

# Ecological stability and ecosystem interaction

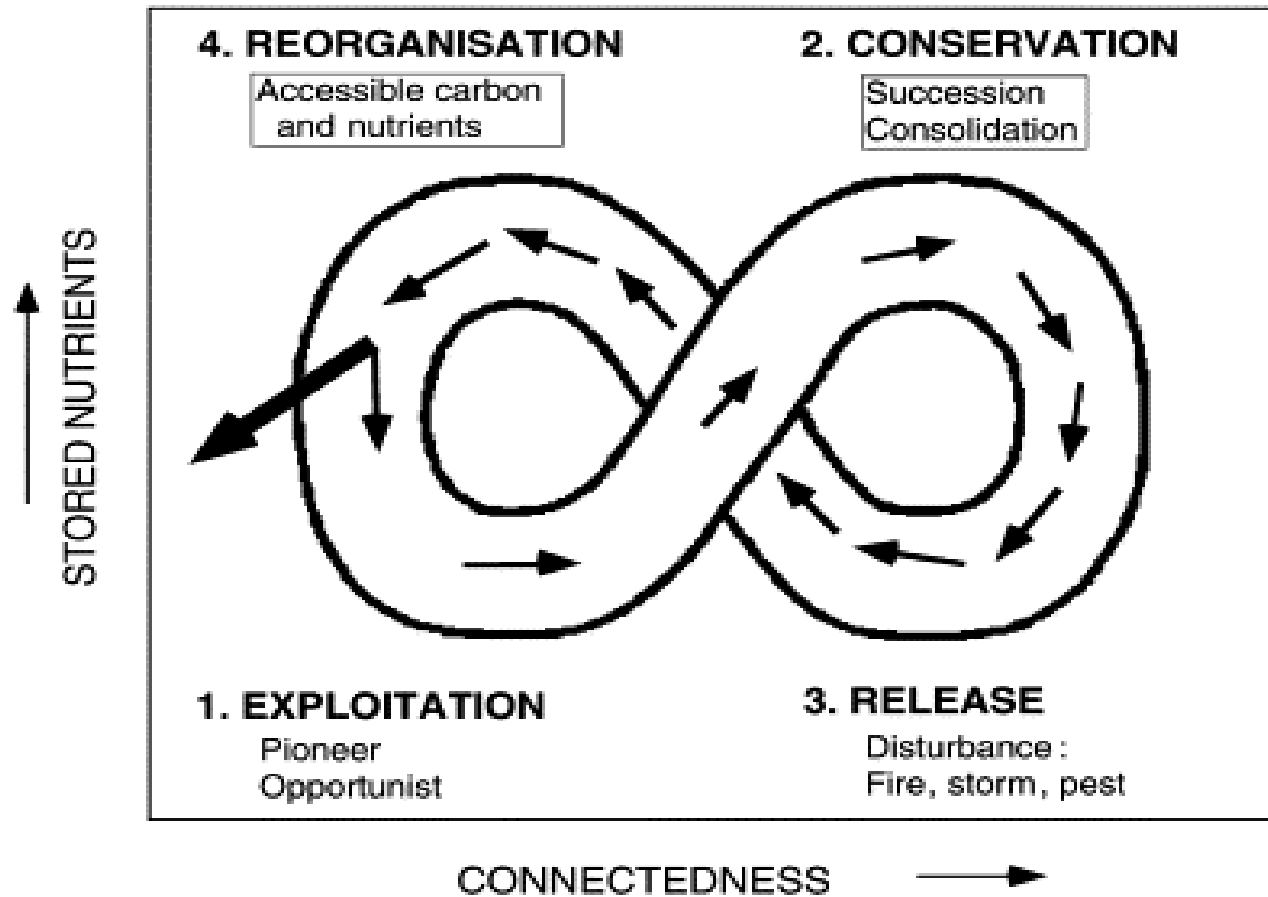


INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

# Content

- Stress theory
- Identification of stress factors
- Susceptibility and response of forest to disturbance
- Ecological stability
- Resilience vs. resistance, adaptation
- Main hypotheses of forest decline
- Ecosystem rehabilitation
- Applications in forestry

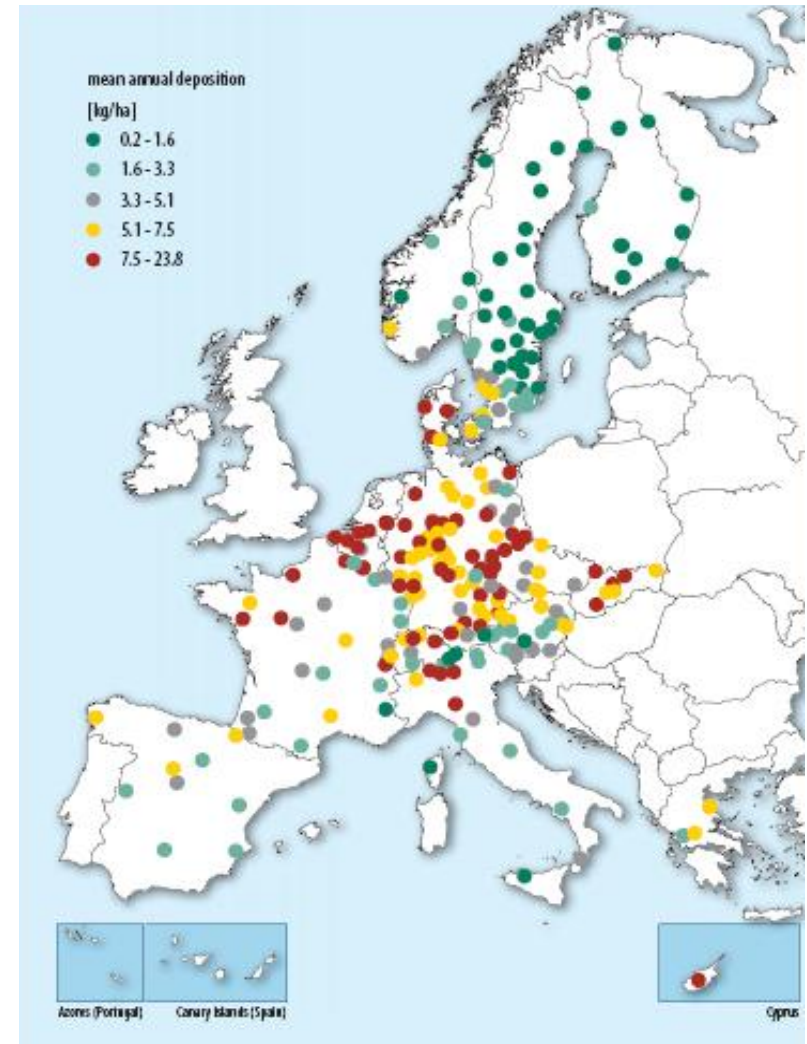
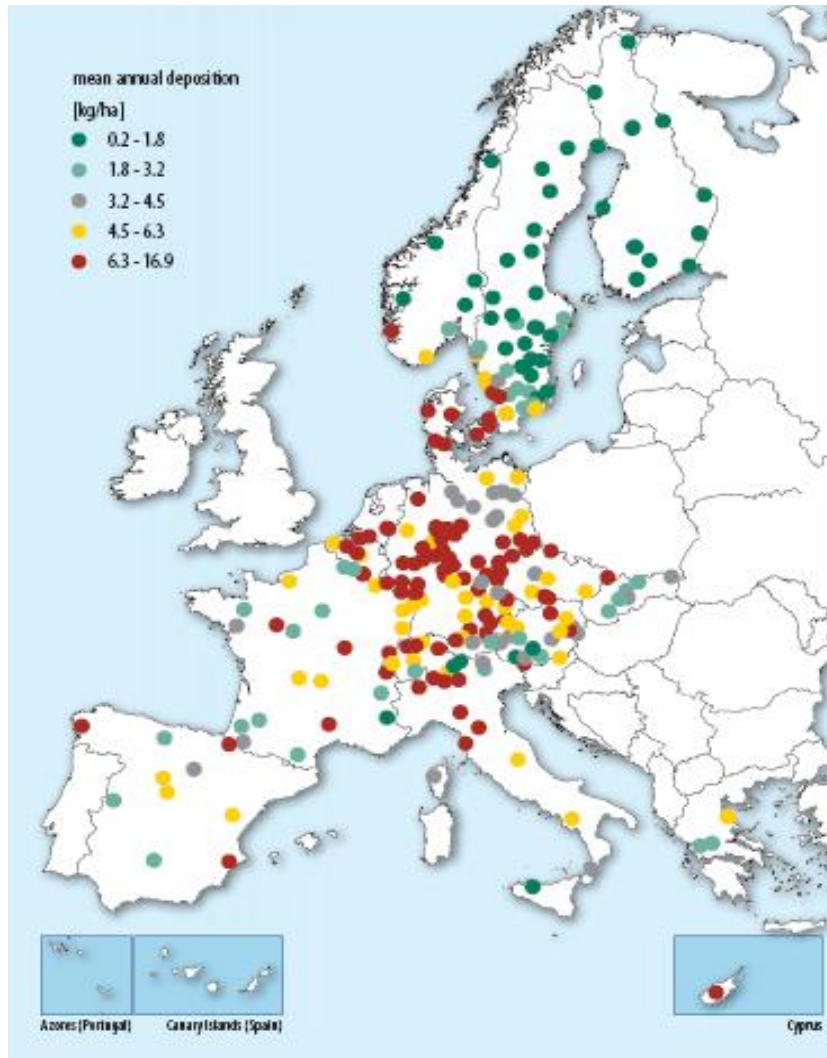
# Stress theory



