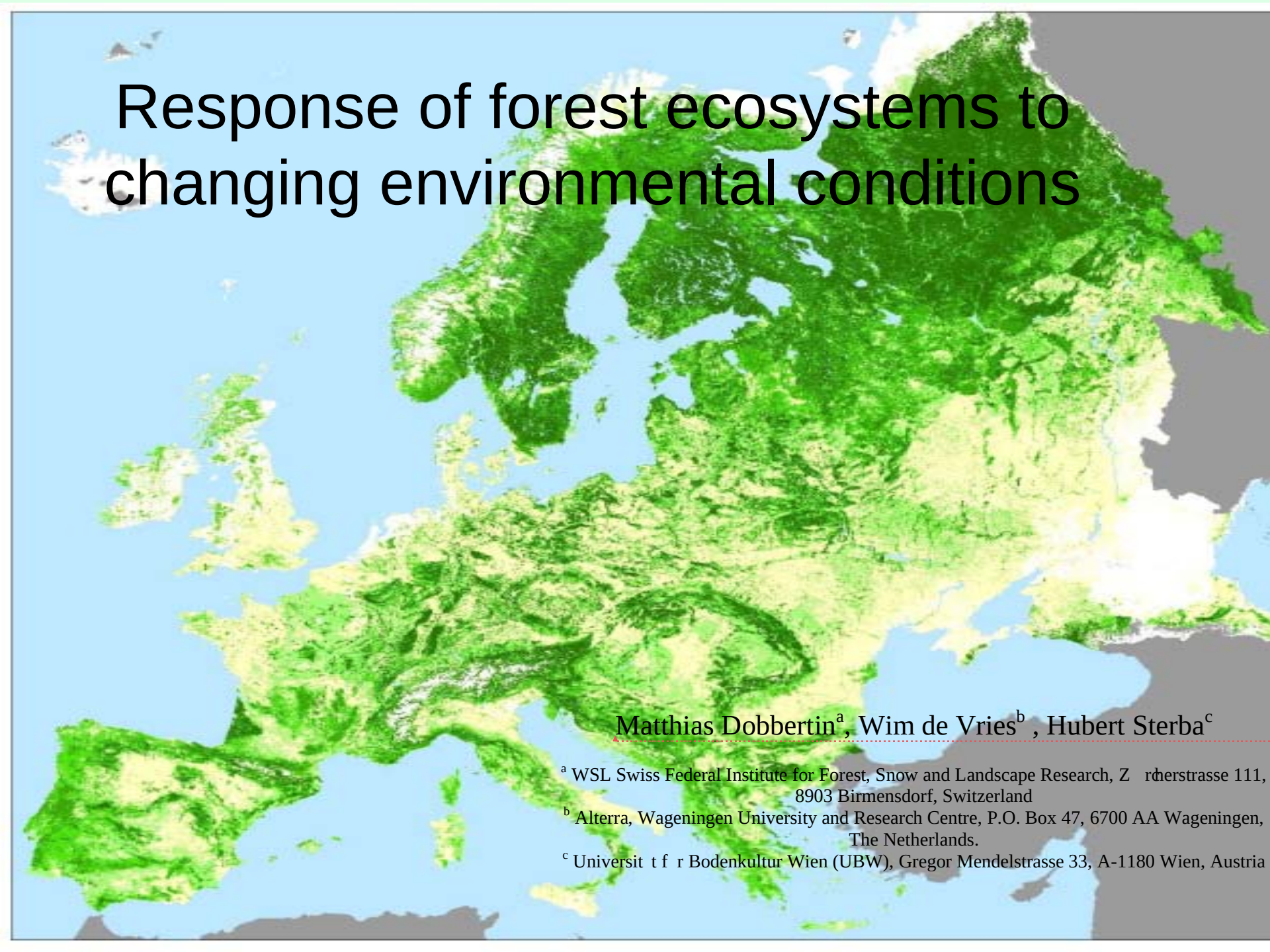
Response of forest ecosystems to changing environmental conditions



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[c] Universit t f r Bodenkultur Wien (UBW), Gregor Mendelstrasse 33, A-1180 Wien, Austria

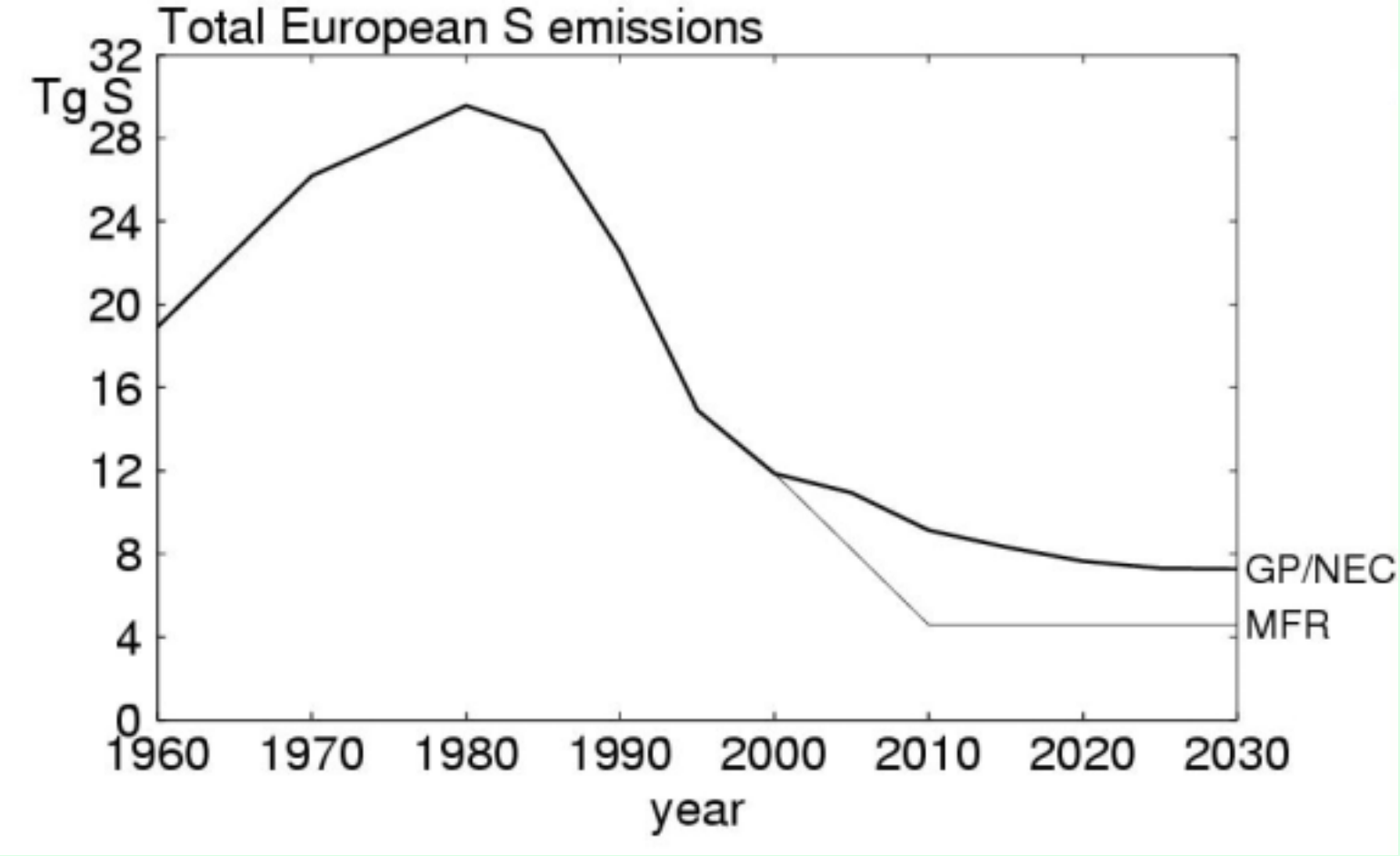
Outline

- Changes in Environmental Conditions
- Changes in Forest Conditions
- How is the changing environment affecting forests
- Anticipated future effects

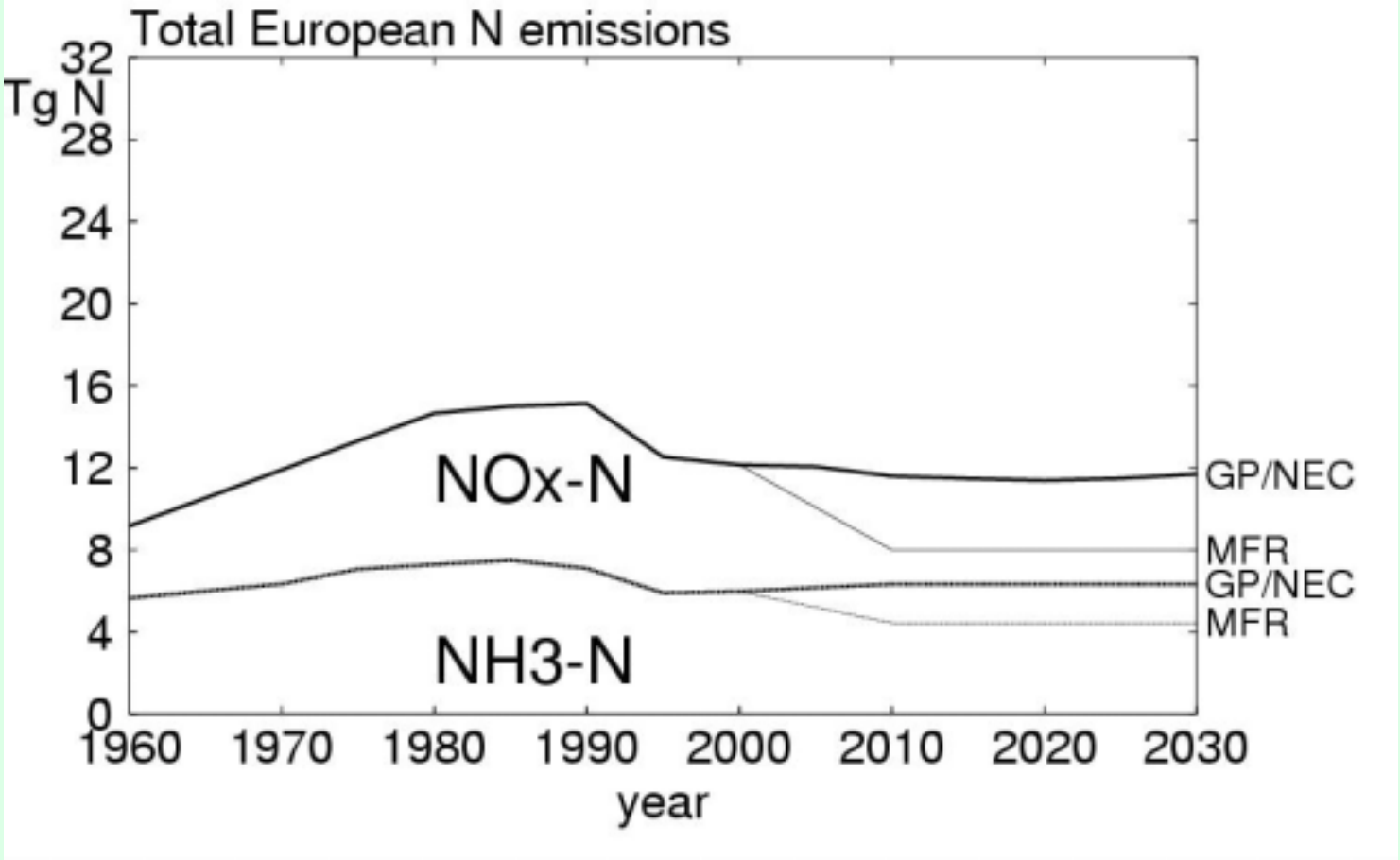
Changing Environmental Conditions

- Air Pollution
  - S-Emissions
  - N-Emissions (=> Ozone)
- Other atmospheric Emissions
  - Green House Gas emissions (in particluar CO_2)
- Climate Change
  - Temperature rise
  - Precipitations pattern /drought

