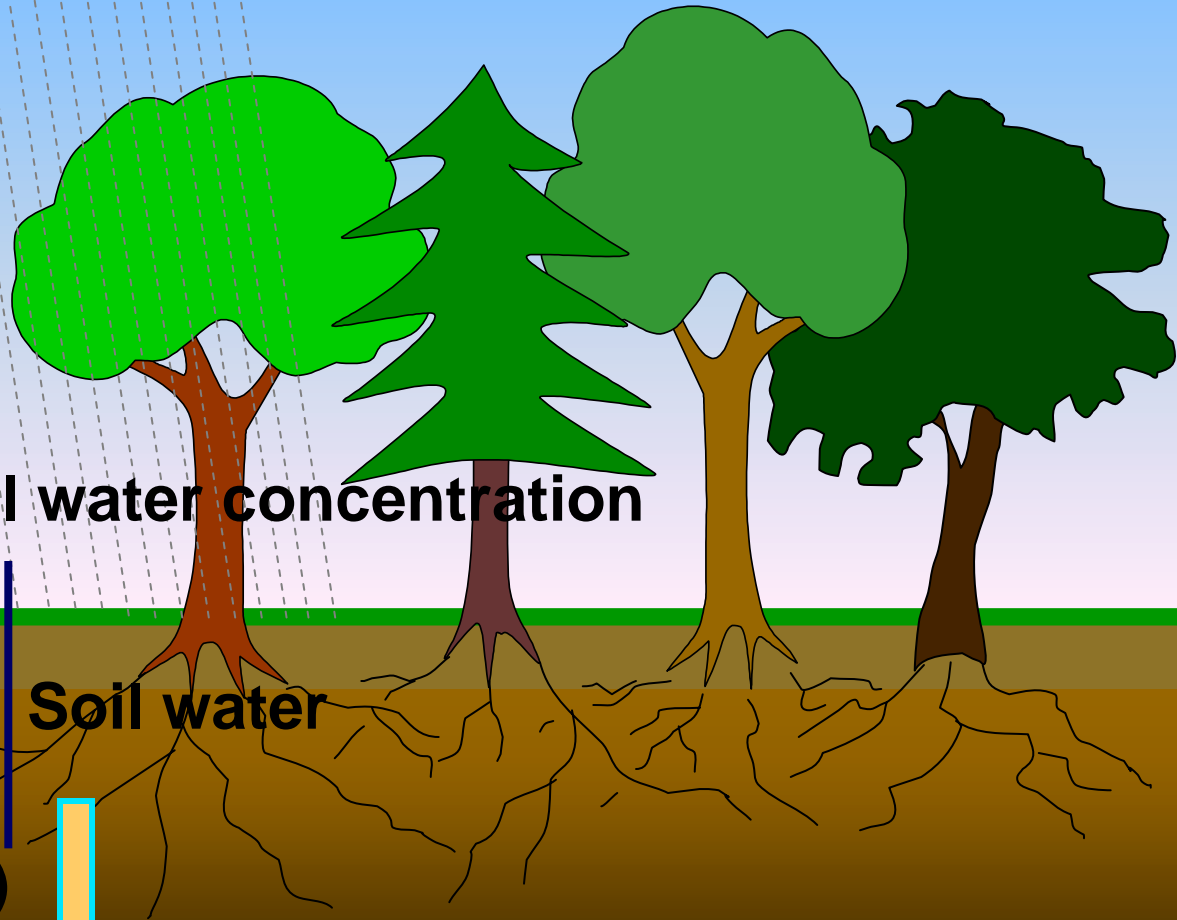
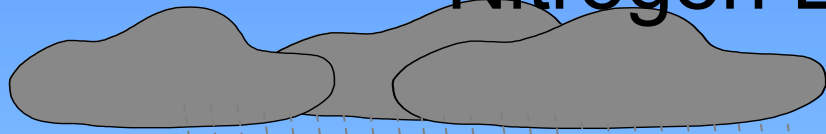
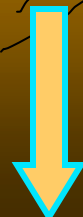