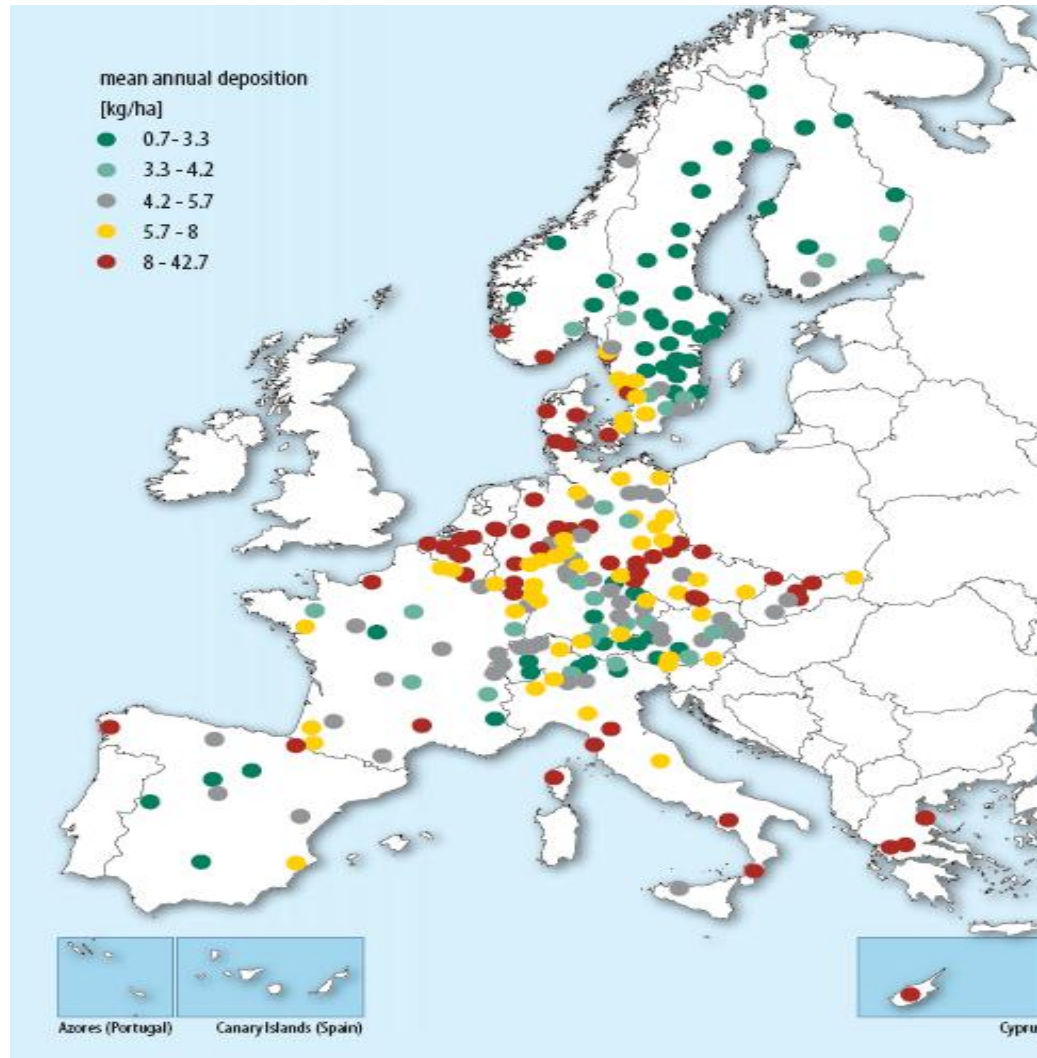
# Soil Acidification

- Soil acidification represents a serious problem in Europe for a long time.
- Soil acidification is caused by the  $\text{SO}_2$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{NO}_x$ ,  $\text{HNO}_3$  fallout and acid rain containing high concentrations of  $\text{H}_3\text{O}^+(\text{H}^+)$ .
- Acidification and nutrition degradation is the priority problem of forest soils in areas in the Czech Republic with high level of acid deposition (mountains and highlands area)
- Importance in European context - **Direction for Soil Protection in EU.**

# Mean nitrate ( $\text{NO}_3\text{-N}$ - left) and ammonium ( $\text{NH}_4\text{-N}$ - right) throughfall deposition, 2003-2005 on 249 plots (ICP Forest 2008)



# Mean sulphate ( $\text{SO}_4\text{-S}$ ) throughfall deposition, 2003-2005 on 249 plots (ICP Forest 2008)



# THE CZECH REPUBLIC

- long-term effect of acid deposition in mountain regions
- exceeding the critical loads (acid neutralization capacity ) in forested areas
- about  $\frac{1}{4}$  forest land is affected by acidification and nutritional degradation (about 0.7 million ha)
- highest level of acid inputs (more than 7 kmol) was measured in period 1960-1980 – Krušné hory Mts., Krkonoše Mts., Jeseníky Mts., etc.
- at present the Critical Loads are still exceeded exceeding by more than 1,5 kmol in mountain areas

# Regions of the Czech Republic with soil acidification

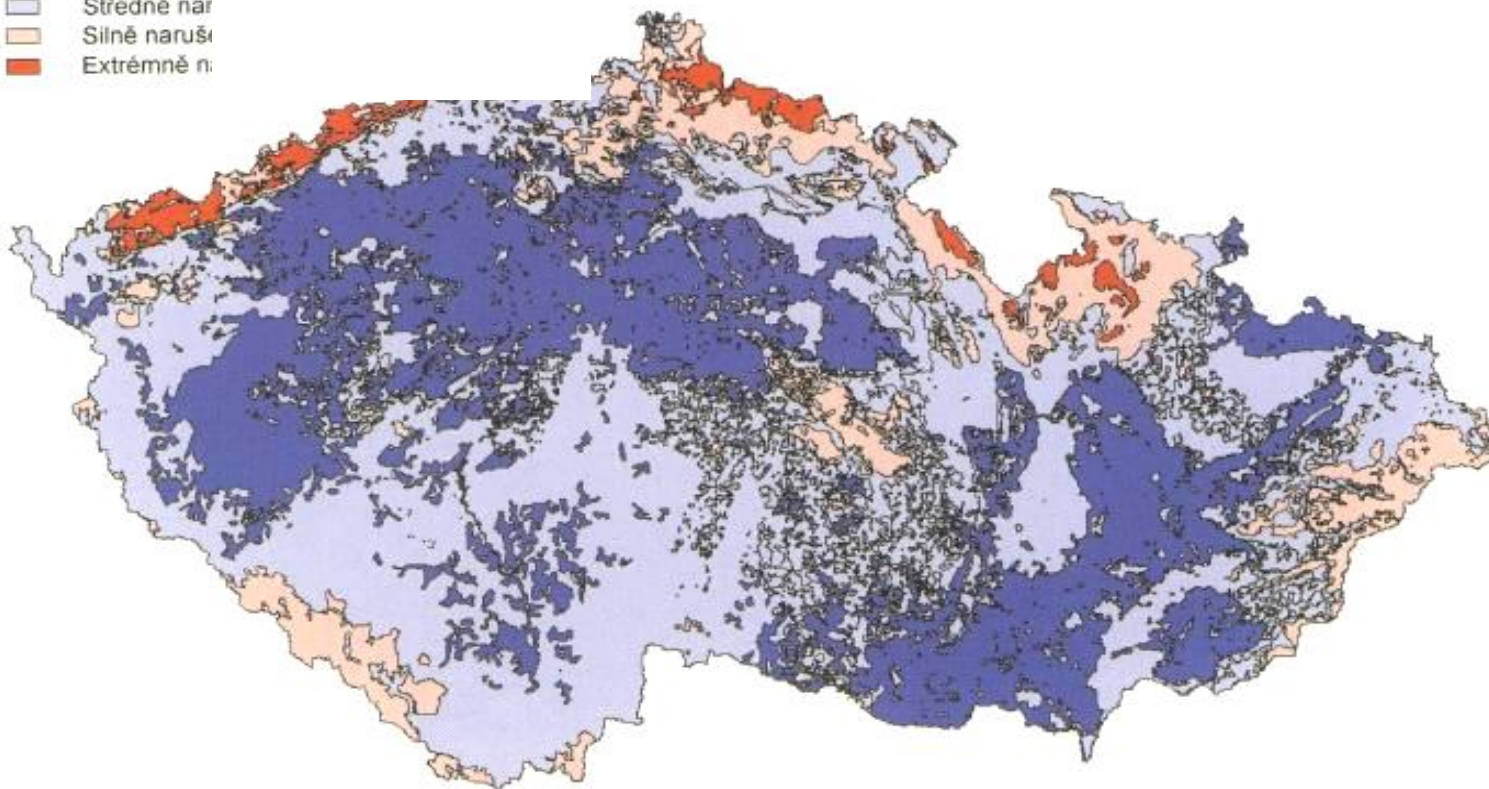
(HRUŠKA et al. 2001)