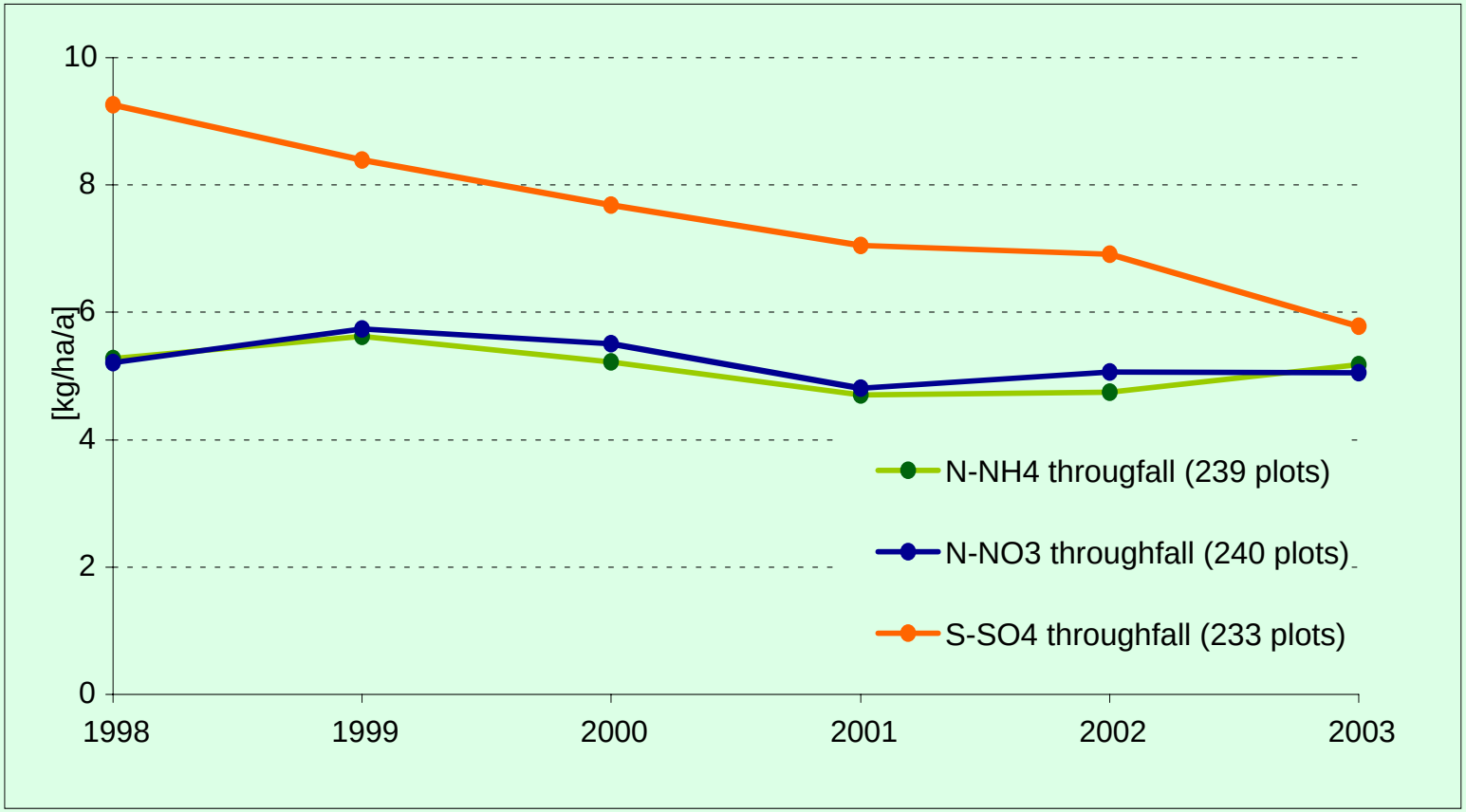
Sulphur emissions have substantially declined



Nitrogen emissions have only slightly declined

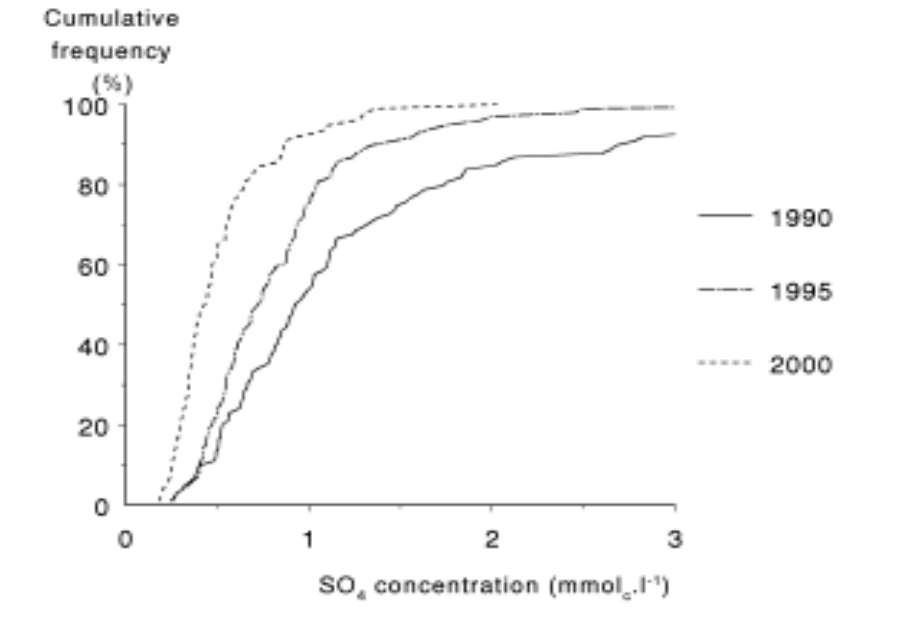


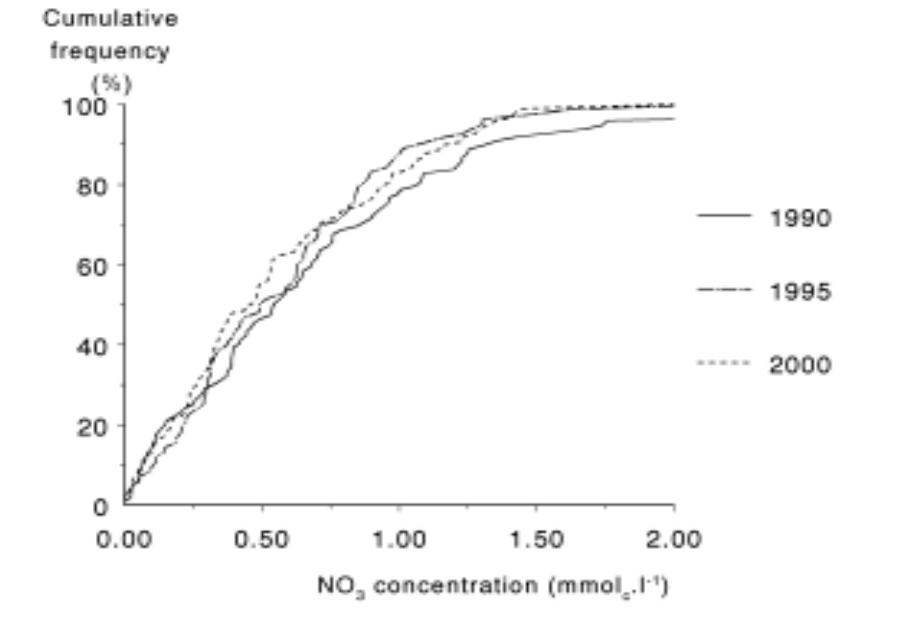
Measured Throughfall deposition on Level II plots



Posch et al. in Fischer et al. 2006

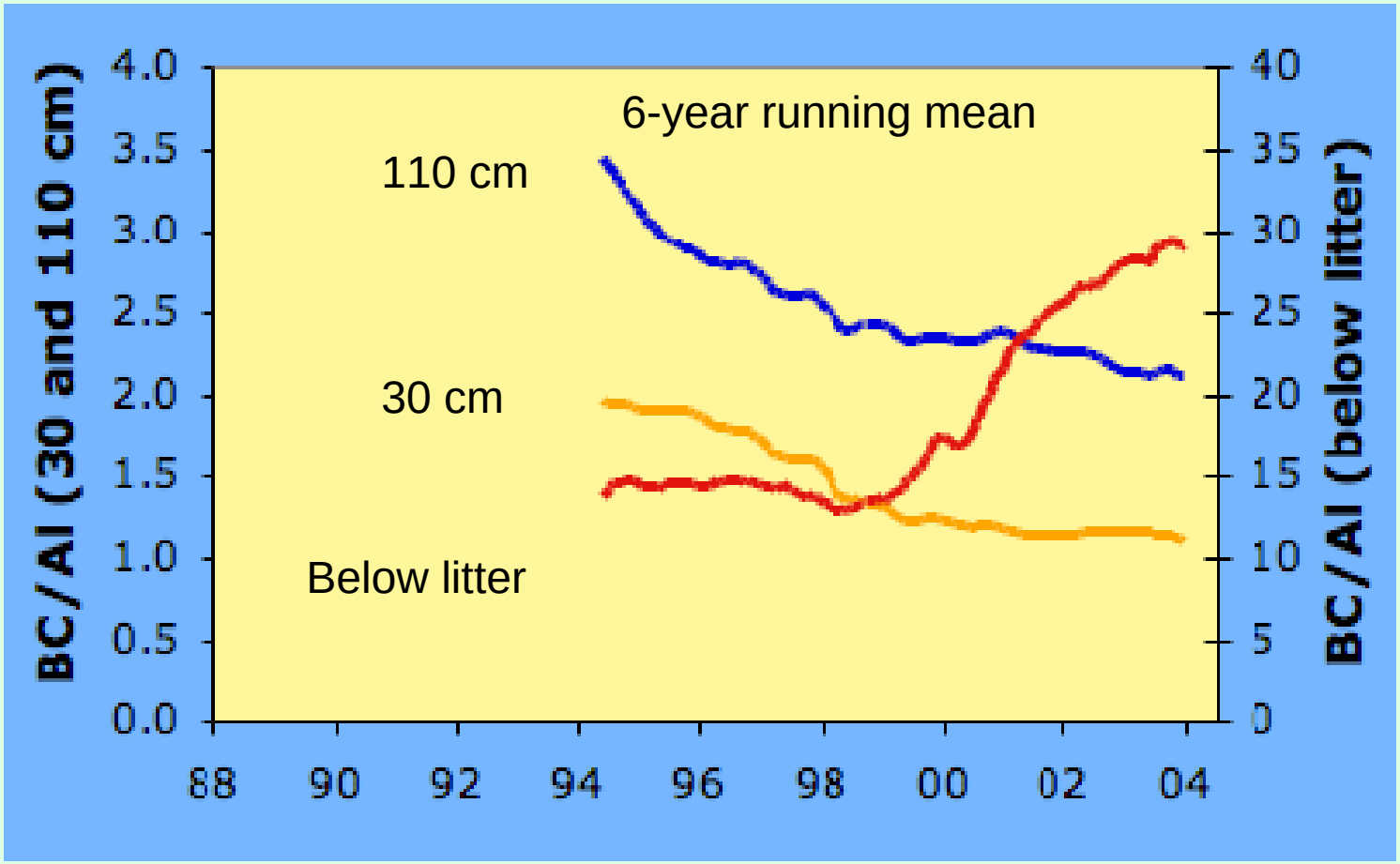
Effects emission reductions on soil solution