**Lysimeter: soil water concentration**



**Leaching (le)**

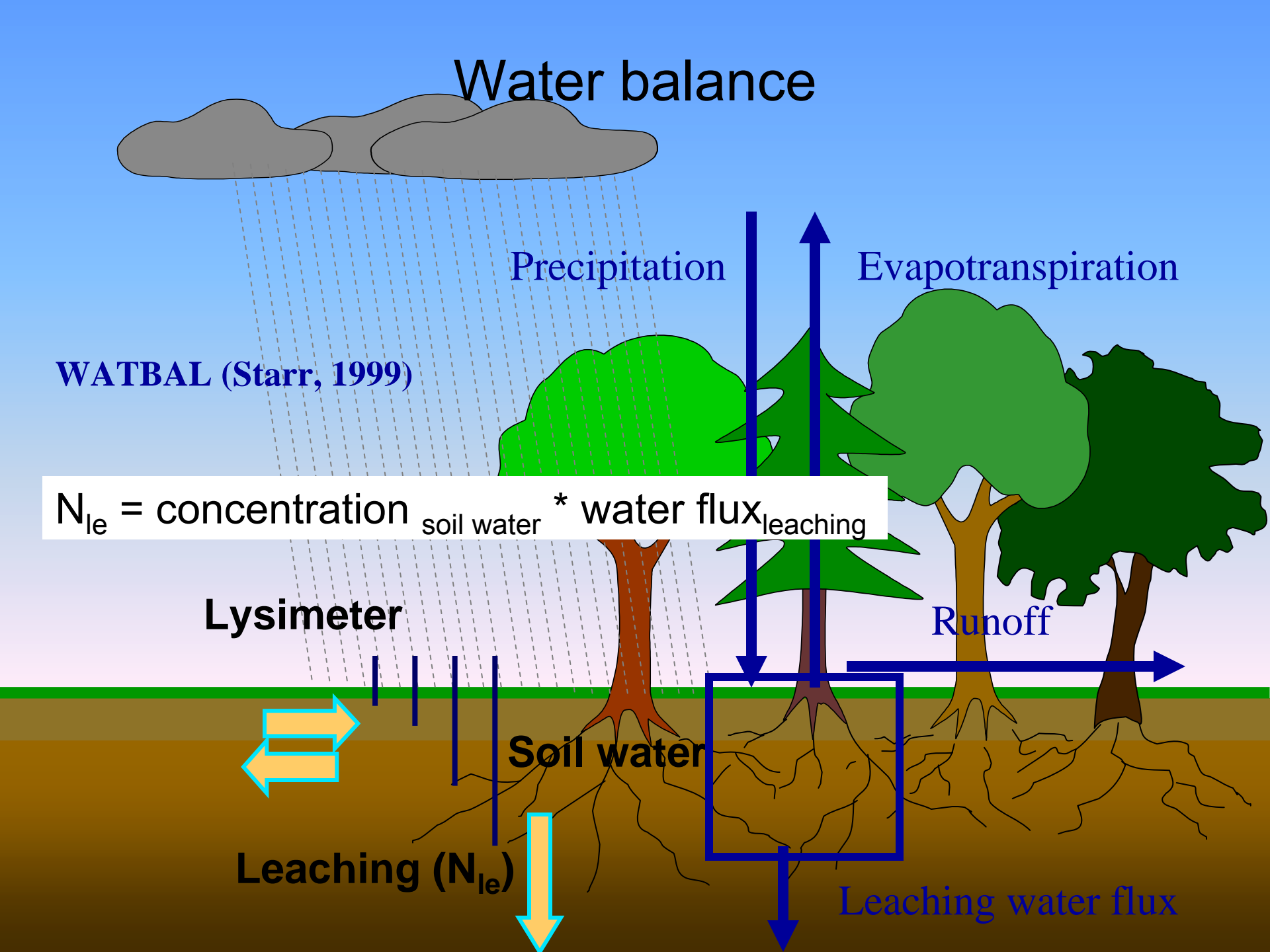
**Soil water**



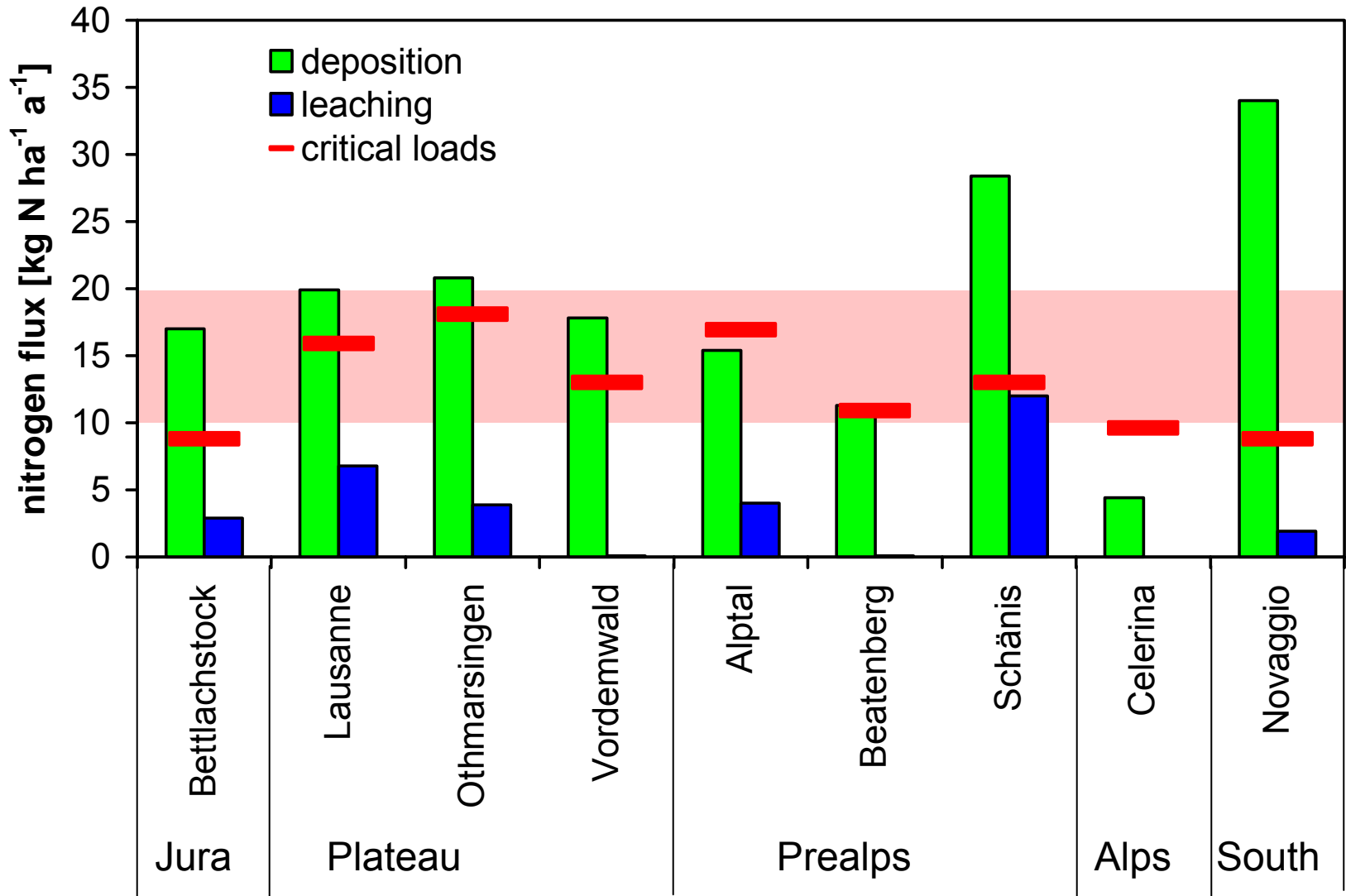
# Water balance

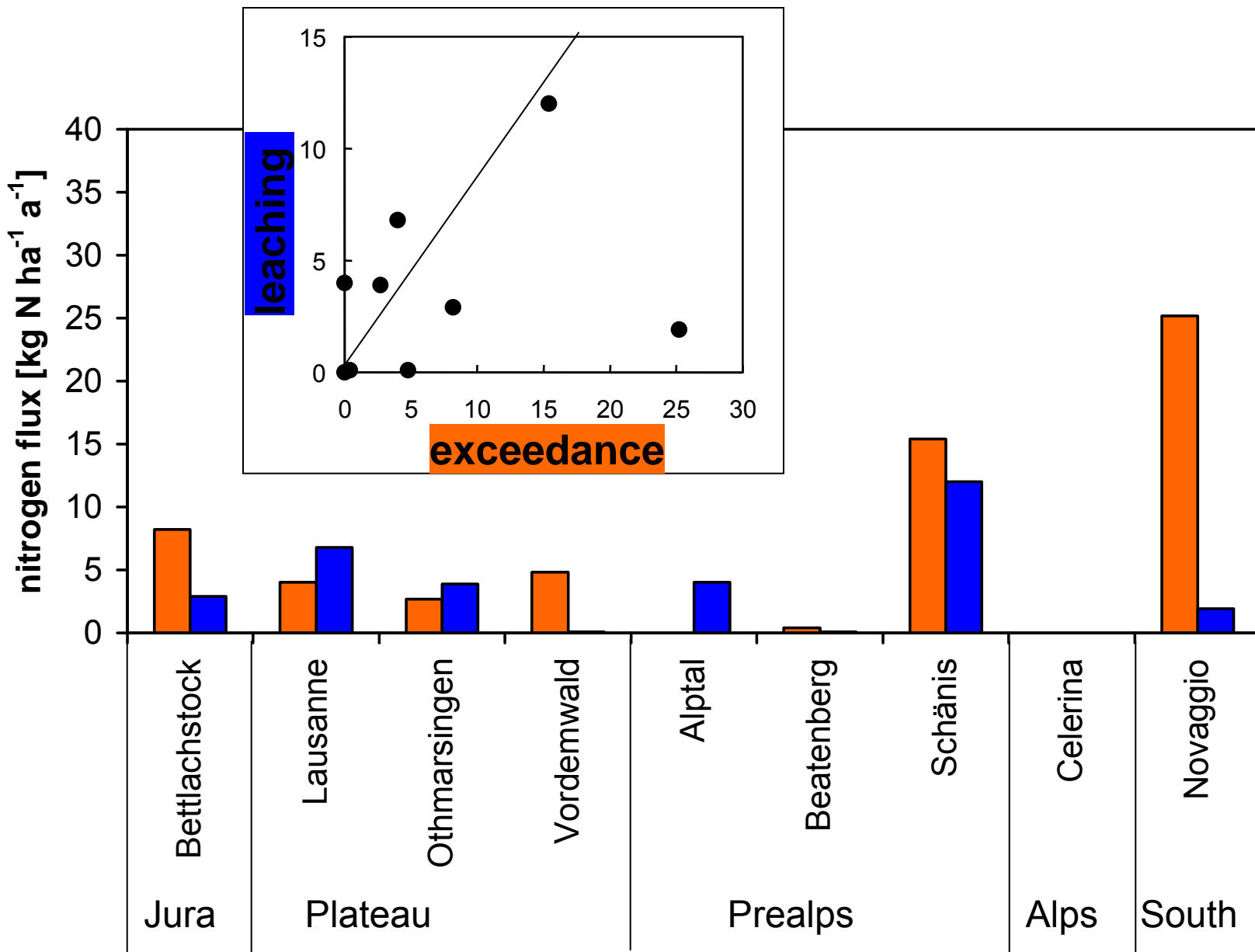
WATBAL (Starr, 1999)