Blue - light disturbance

Dark blue - medium disturbance

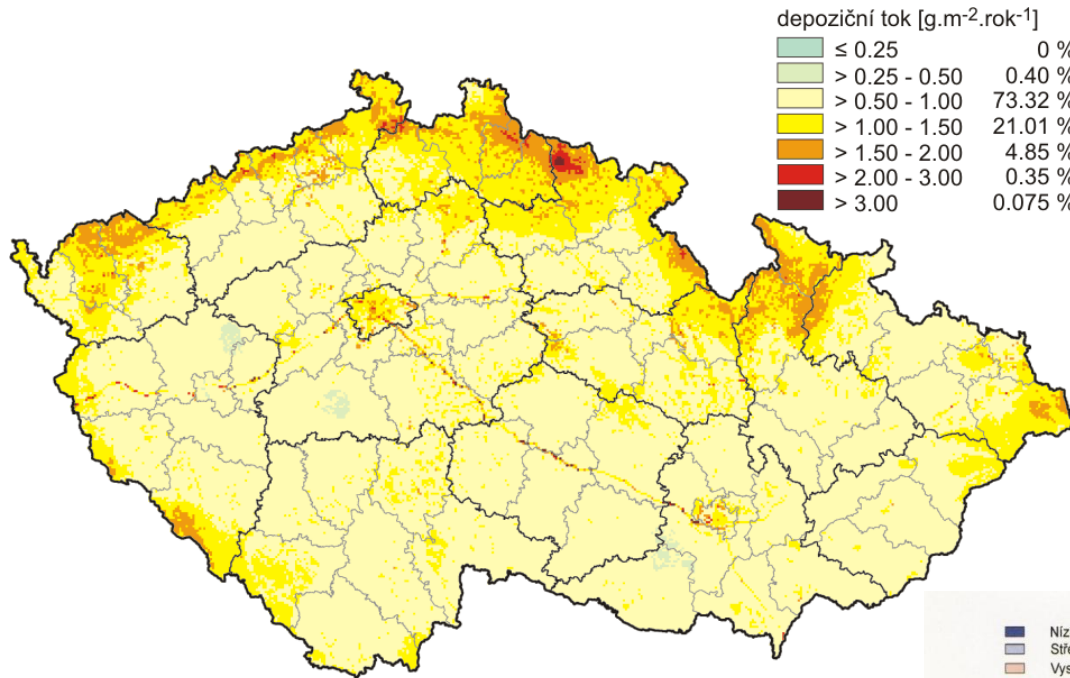
Pink - strong disturbance

Red - extreme disturbance





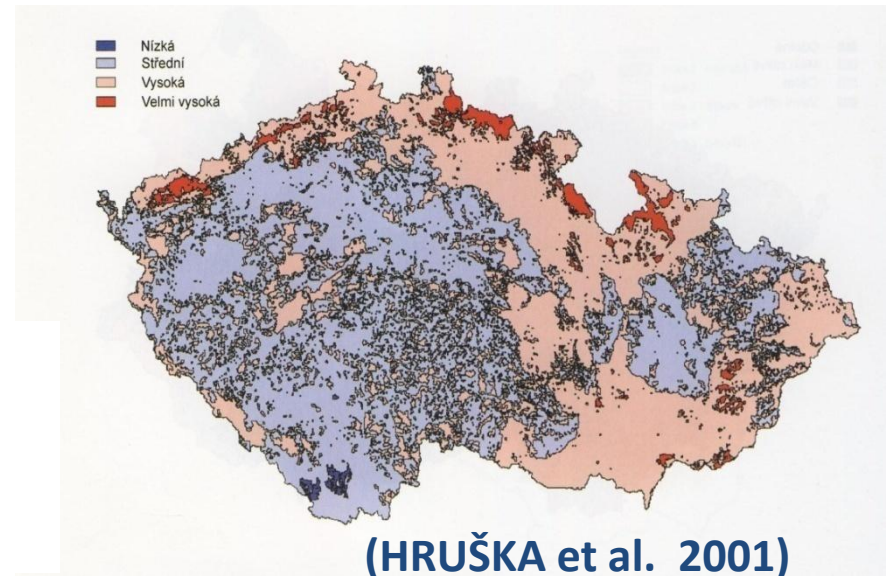
# Total deposition of nitrogen in Czech Republic



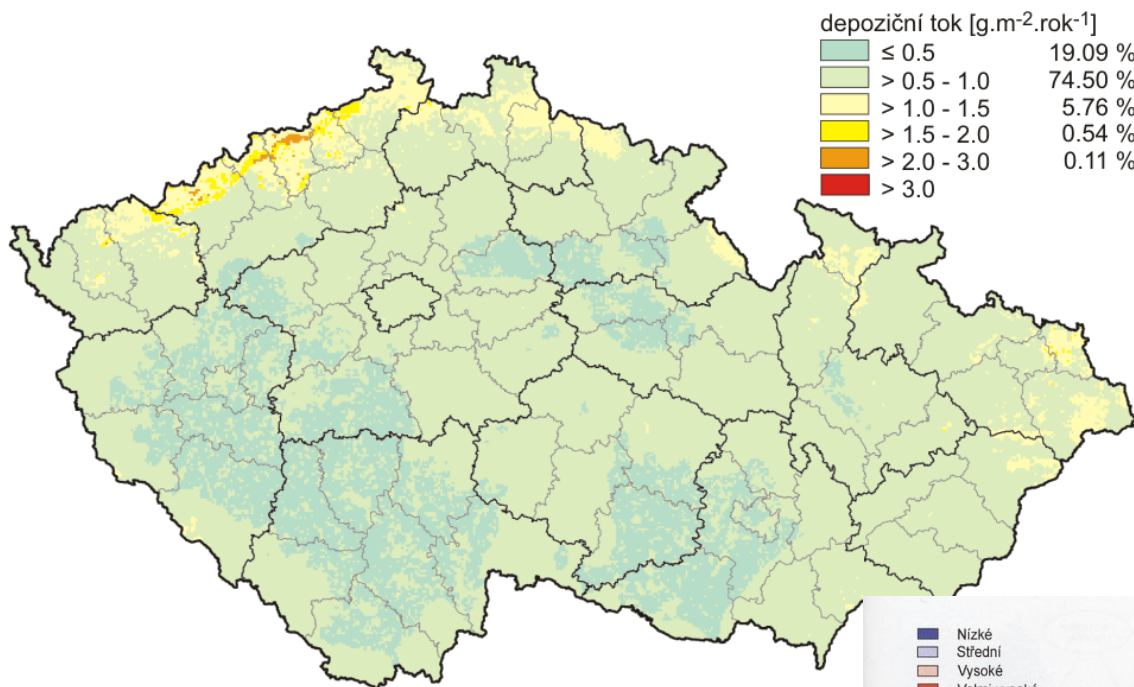
Pole celkové roční depozice dusíku, 2007