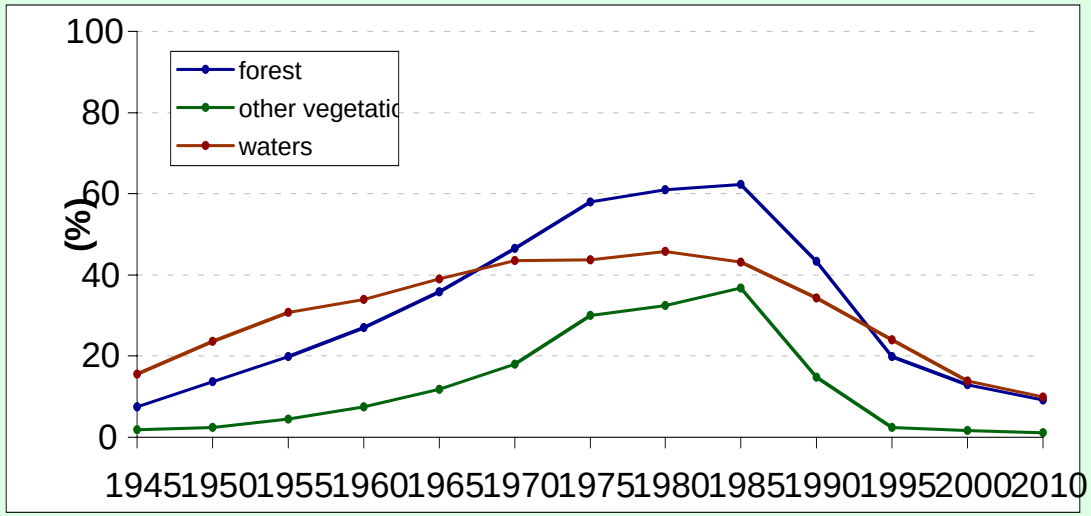
Frequency distributions of SO_4 and NO_3 concentrations in soil solution in more than 100 Dutch forest stands in 1990, 1995 en 2000.

Slowing down of acidification trend at a long-term monitoring site in southern CH



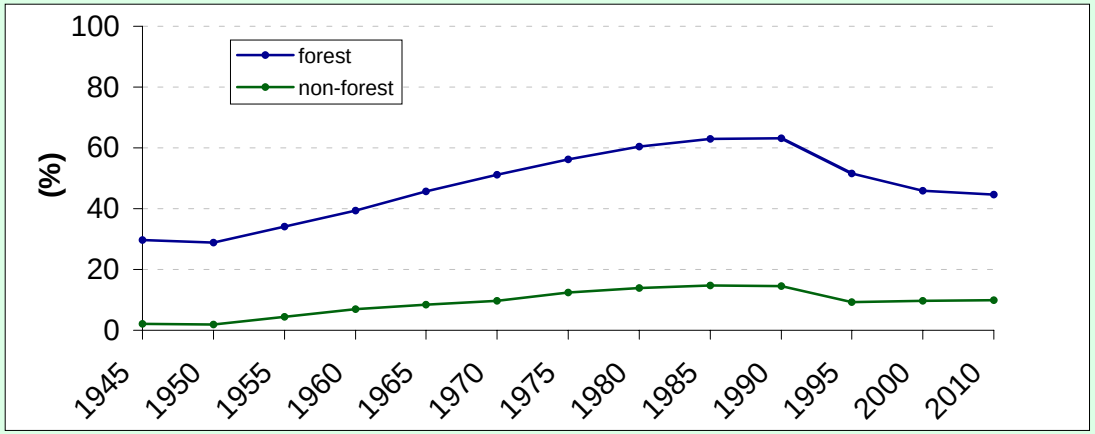
Graf Pannatier et al., ES&T, 2005

Modelled exceeded critical loads



Acidic deposition

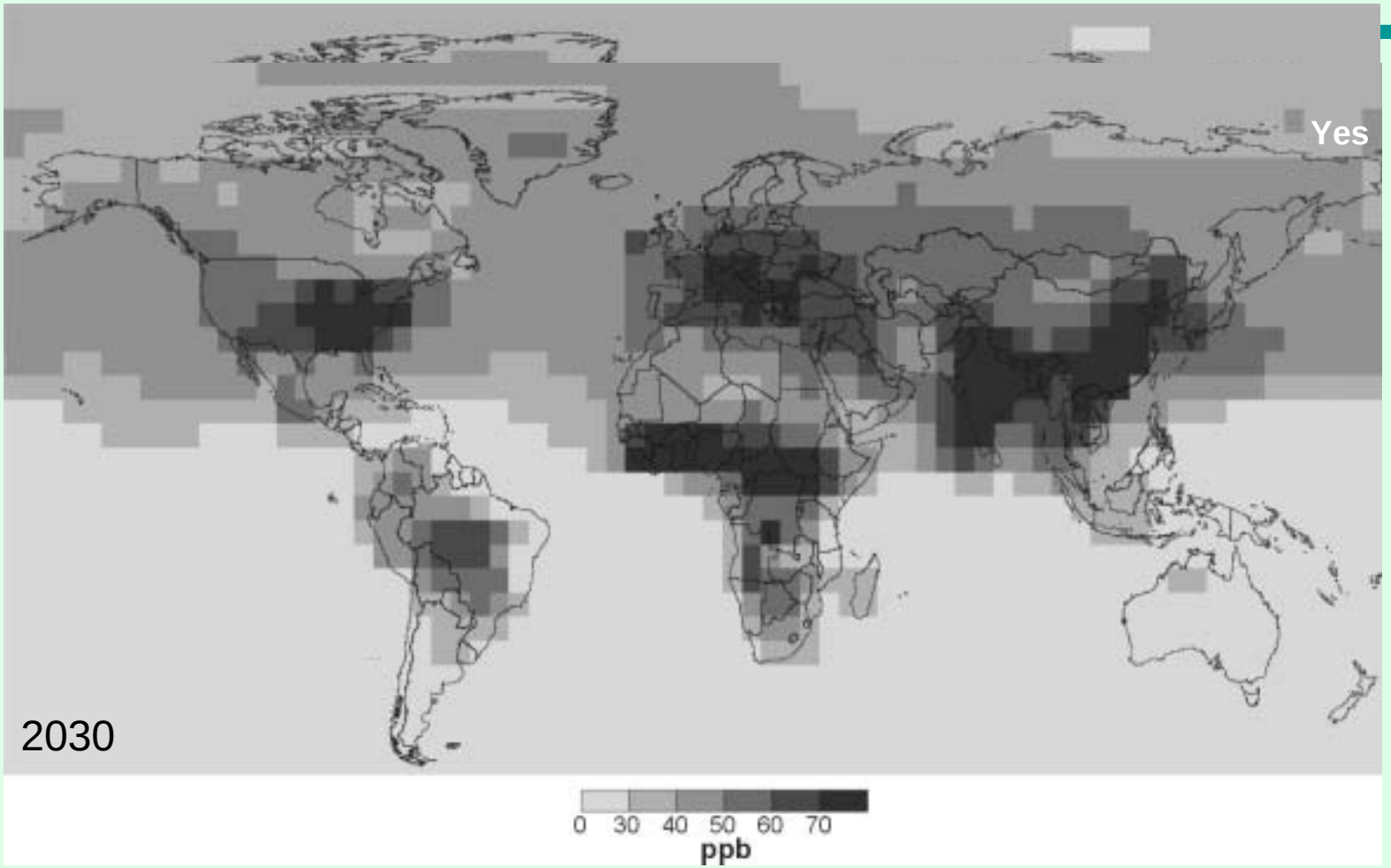
Nitrogen deposition



Posch e al. in Fischer et al. 2006

Ozone concentrations

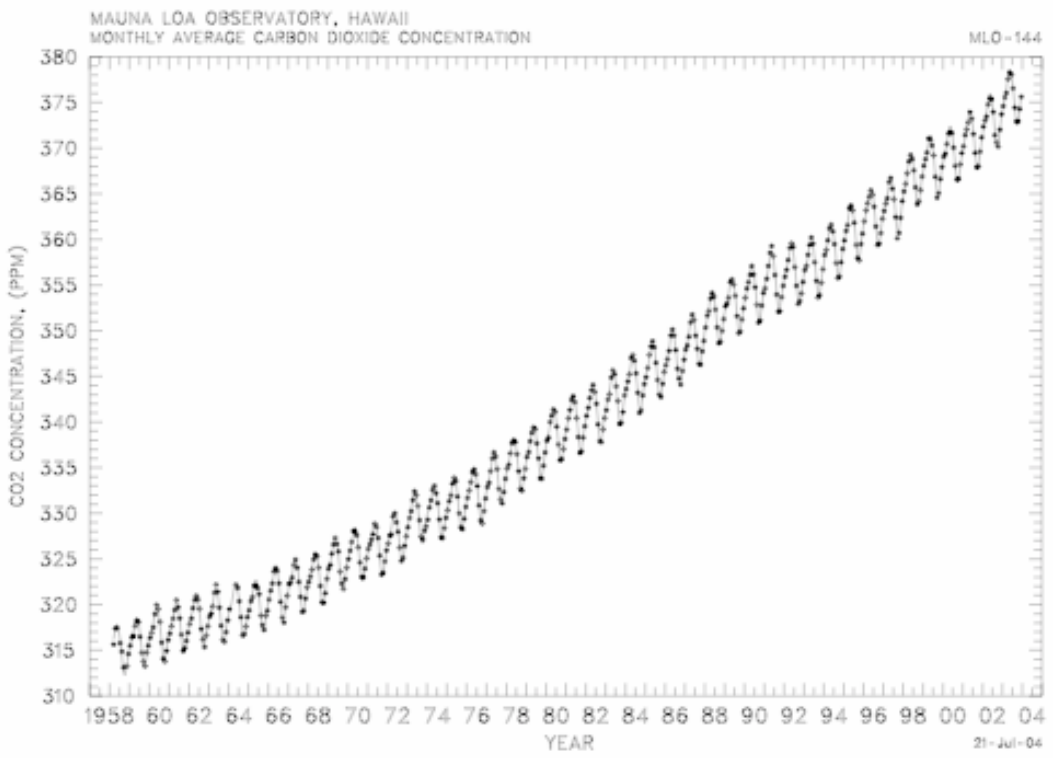
Maximum mean growing season O_3 concentrations



400x

Collins, W.J. et al. 2000. Atmosph. Env. 34, 255-267.