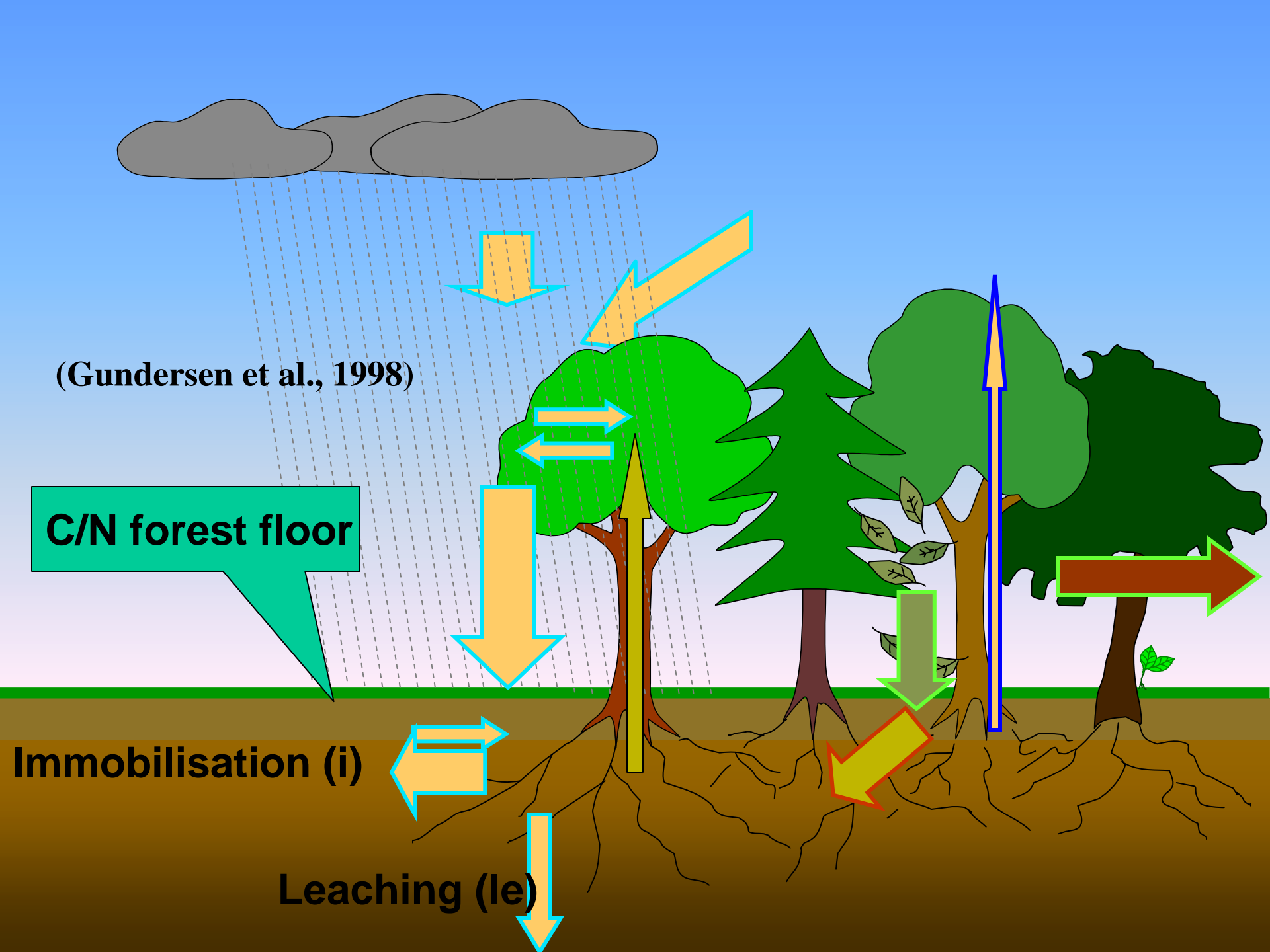
$$N_{le} = \text{concentration}_{\text{soil water}} * \text{water flux}_{\text{leaching}}$$