(HŮNOVÁ et al. 2008)

**Blue - low**  
**Dark blue - medium**  
**Pink - high**  
**Red - extreme**

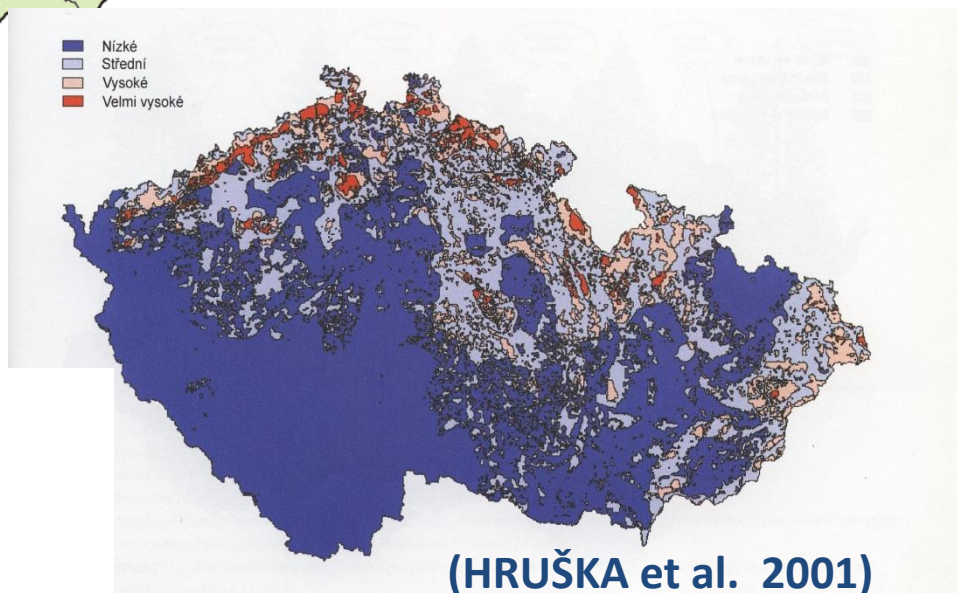


# Total deposition of sulphur in Czech Republic



(HŮNOVÁ et al. 2008)

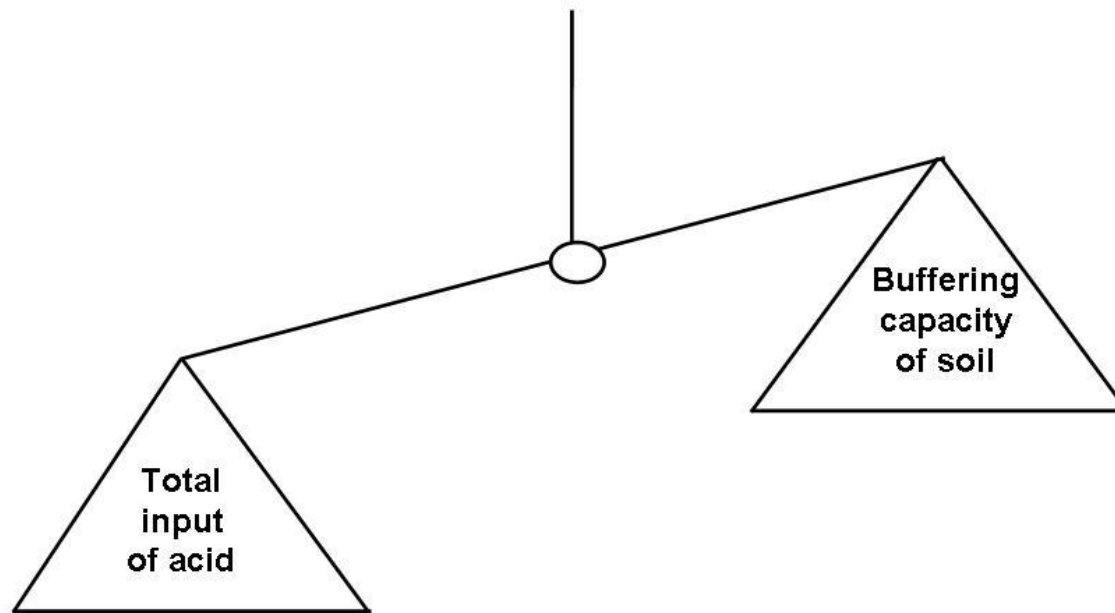
Pole celkové roční depozice síry, 2007



Blue - low  
Dark blue - medium  
Pink - high  
Red - extreme

(HRUŠKA et al. 2001)

# BUFFER CAPACITY, SOIL SENSITIVITY TO ACIDIFICATION



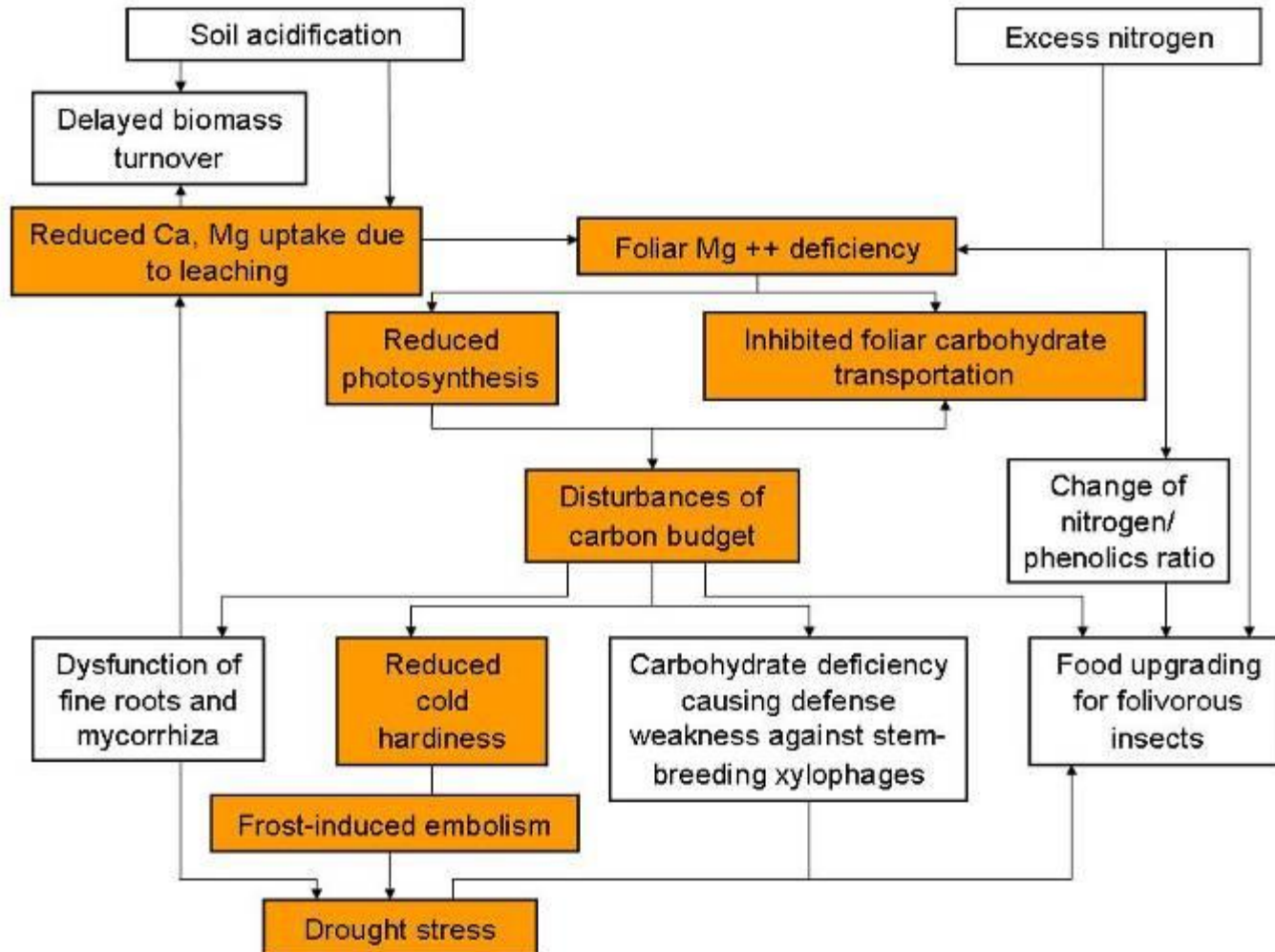
**Acidification of soil**

# CAUSES OF SOIL ACIDIFICATION

- Natural processes (humic acids, ...)
- Harvesting of biomass (loss of cations)
- Deposition of sulfur compounds (input of protons)
- Deposition of nitrogen compounds (input of protons, nitrification)