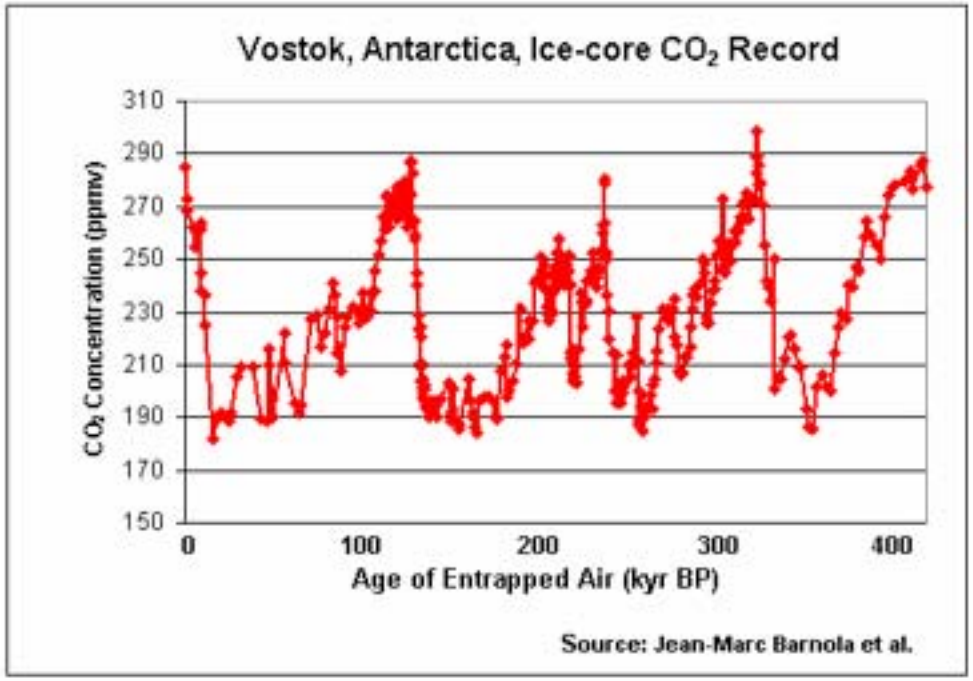
CO_2-Concentration is still increasing



CO_2-Concentration at Mauna Loa (1958-2003)

Data: Keening et al.

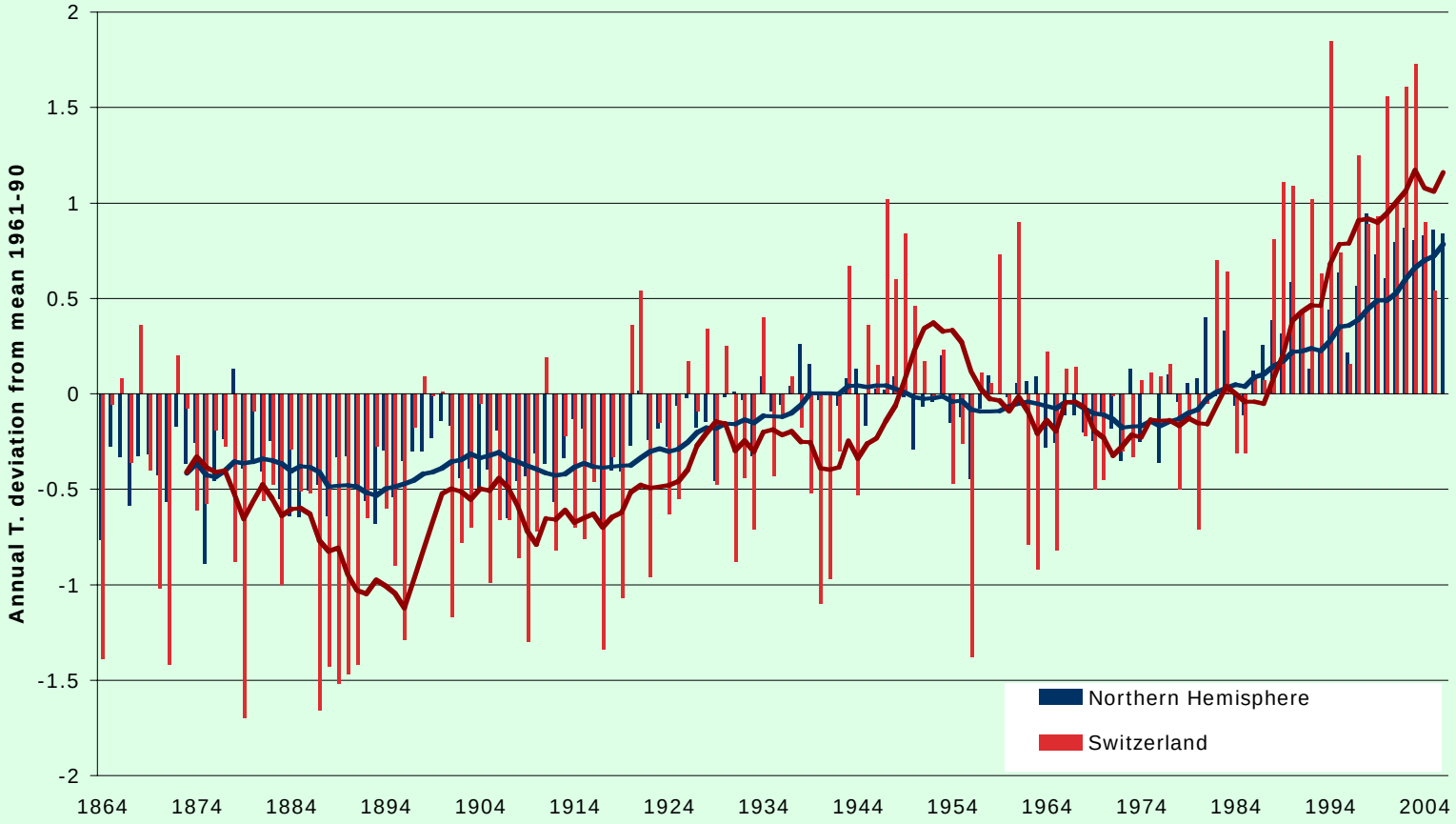
Large CO_2-Concentration fluctuations in the past, but below current values



Data: Barnola, Raynaud, Lorius, Barkov

Annual temperature increase

World-wide (0.7°C/100yr) and in Switzerland (1.4°C/100yr)