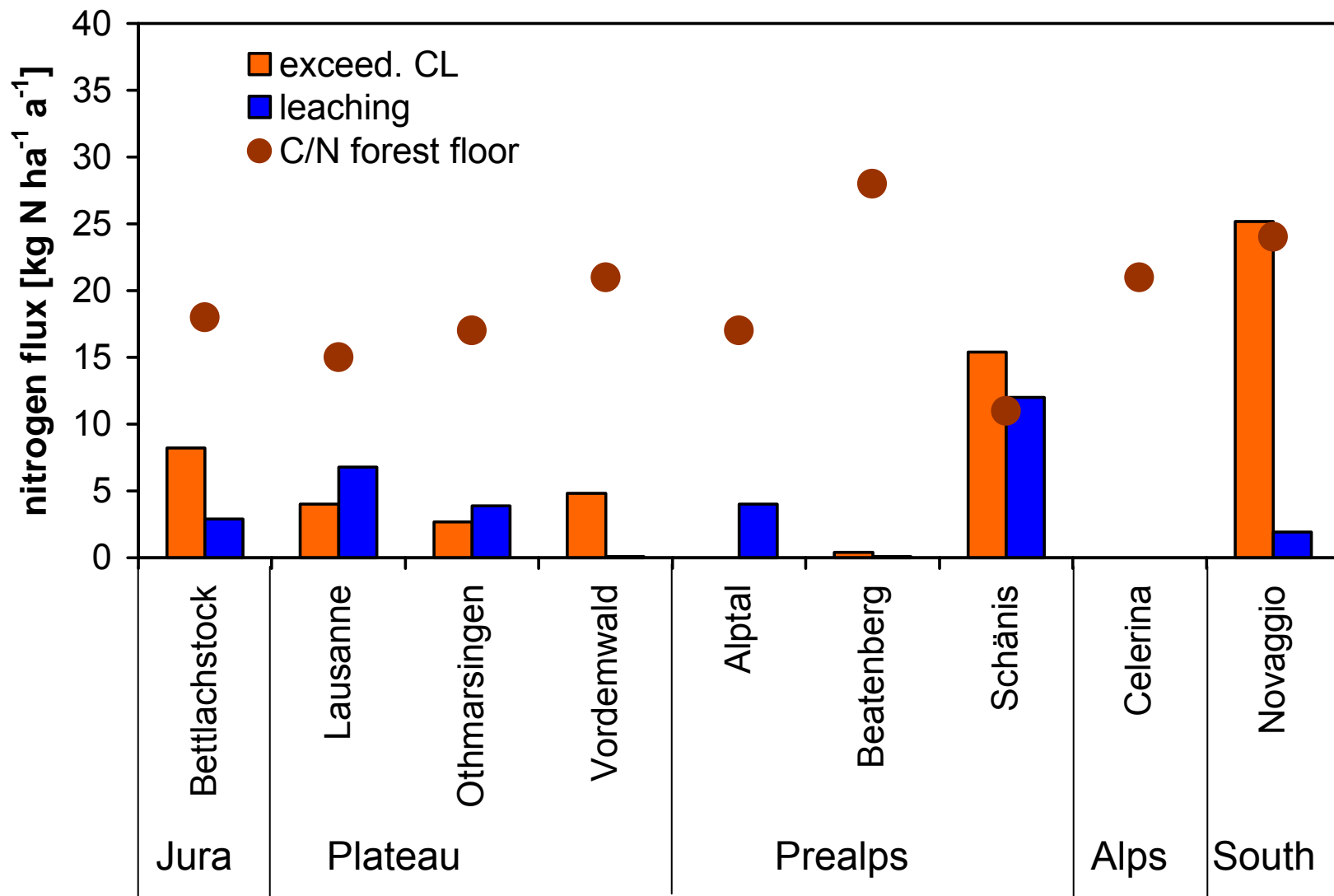


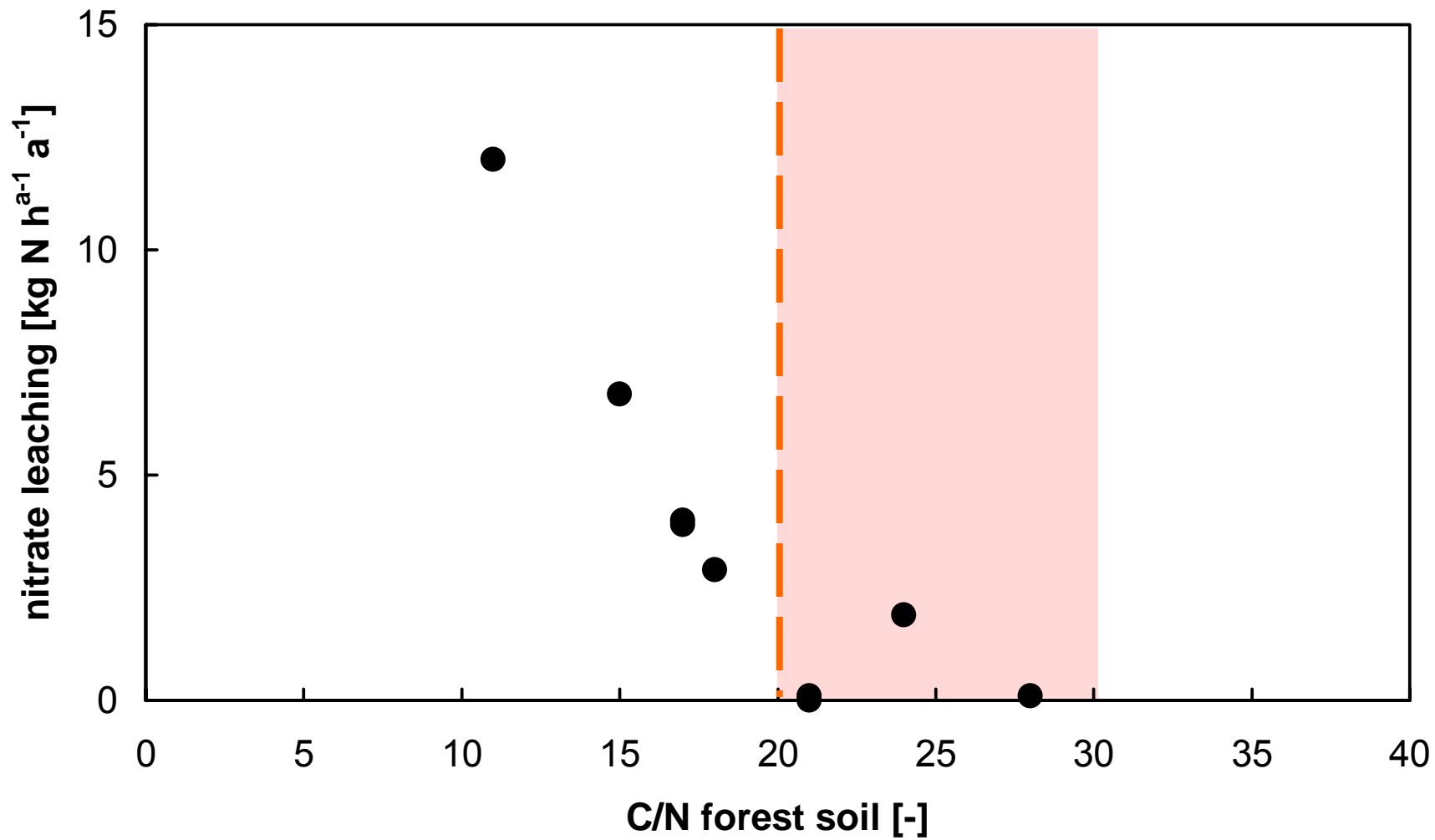
# Nitrate Leaching



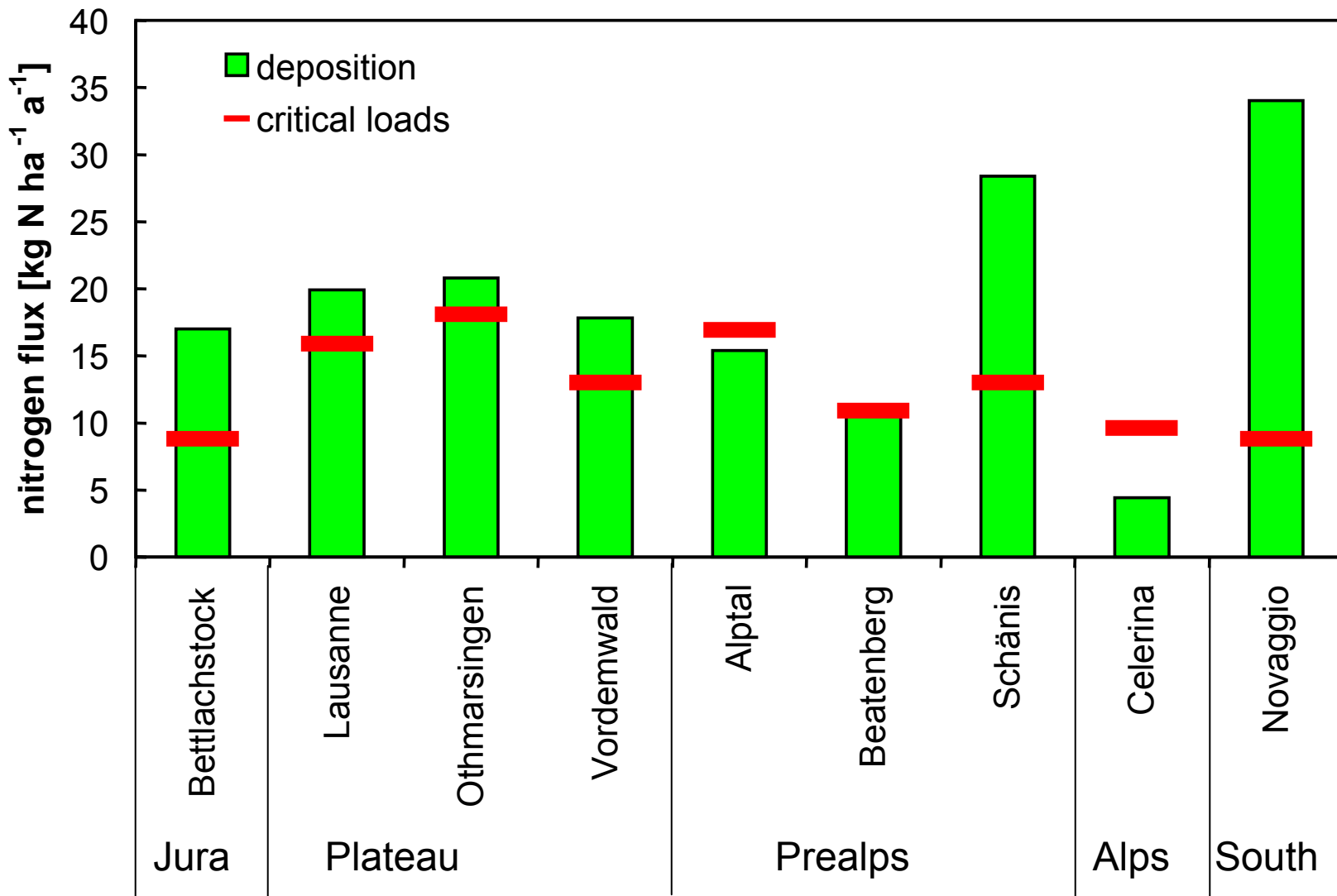