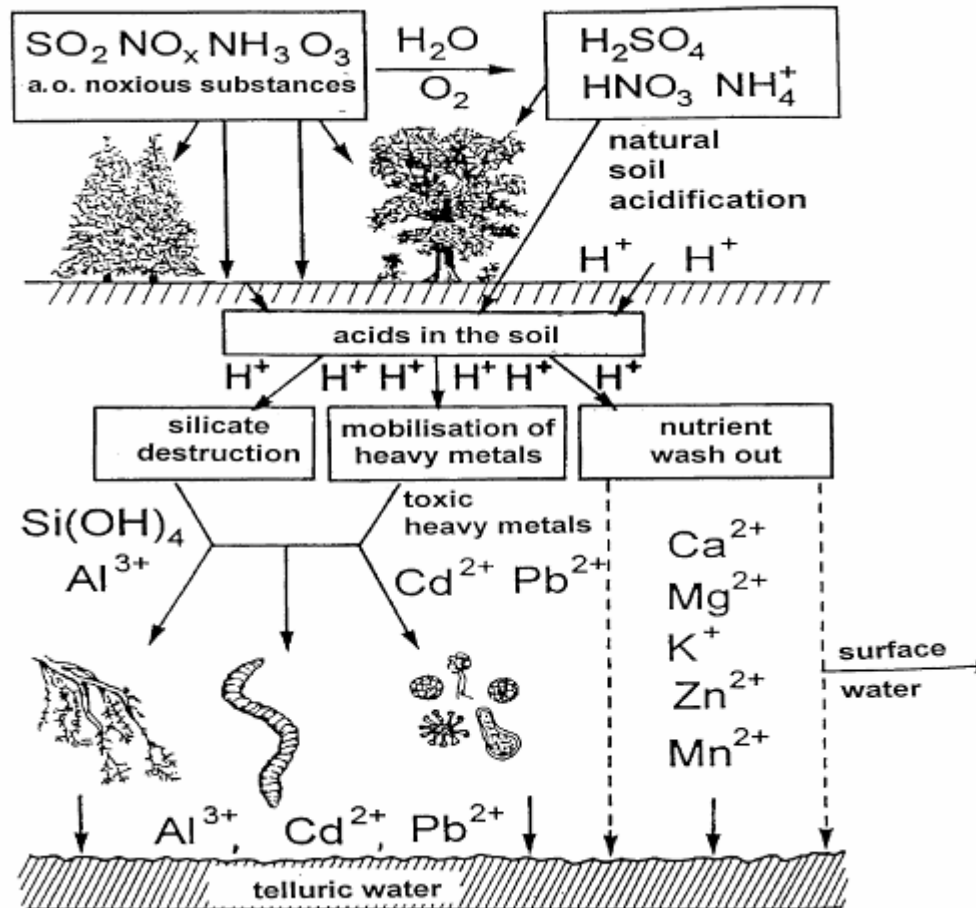
# SOIL ACIDIFICATION - vegetation response

(ANDERSON et al. 2000)



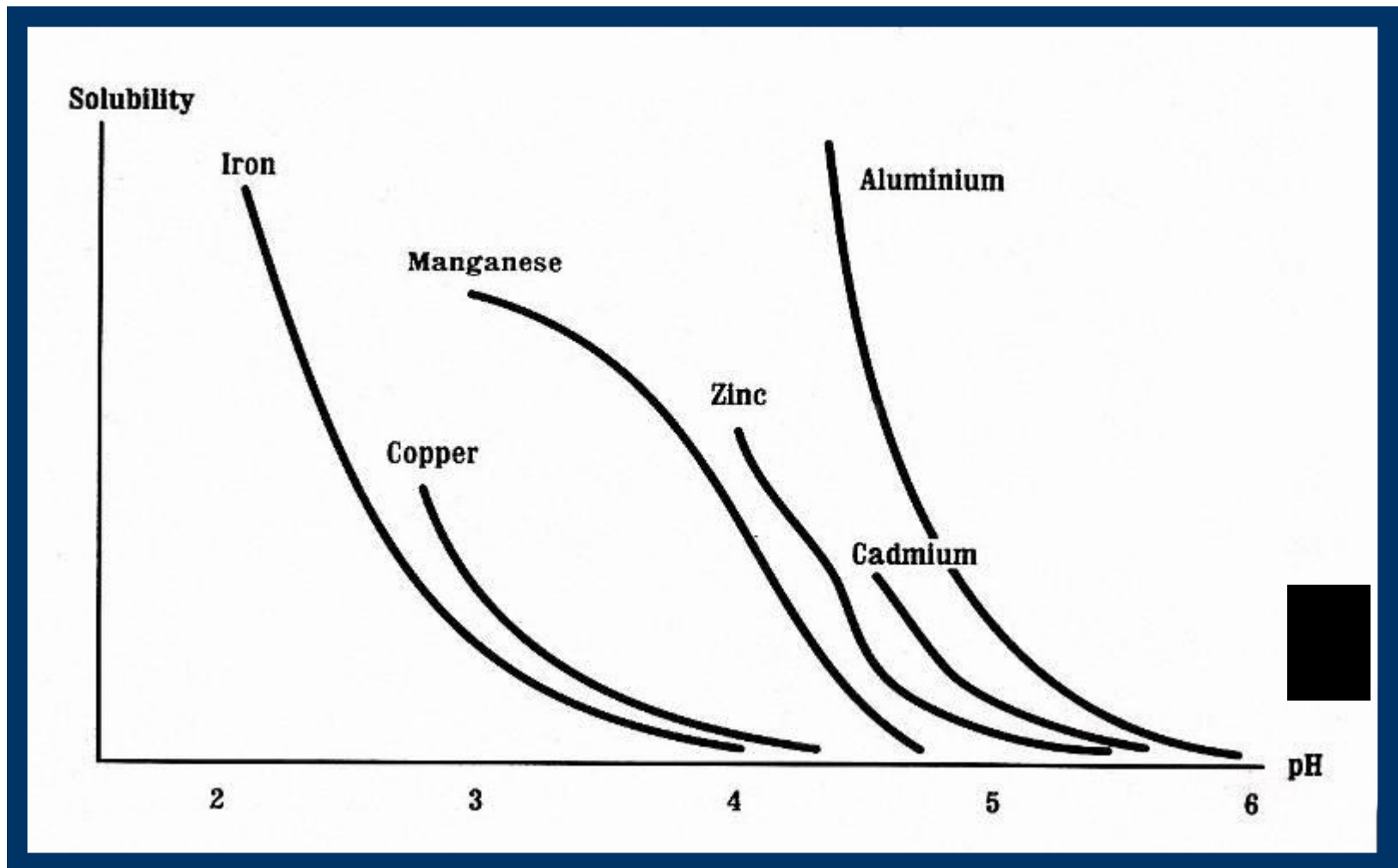
# SOIL ACIDIFICATION - soil response

(Figure by VEERHOFF, ROSCHER, BRÜMMER 1996)



# Release of metals from mineral at different pH levels

(ELVINSON, ÅGREN 2004)



# Identification of stress factors in the CR (1)

- in spite that the proportion of broadleaves species has nearly doubled in the last fifty years, coniferous trees prevailed (coniferous 76,7 %, broadleaves 22,3 %)
- spruce is main tree species (54,3 %)
- the uniform age structure (even- age stands)
- the permanently increasing stock volume in forests (total mean increment reached 16,6 mil.m<sup>3</sup>, total mean increment per ha is 6.4 m<sup>3</sup>)
- the total volume of spruce wood infested by bark beetles amounted to 331.000 m<sup>3</sup>. The serious situation is still prevailing in the Šumava NP – 23% infested wood volume of the total volume in the CR)