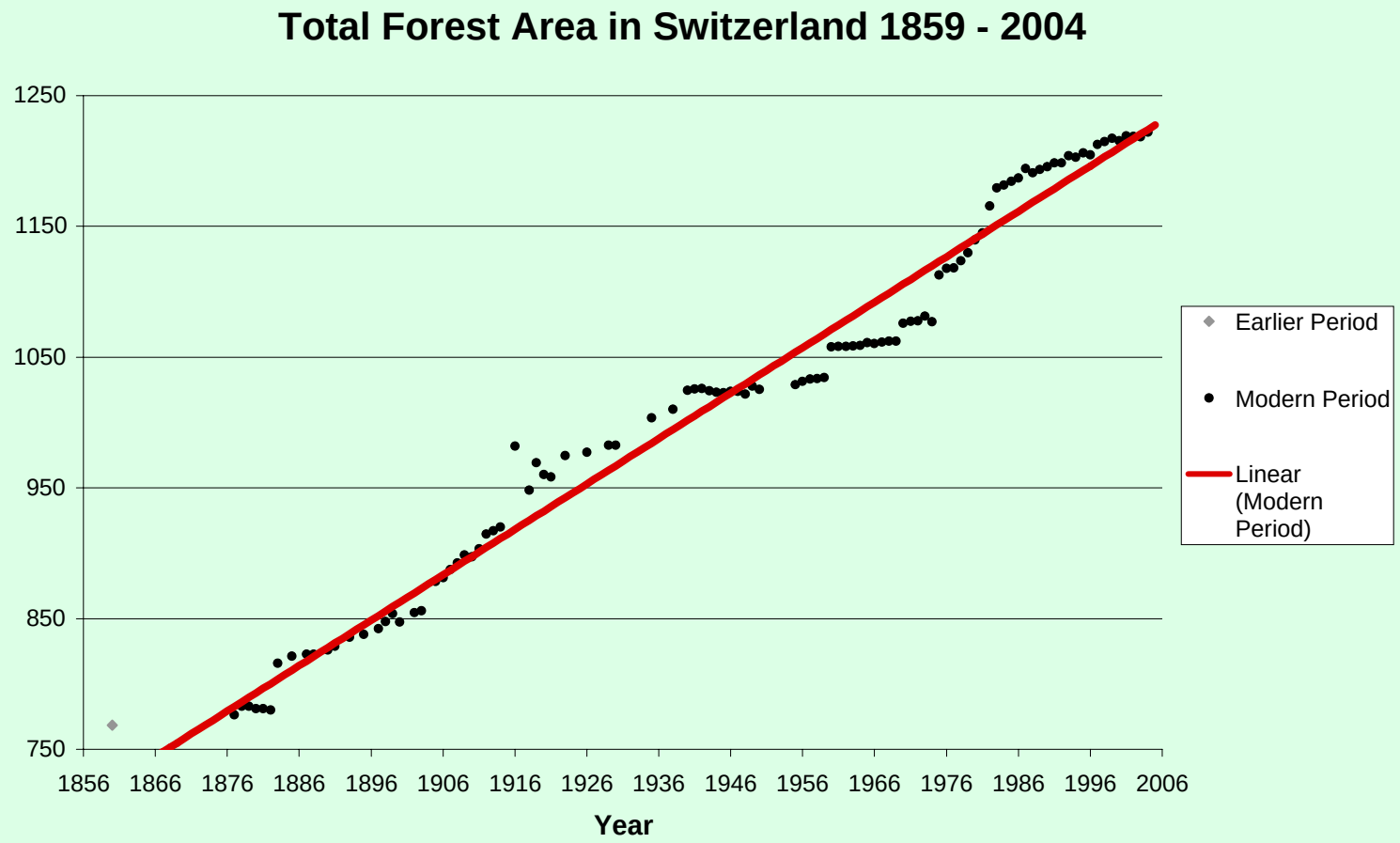
Data: MeteoSwiss

University of East Anglia

Changing Forests

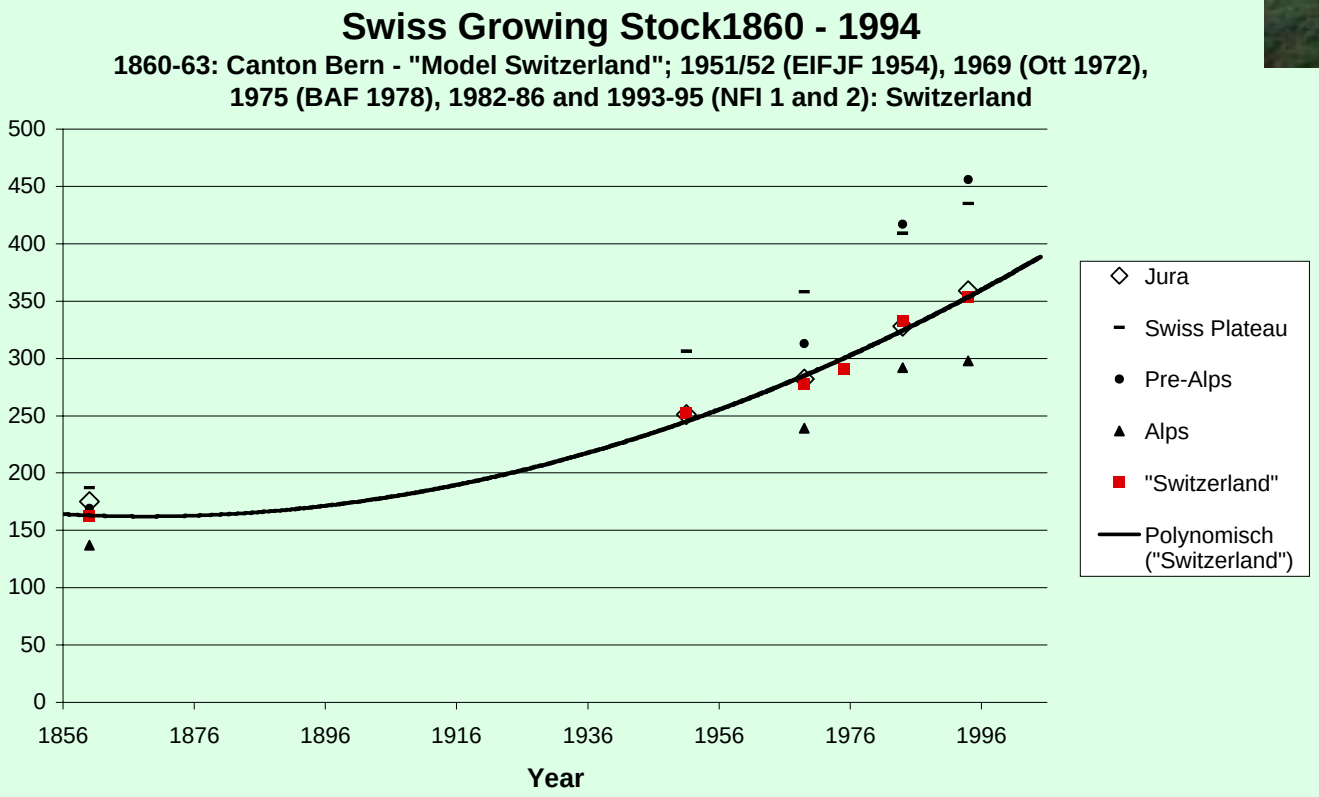
- Forest Area
- Forest Density / Stocking Volume
- Age distribution

Forest Area has increased in parts of central Europe



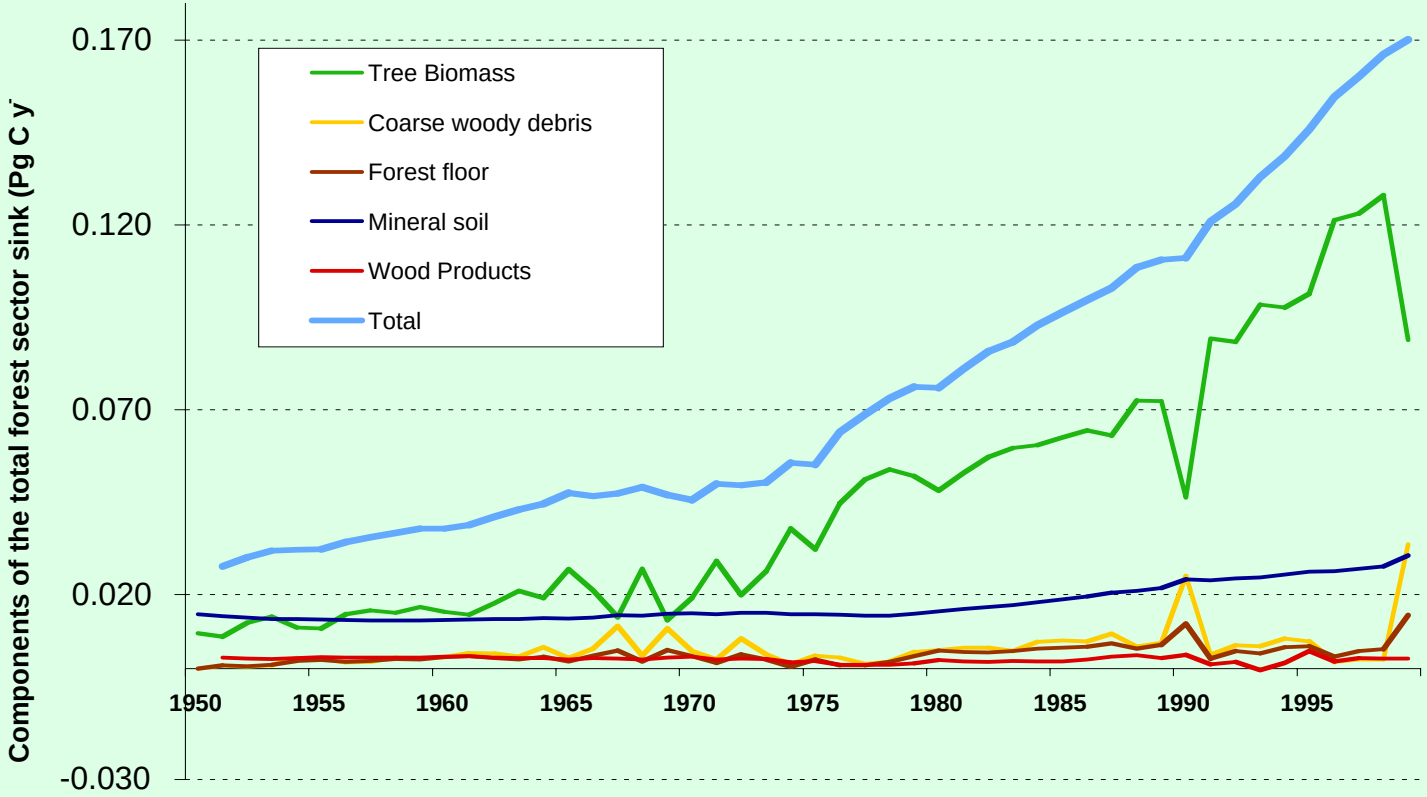
Usbeck et al. in prep.

Increasing Growing Stock - Example Switzerland



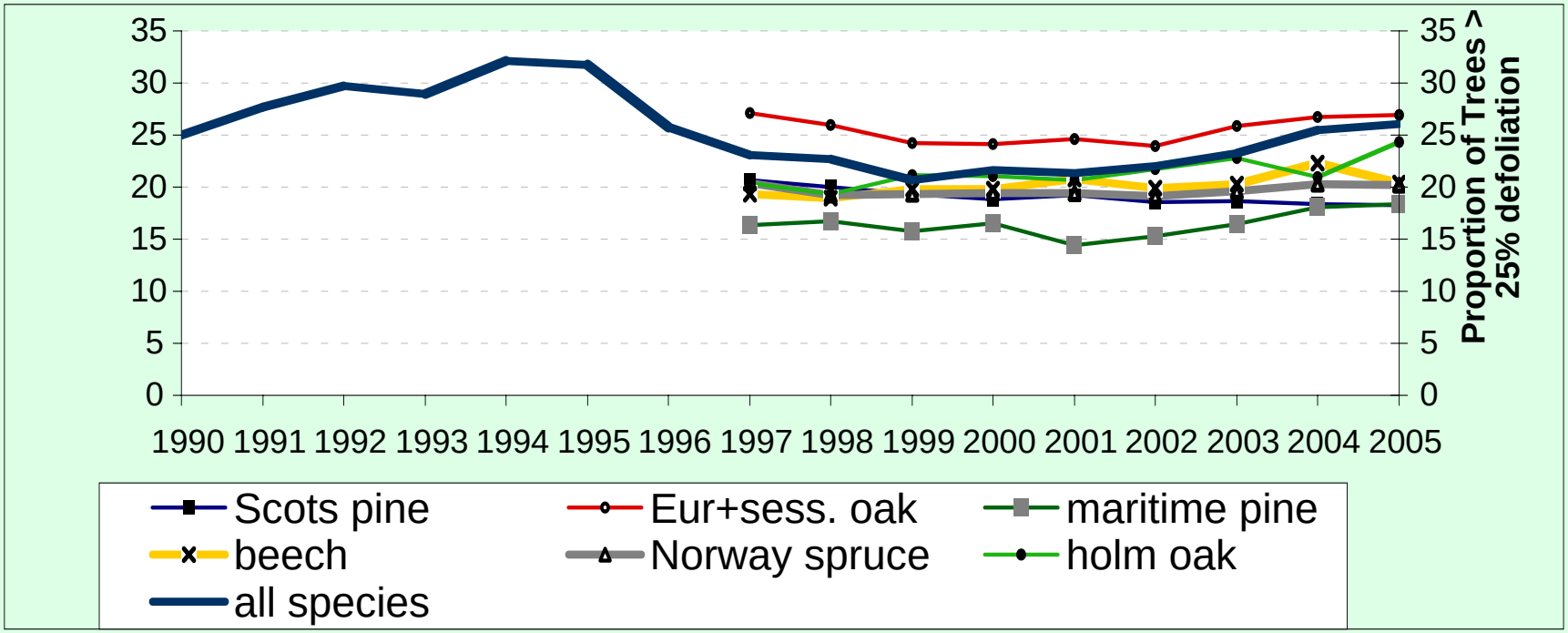
Usbeck et al. in prep.