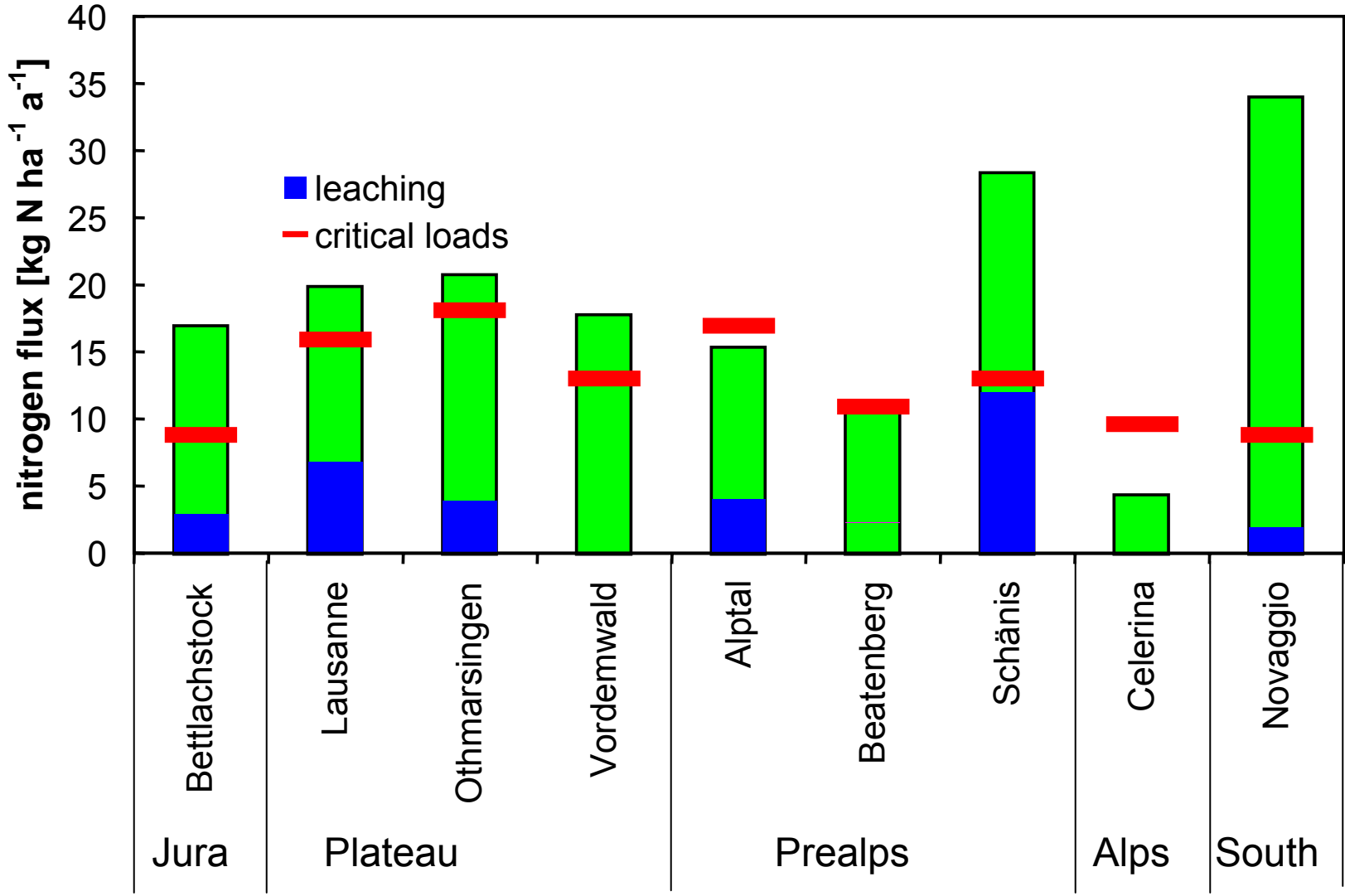






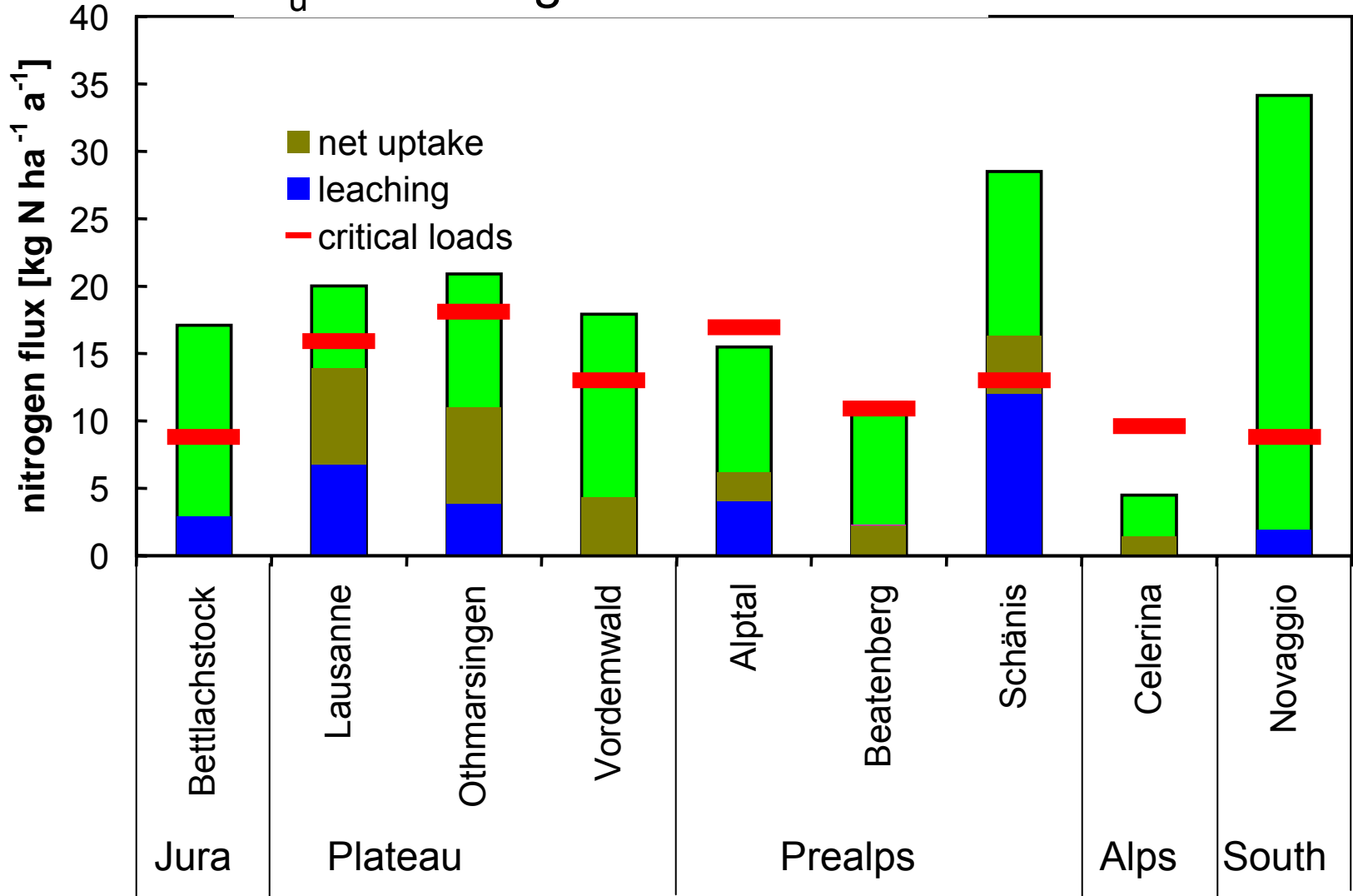
(see also Gundersen et al., 1998 and others)