## Identification of stress factors in the CR (2)

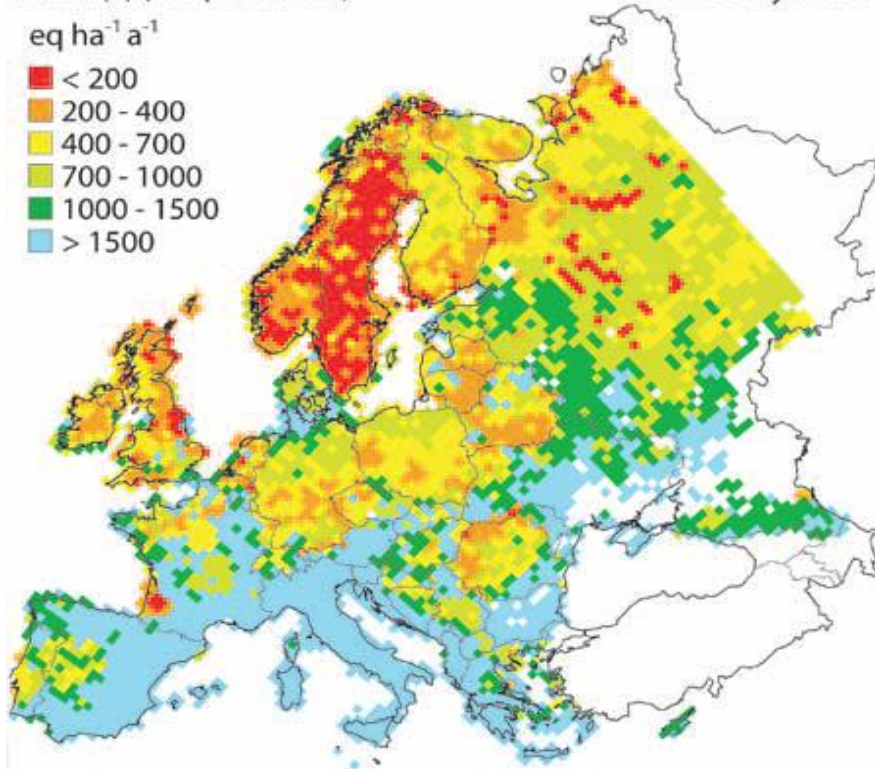
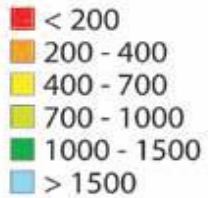
- damage to forest stands caused by game
- despite the generally positive trend in air pollution (lower concentration) of sulfur the single high value of pollution in some places are still dangerous
- the concentration of NO<sub>x</sub> and ozon did not fall but it slowly grew (on 15-25 % of area the mean concentration of NO<sub>x</sub> is above critical concentration 30ug/m<sup>3</sup> and currently, the AOT 40 index exceeded on the whole territory of the Czech Republic)
- deposition of sulfur and nitrogen is still high and neurtlization capacity of soil is not sufficient
- defoliation of coniferous stands is highest in Europe (classes 0-1 41.7 %, classes 2-4 58.3 %)
- Further drop of the content of basic nutrient was found out in the needles of spruce stands (the decline was seen most significantly in the magnesium content (lower than 800 mg.kg)

# CRITICAL LOADS

CLmax(S) (5th percentile)

All ecosystems

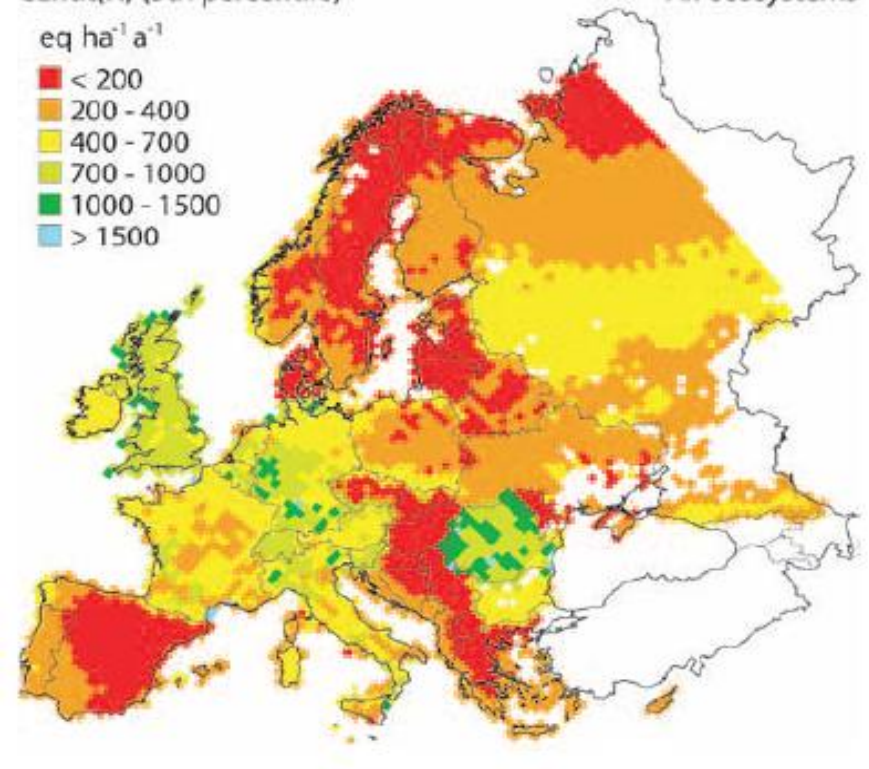
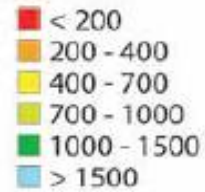
eq ha<sup>-1</sup> a<sup>-1</sup>



CLnut(N) (5th percentile)