Carbon stocks have increased in Europe



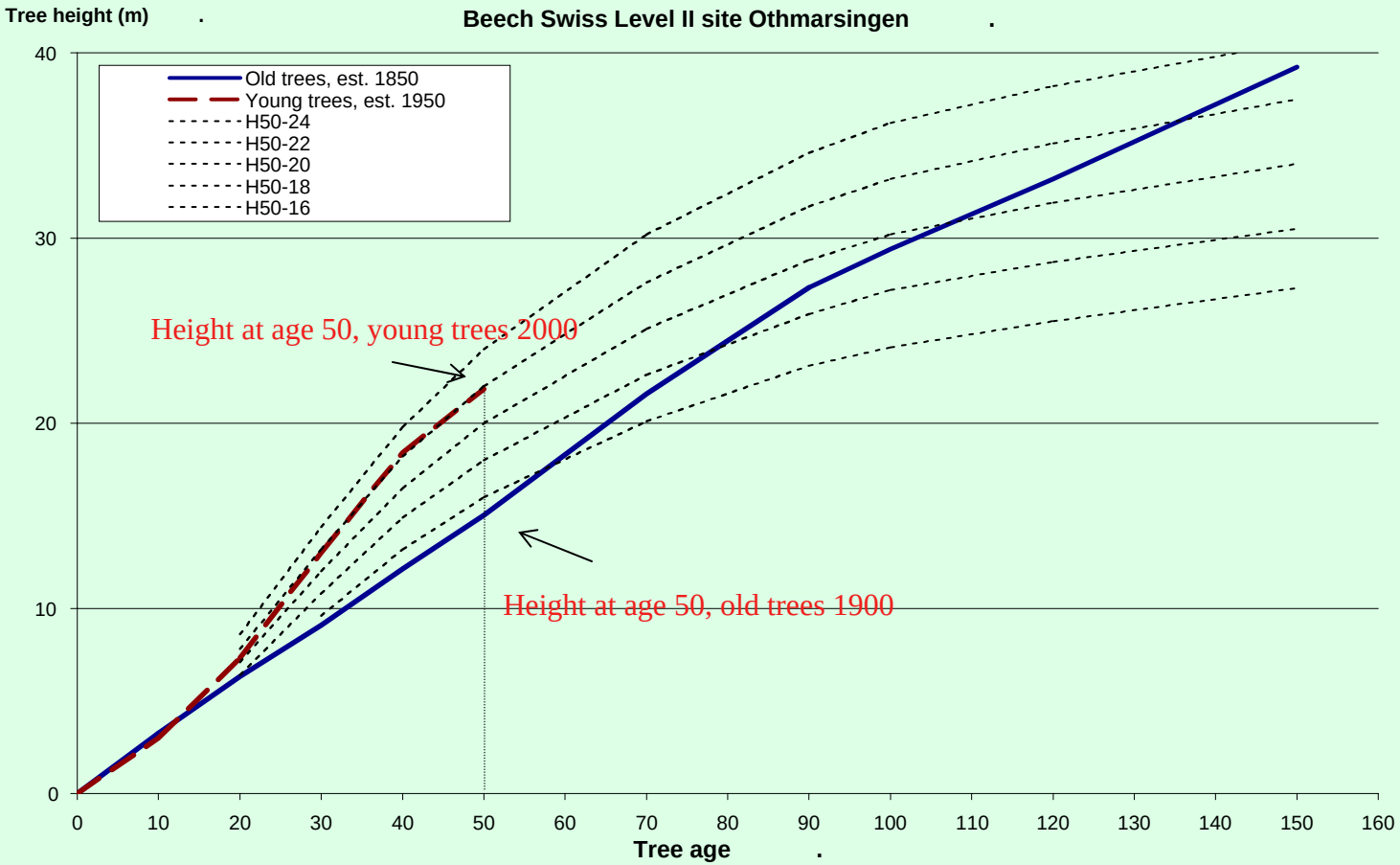
Nabuurs et al. 2003

Development of tree defoliation in Europe early increase, stagnation since



Fischer et al. 2006

Tree growth has increased in Central Europe

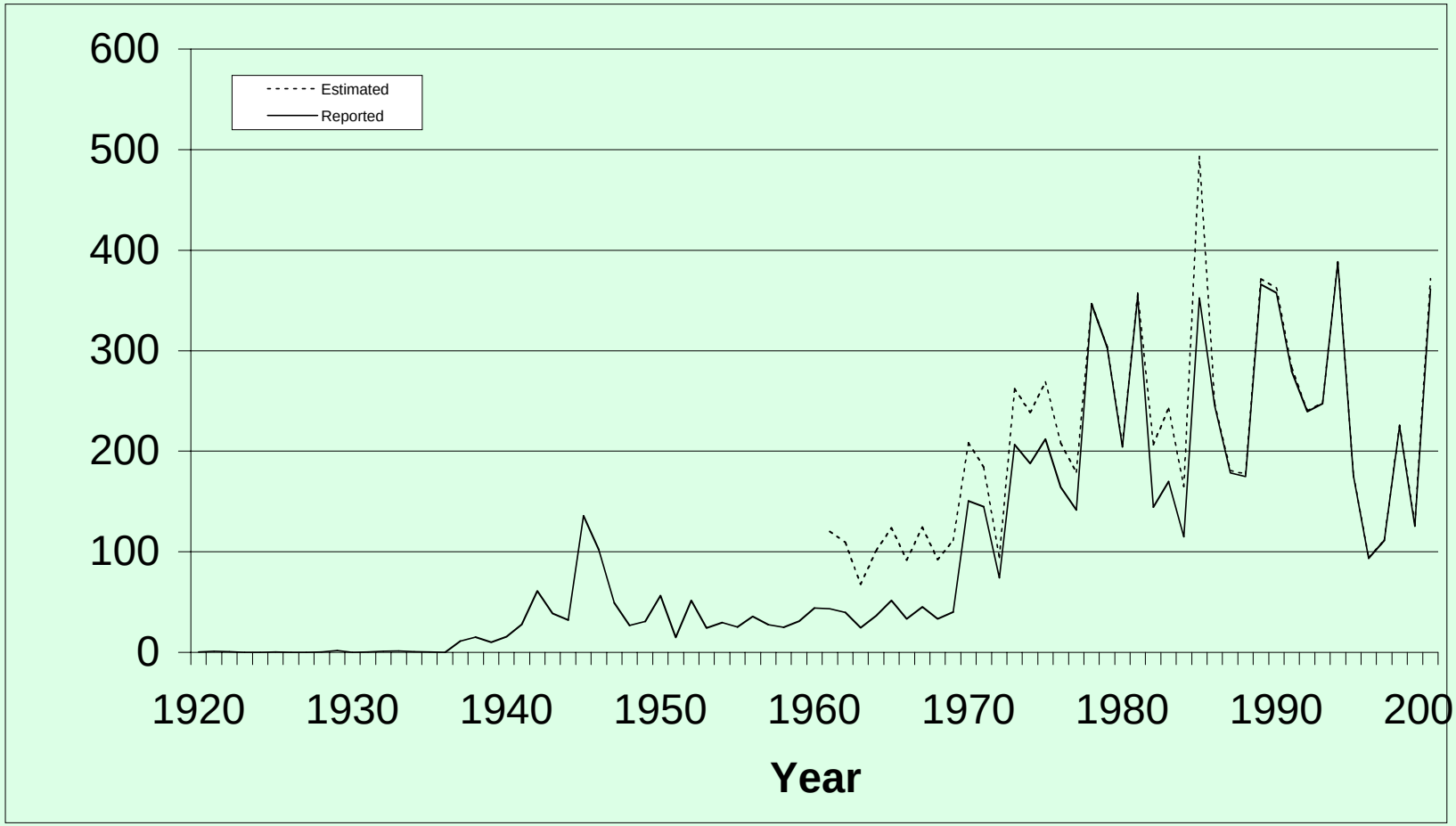


Sampled Tree height at a CH Level II site Data from RECOGNITION (Kahle et al.)

Changing Damages to Forests

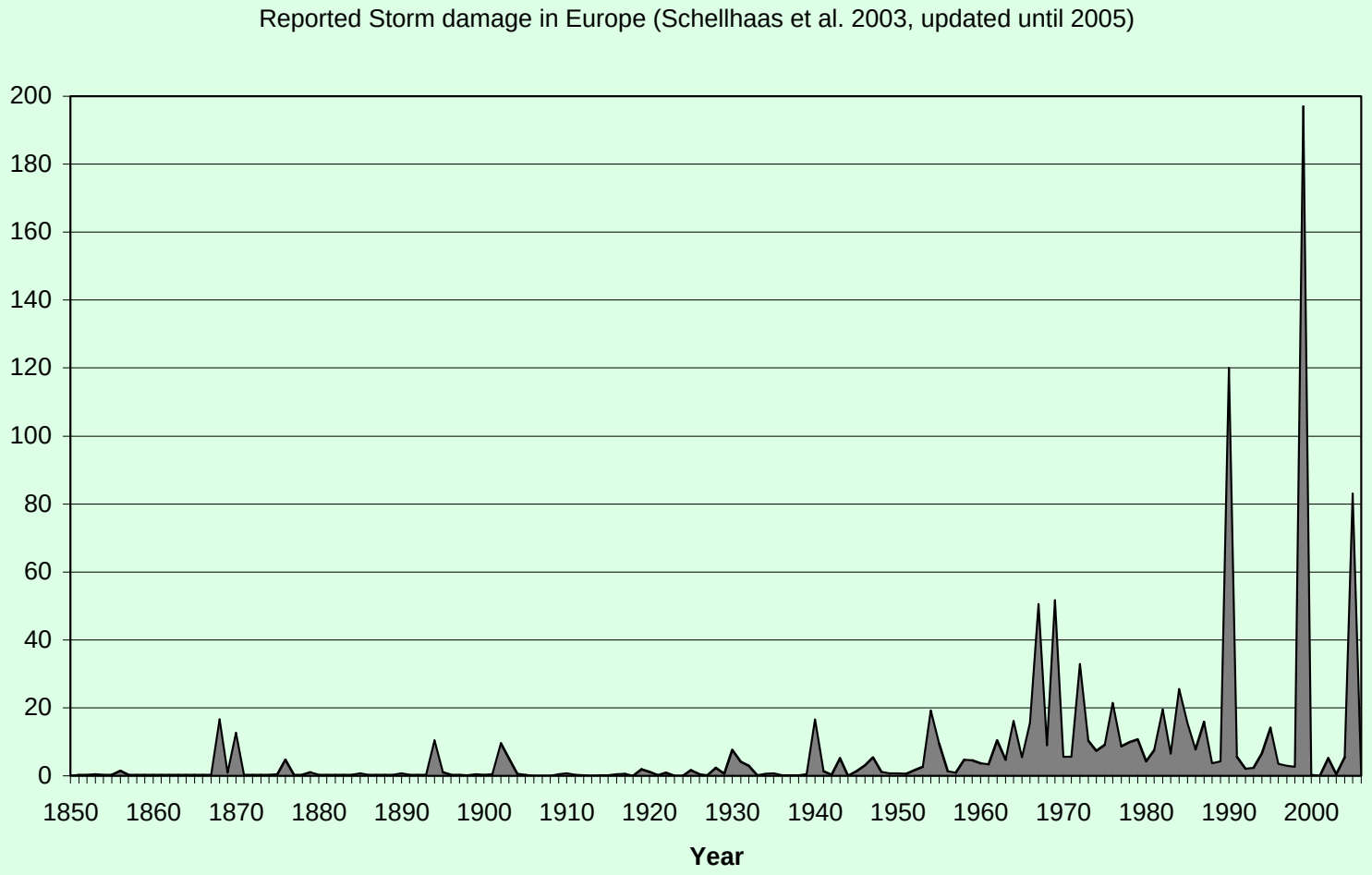
- Fire frequency and severity
- Storm damage
- Insect (in particular bark beetle) damages