# Net uptake ( $N_u$ )

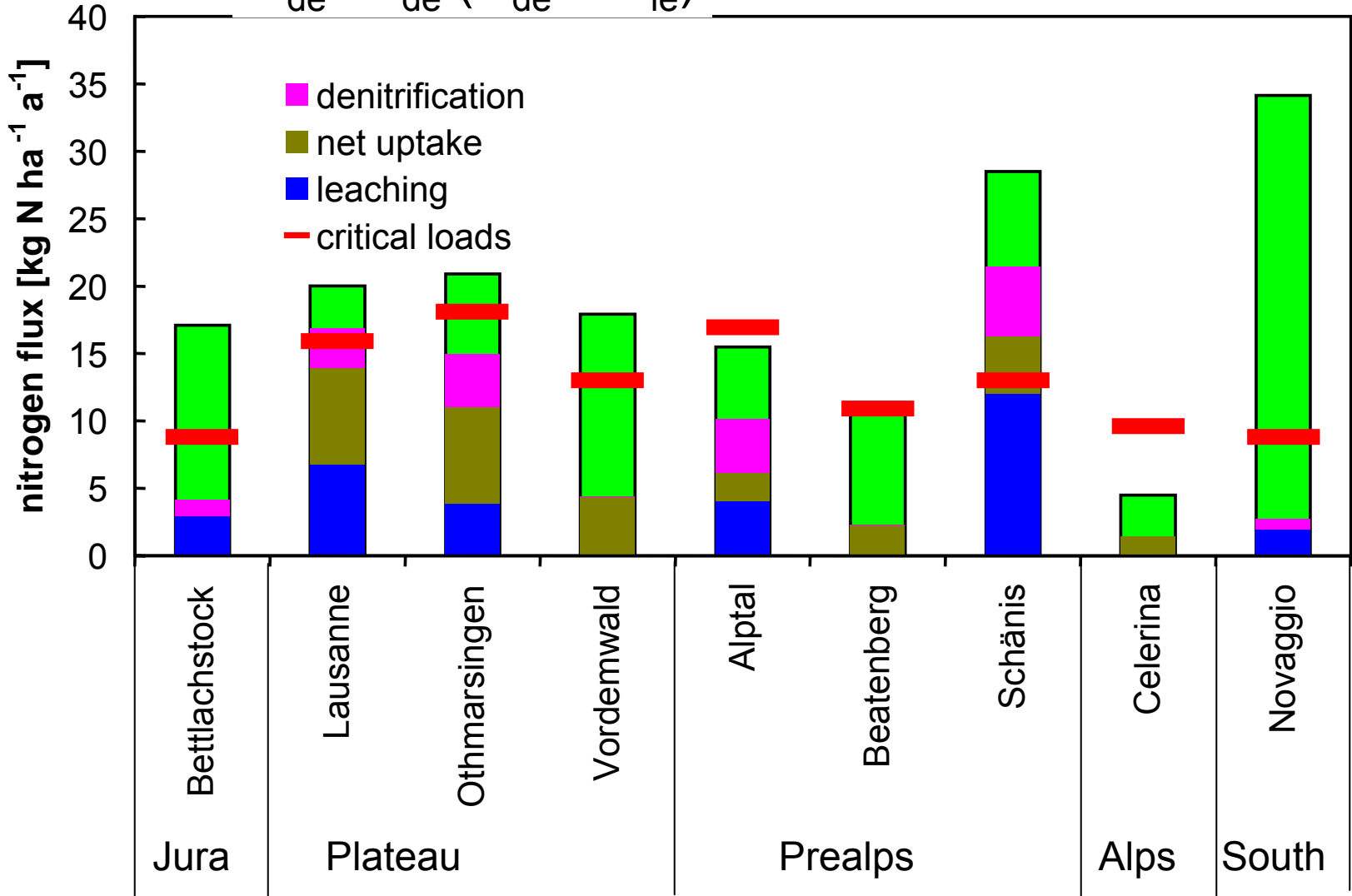
$N_u$ : mean regional harvest rate



# Denitrification ( $N_{de}$ )

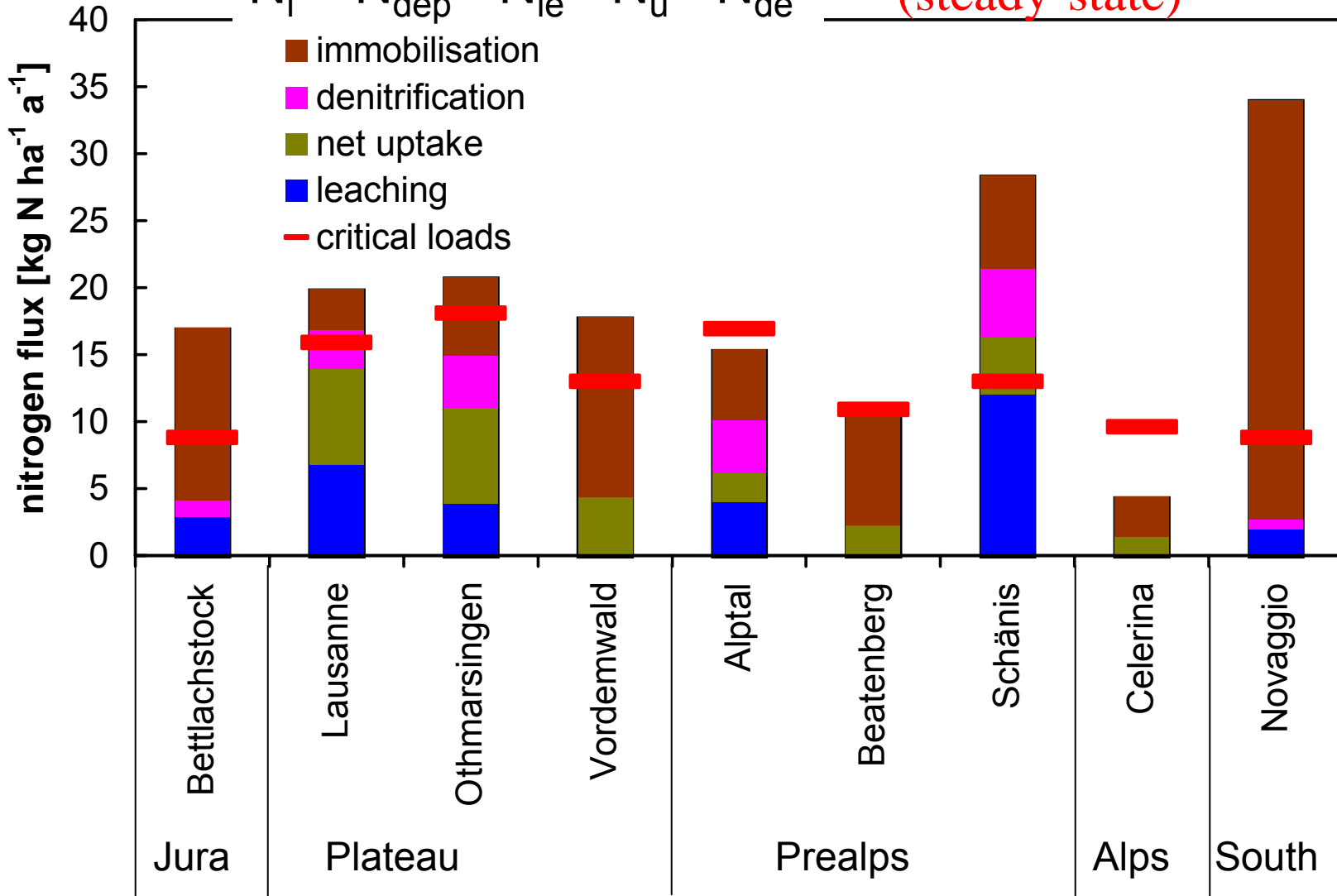
$$N_{de} = f_{de} (N_{de} + N_{le})$$

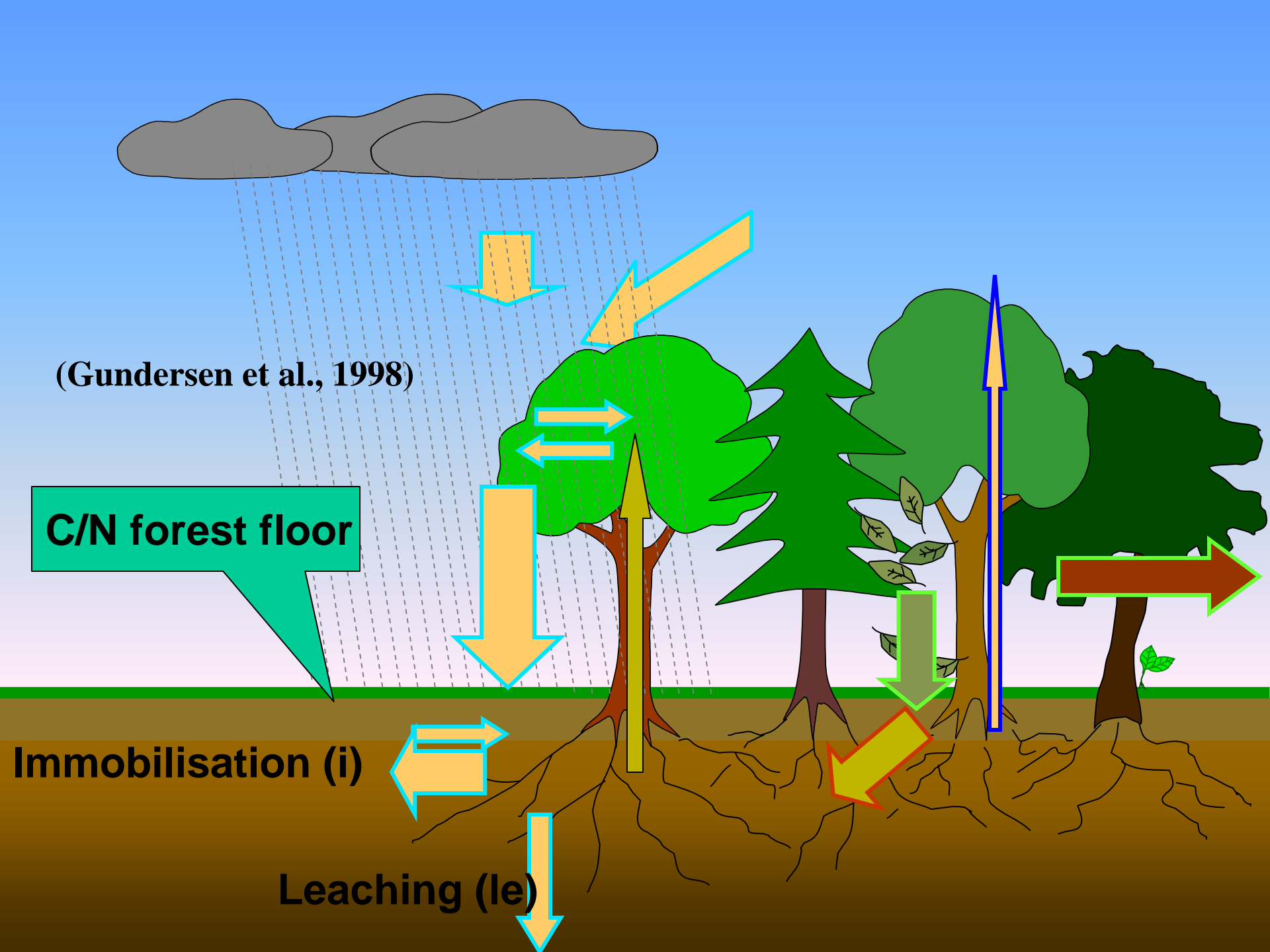
deVries, Lökeberg (Rihm, 1996)