All ecosystems

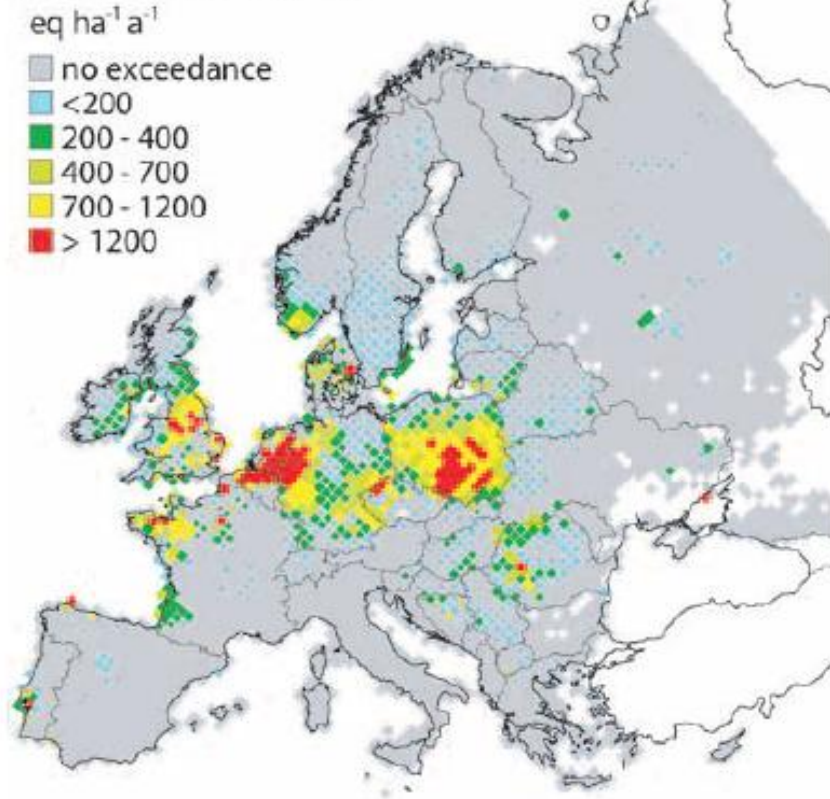
eq ha<sup>-1</sup> a<sup>-1</sup>



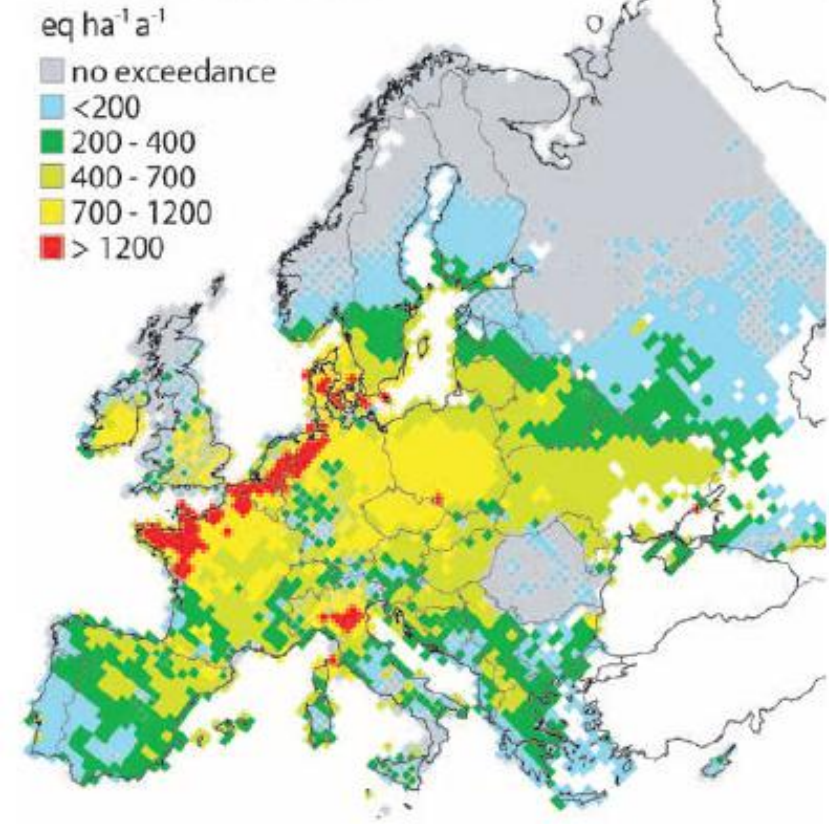
**Critical loads for acidity (left) and nutrient nitrogen (right) in Europe. (ÅGREN 2009)**

# Exceedance of CRITICAL LOADS

Exceedance of acidity CLs

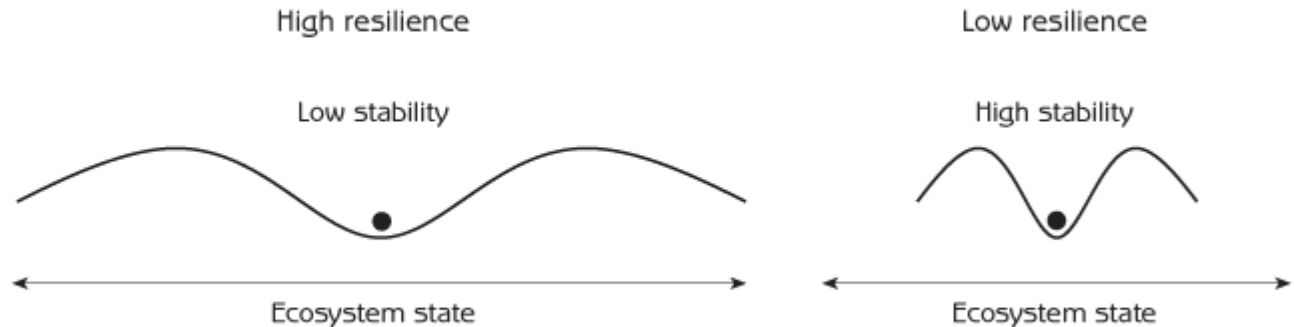
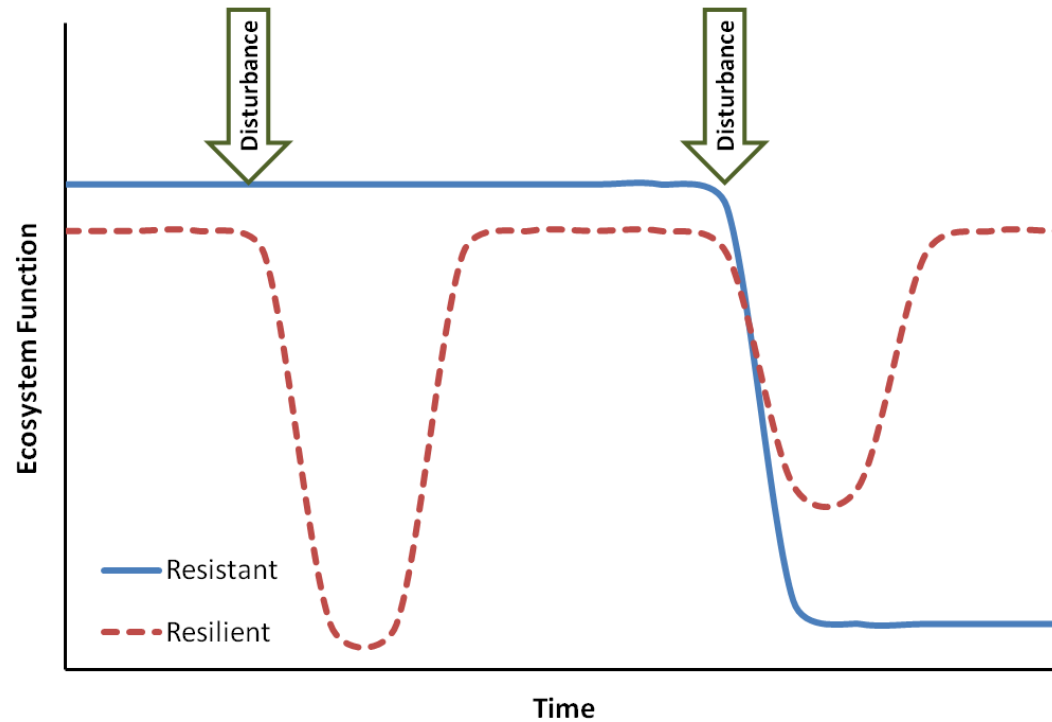


Exceedance of nutrient CLs

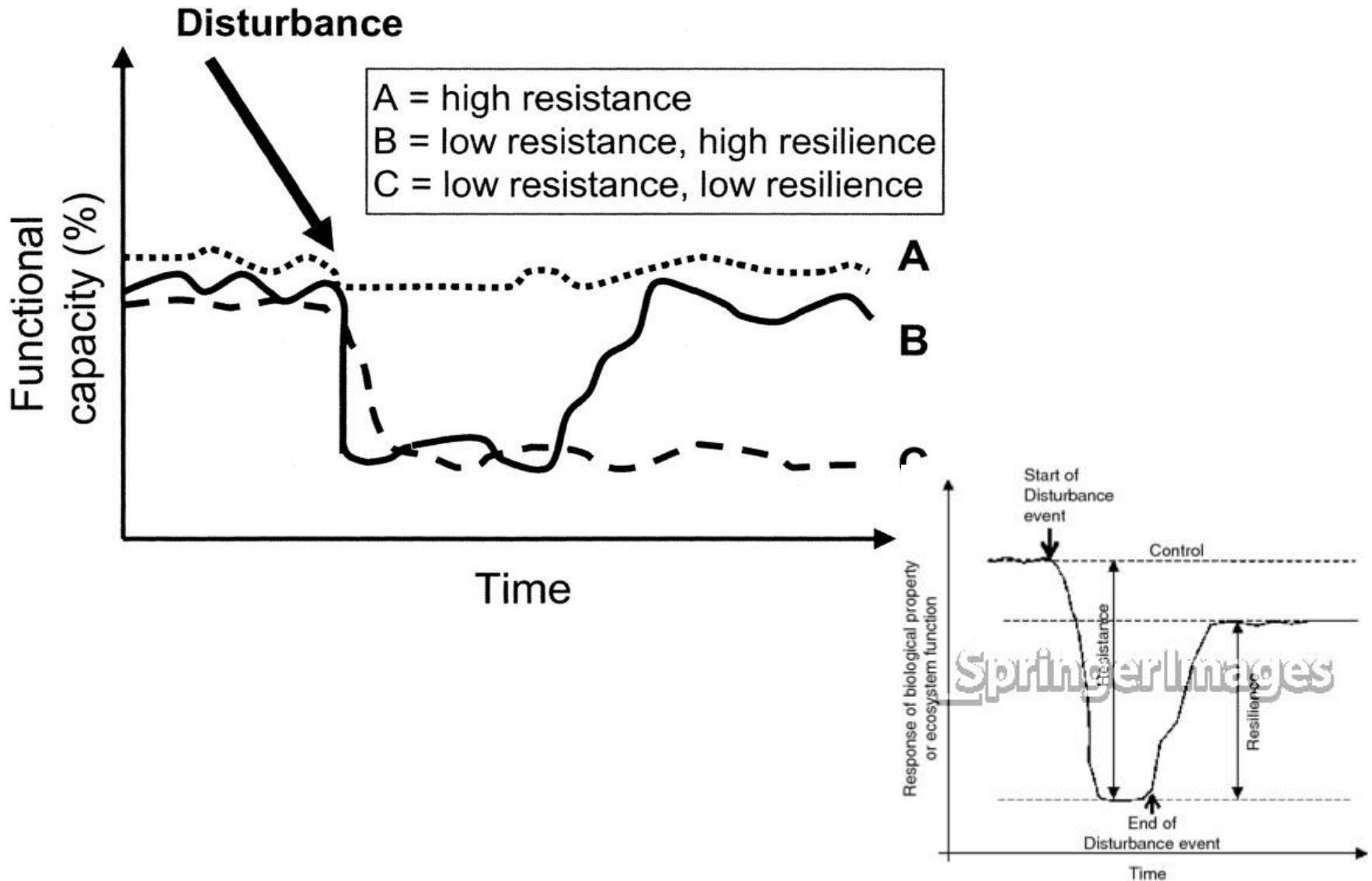


Areas where the critical loads for acidity (left) and nitrogen (right) were exceeded in 2000. (Ågren 2009)