Area affected by fire has increased in Europe



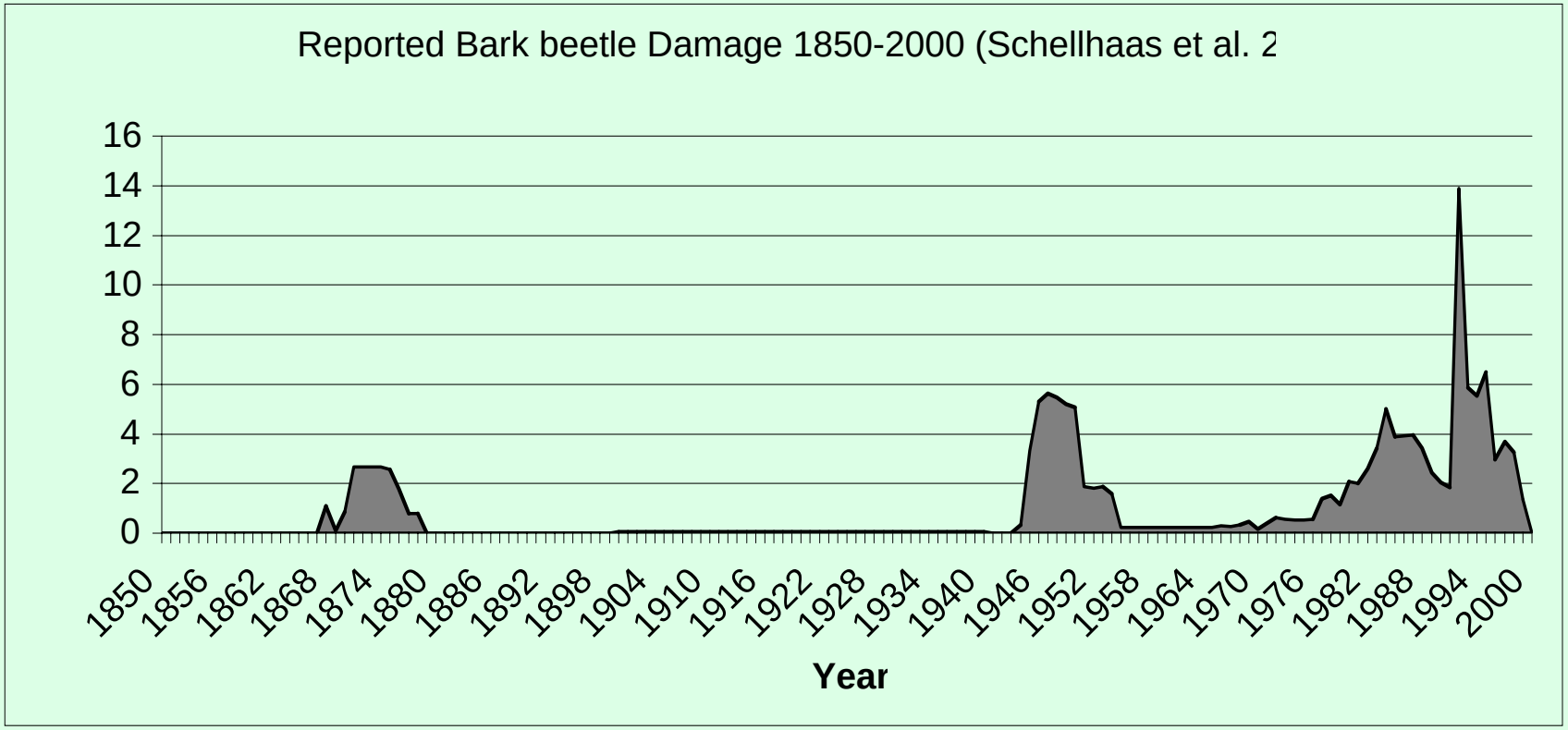
Schellhaas et al. 2003

Storm damage amount has increased in Europe



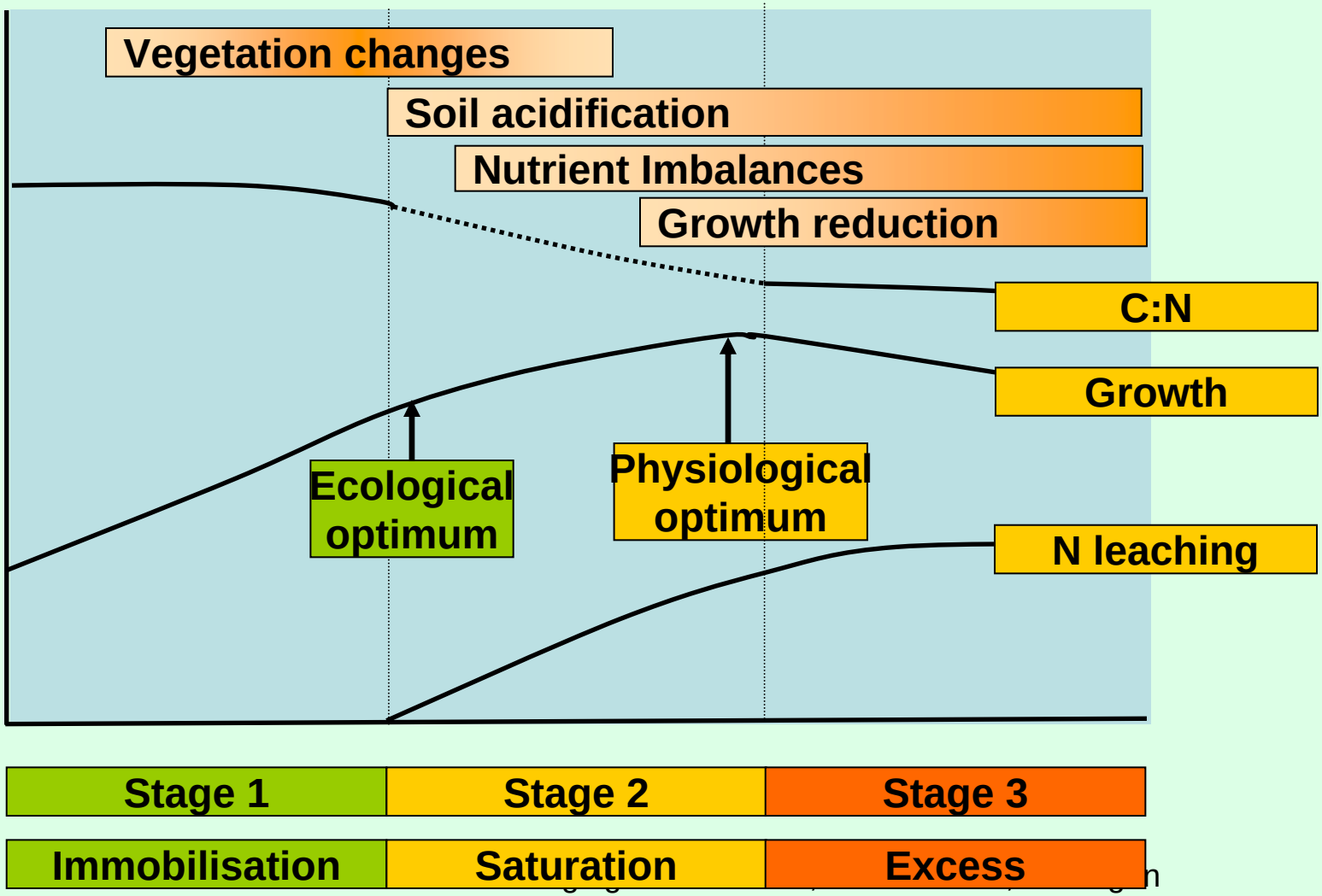
Schellhaas et al. 2003

Bark beetle damage has increased in Europe

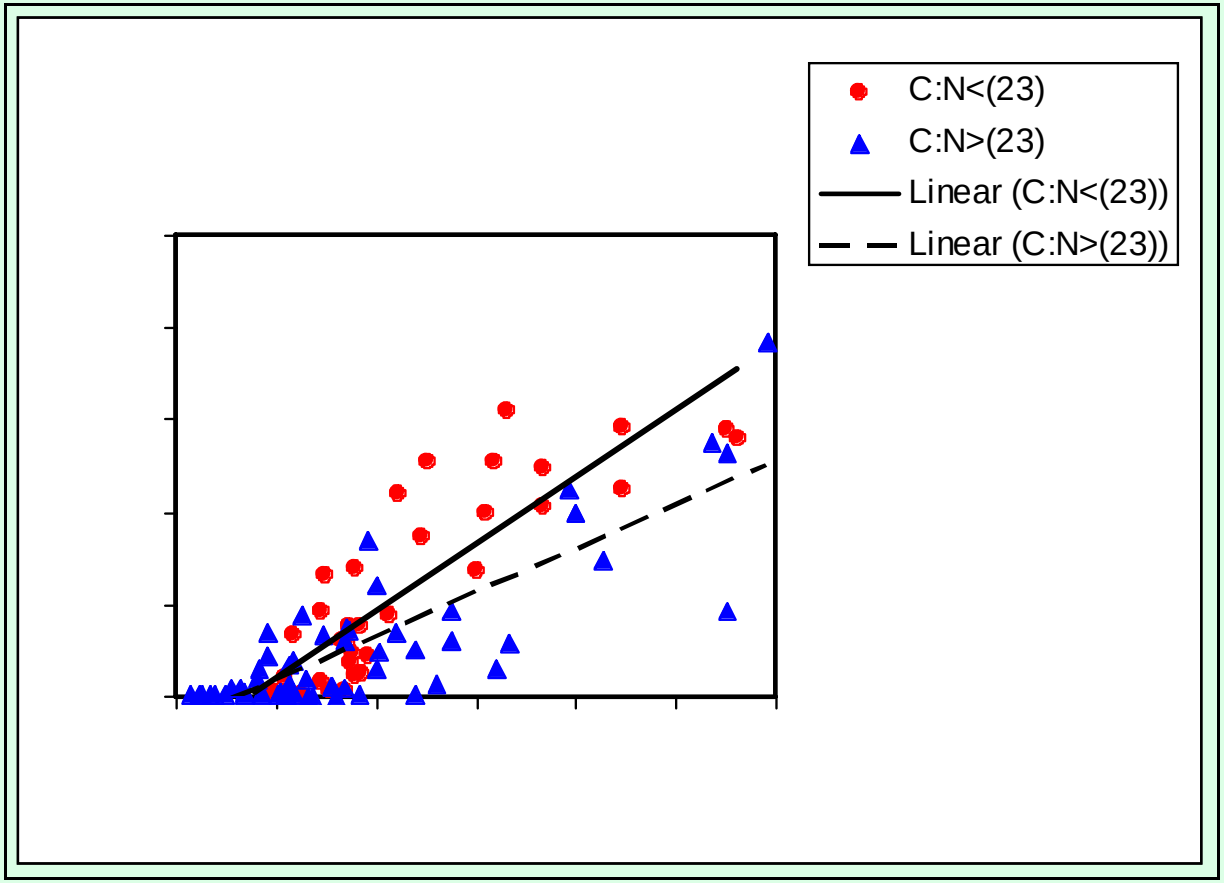


Schellhaas et al. 2003

N saturation stage and effects on terrestrial ecosystems