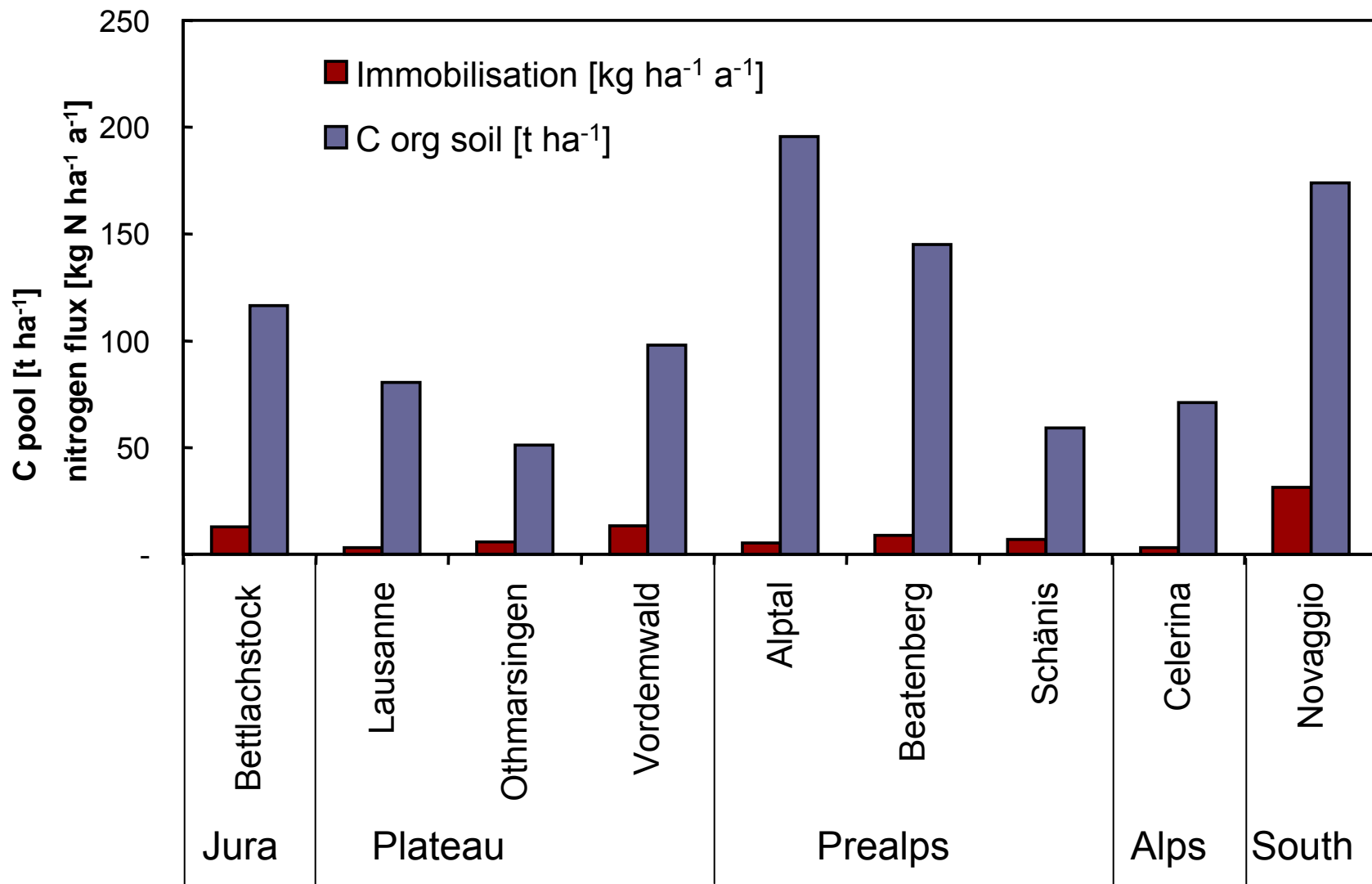


# Net immobilisation ( $N_i$ )

$$N_i = N_{\text{dep}} - N_{\text{le}} - N_{\text{u}} - N_{\text{de}} \quad \text{(steady-state)}$$



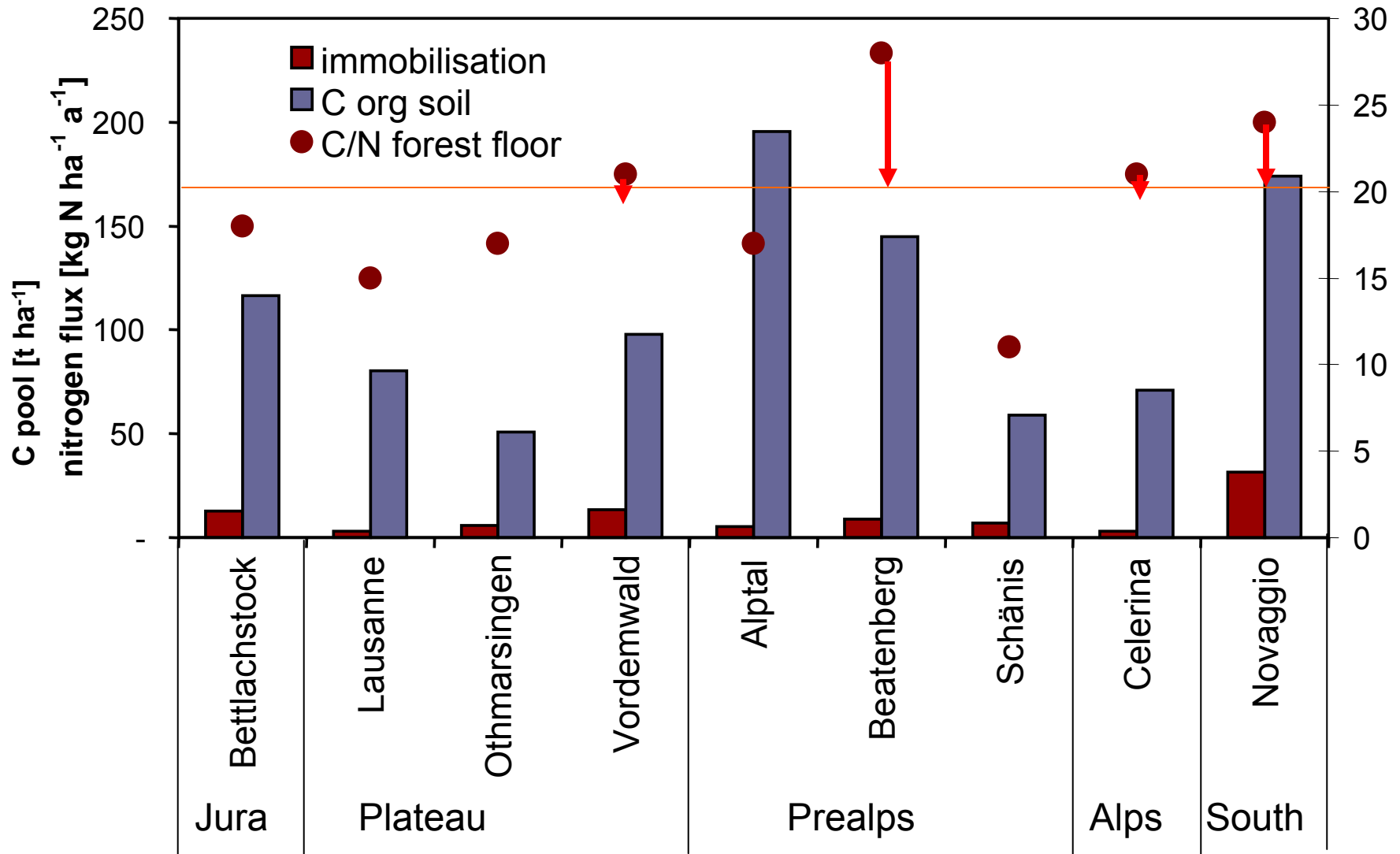




$C_{\text{pool}} = \text{const.}$

$$\Delta N = C_{\text{pool}} \cdot \left( \frac{1}{C/N^{\text{crit}}} - \frac{1}{C/N^{\text{actual}}} \right)$$