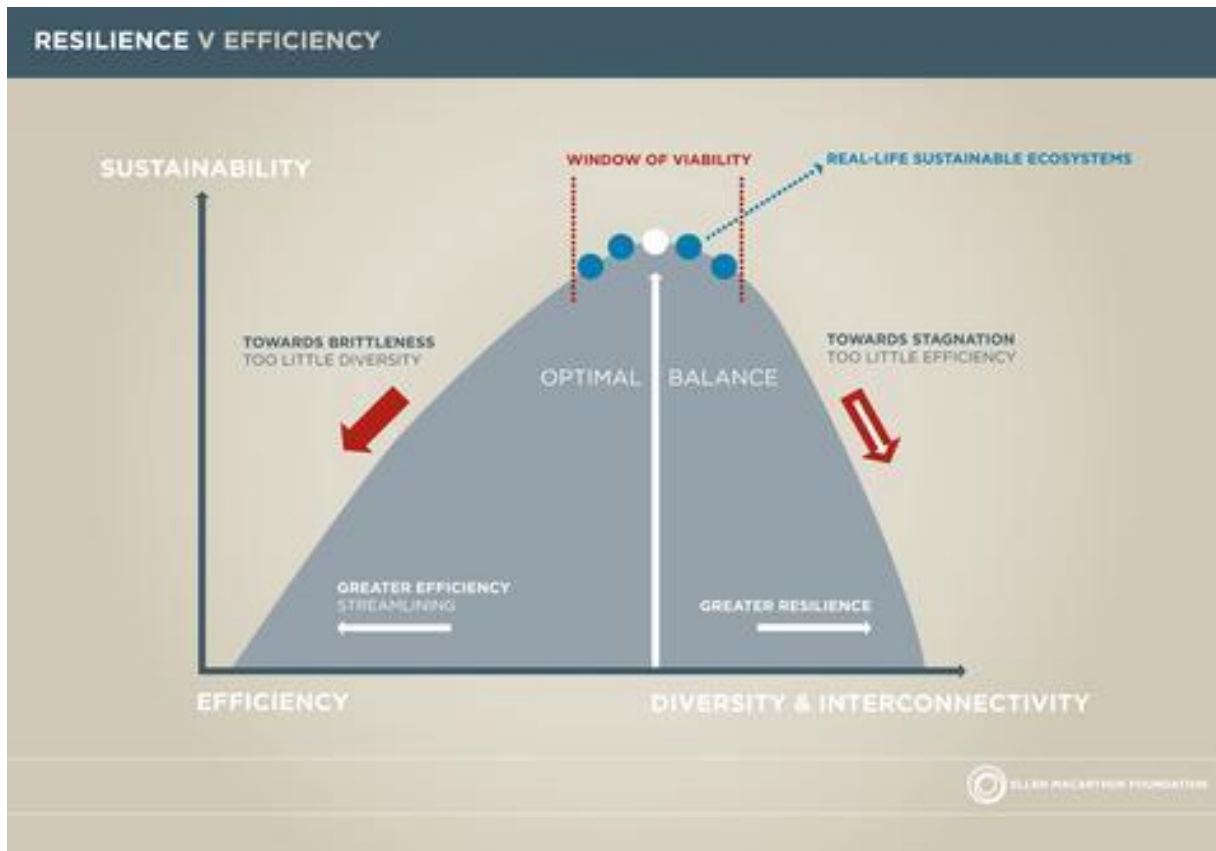
# Disturbance, Resistance and Resilience (1)



# Disturbance, Resistance and Resilience (2)

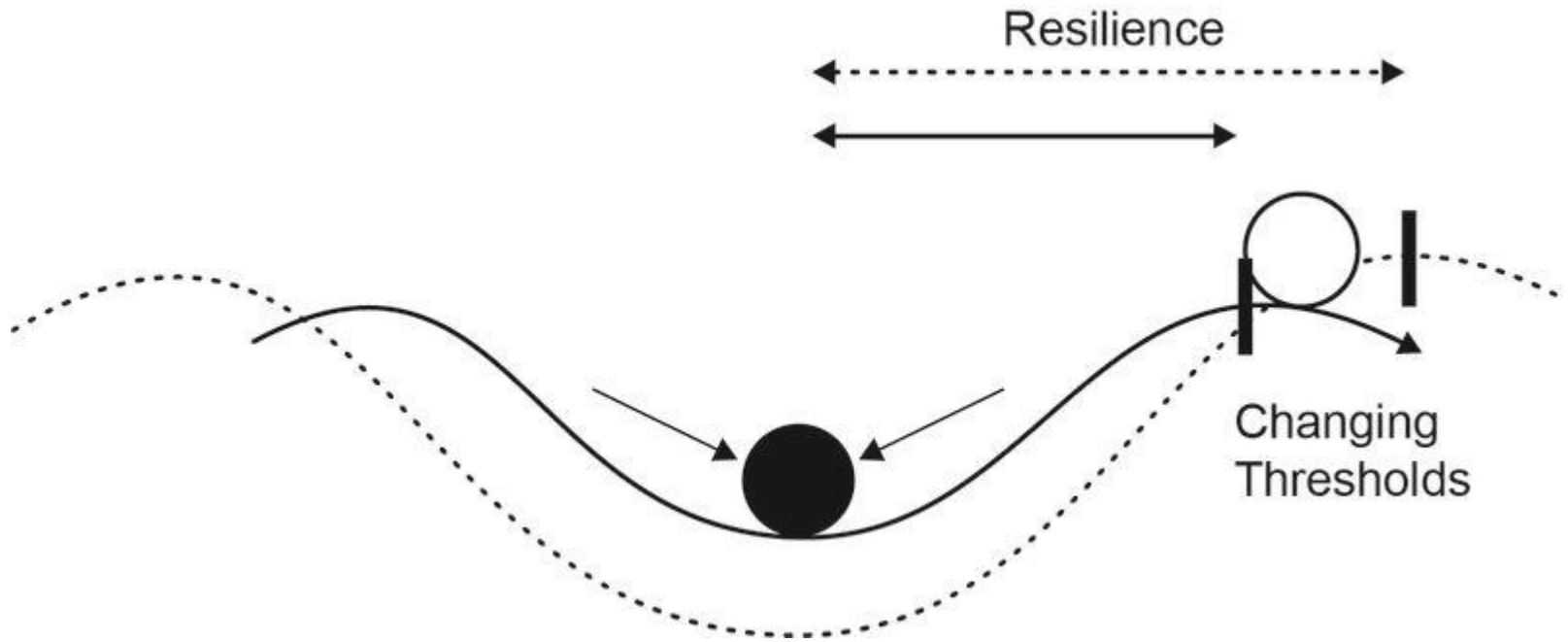


# Resilience vs. resistance, adaptation



*Resilience is the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.”*

# Scheme of Dynamic Balance in Forest Ecosystem



## Main hypotheses of forest decline

- **Ulrich's soil acidification hypothesis on forest decline**
- "New Type" of Forest Decline, Nutrient Deficiencies and the "Virus"-Hypothesis
- Ozon theory
- Aluminium hypotheses
- .....



# Questions

- Stress theory
- Ecological stability
- Disturbancem, Resilience, resistance, adaptation
- Main hypotheses of forest decline
- Applications in forestry