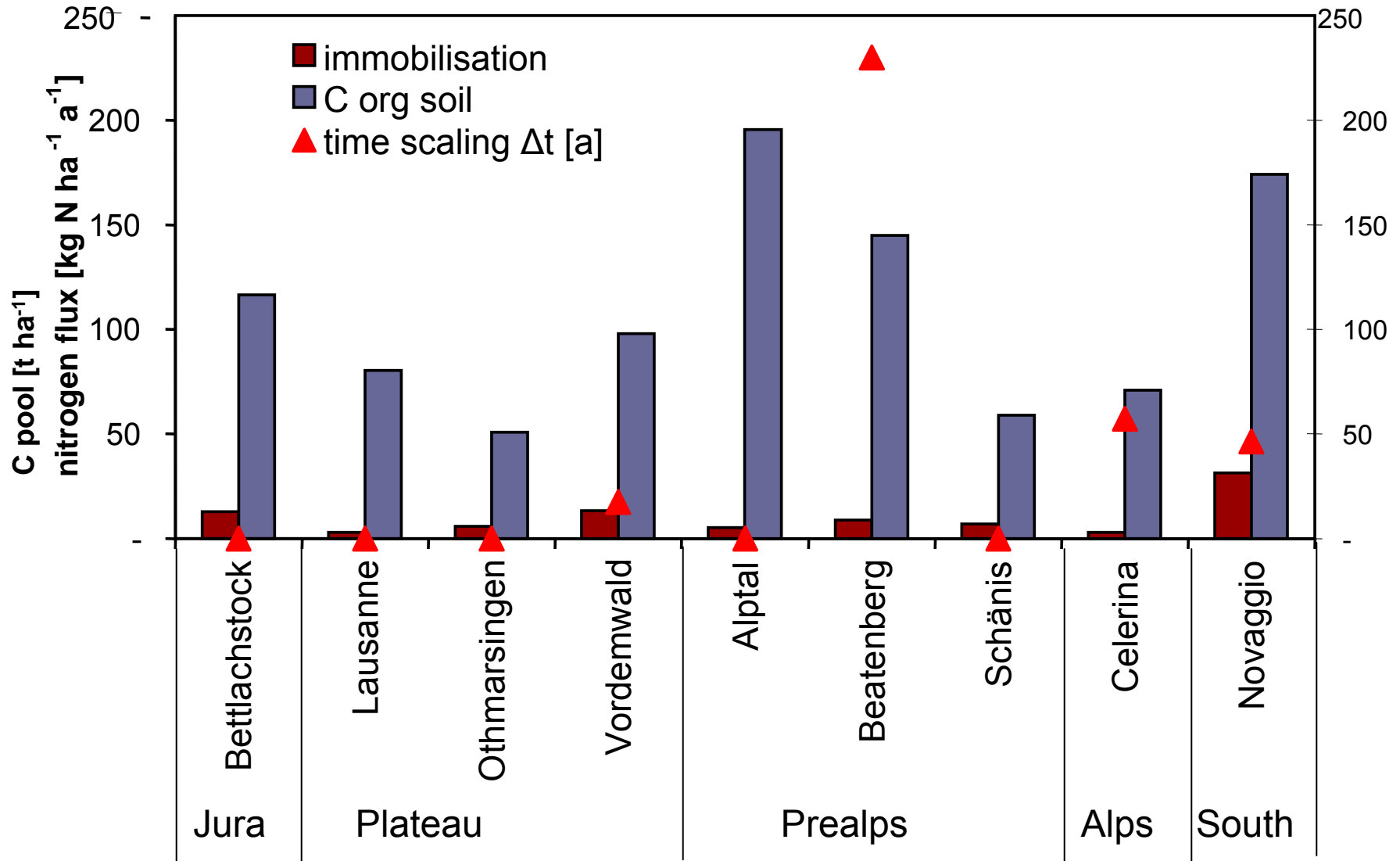
$$\Delta t = \frac{\Delta N}{N_i}$$



$C_{\text{pool}} = \text{const.}$

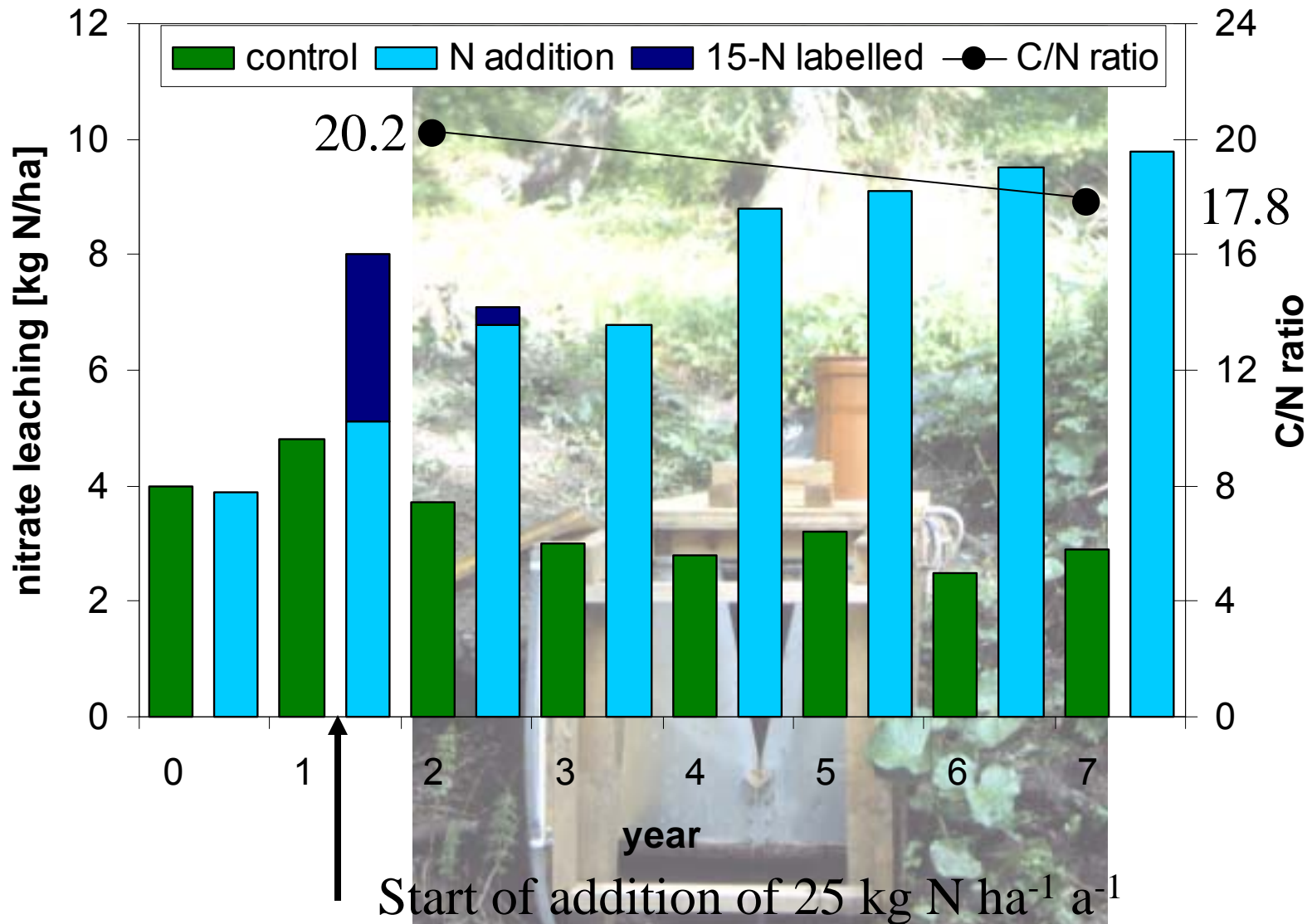
$$\Delta N = C_{\text{pool}} \cdot \left( \frac{1}{C/N^{\text{crit}}} - \frac{1}{C/N^{\text{actual}}} \right)$$

$$\Delta t = \frac{\Delta N}{N_i}$$



# Nitrogen addition experiment in Alptal

NITREX: e.g. Schleppi et al., 2004.



# Remarks



- mass balance: actual denitrification, uptake, leaching, etc.
- steady state assumption: changes of N-fluxes and C-pools
- fate of nitrate: which is the relevant pool in respect to C/N changes?
- Effect of future disturbances (e.g. storm) on N-fluxes
- Effects of future eutrophication

# Conclusions



- Atmospheric Deposition exceeds Critical Loads for Nitrogen in some regions
- Depending on nitrogen status, such exceedance may lead to either immediate nitrate leaching or in future
- Time up to a change of the nitrogen status may differ largely from plot to plot.

# Thanks

- Local foresters for field workers and for the support from local authorities
- Collaborators at the WSL working in the field and laboratory
- Scientific Co-operation across the ICP Forests Expert Panels