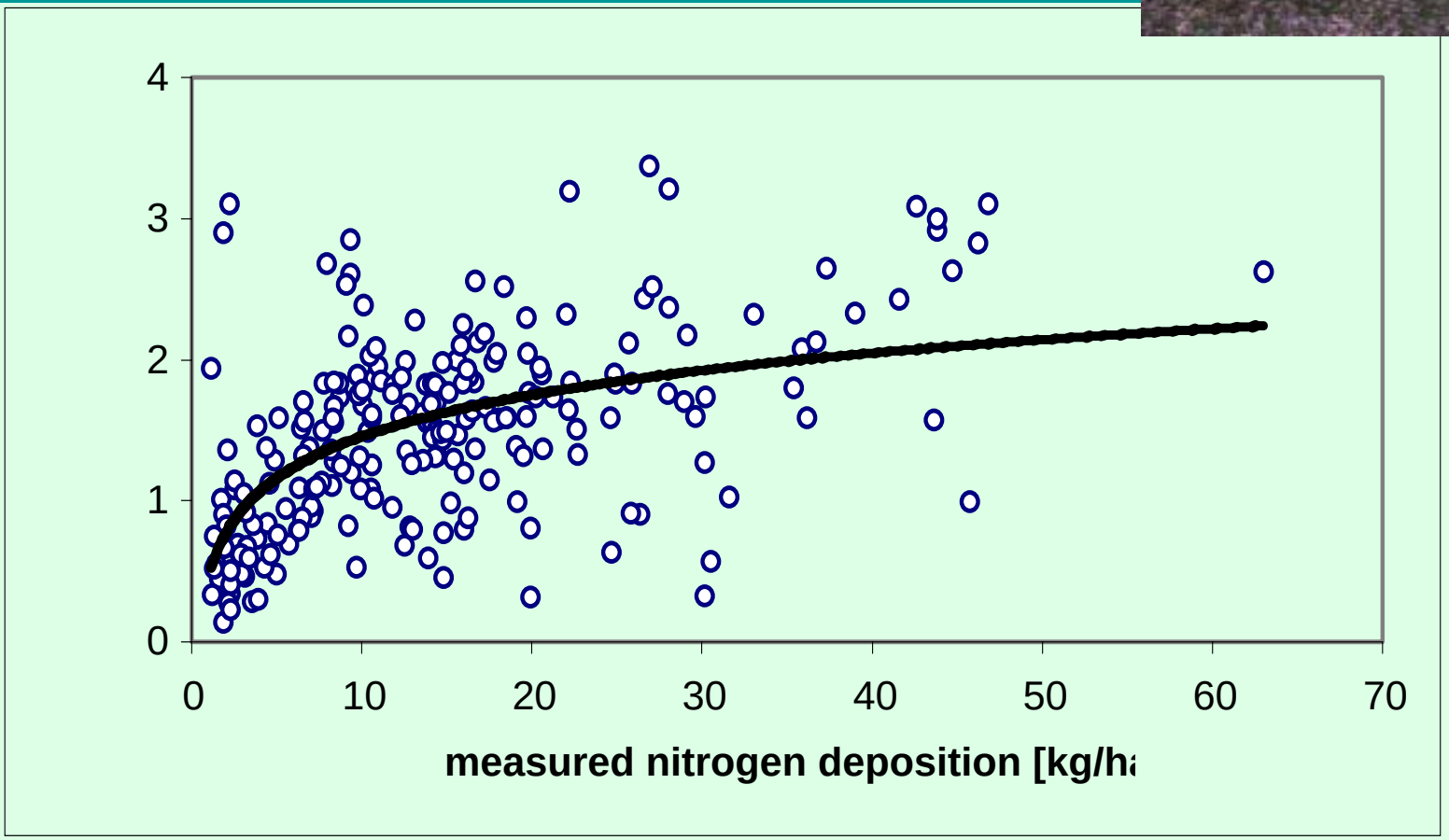


Forest nutrient status and N leaching



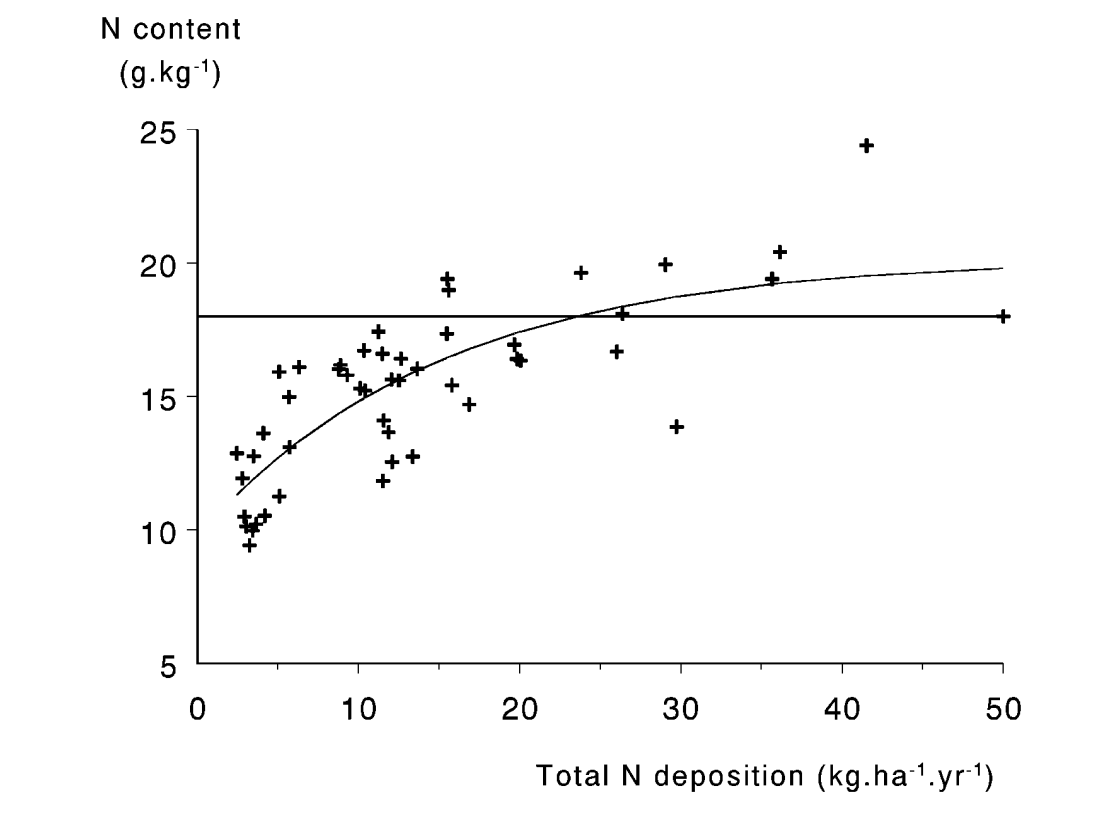
Leaching vs input of of total inorganic N as a function of the C/N ratio (Dise et al., pers. comm).

N deposition and plant diversity



In Fischer et al. 2006

Forest nutrient status



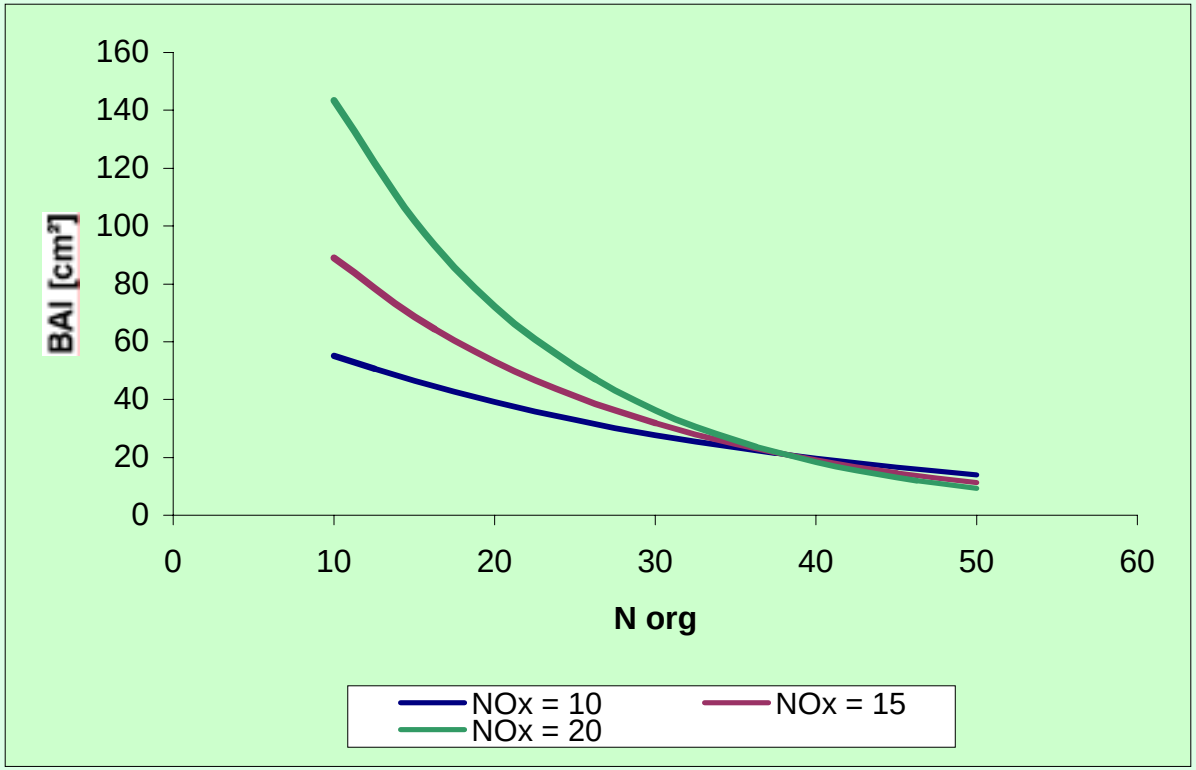
de Vries et al. 2003

68 IM Scots pine plots

N-Deposition and current tree growth

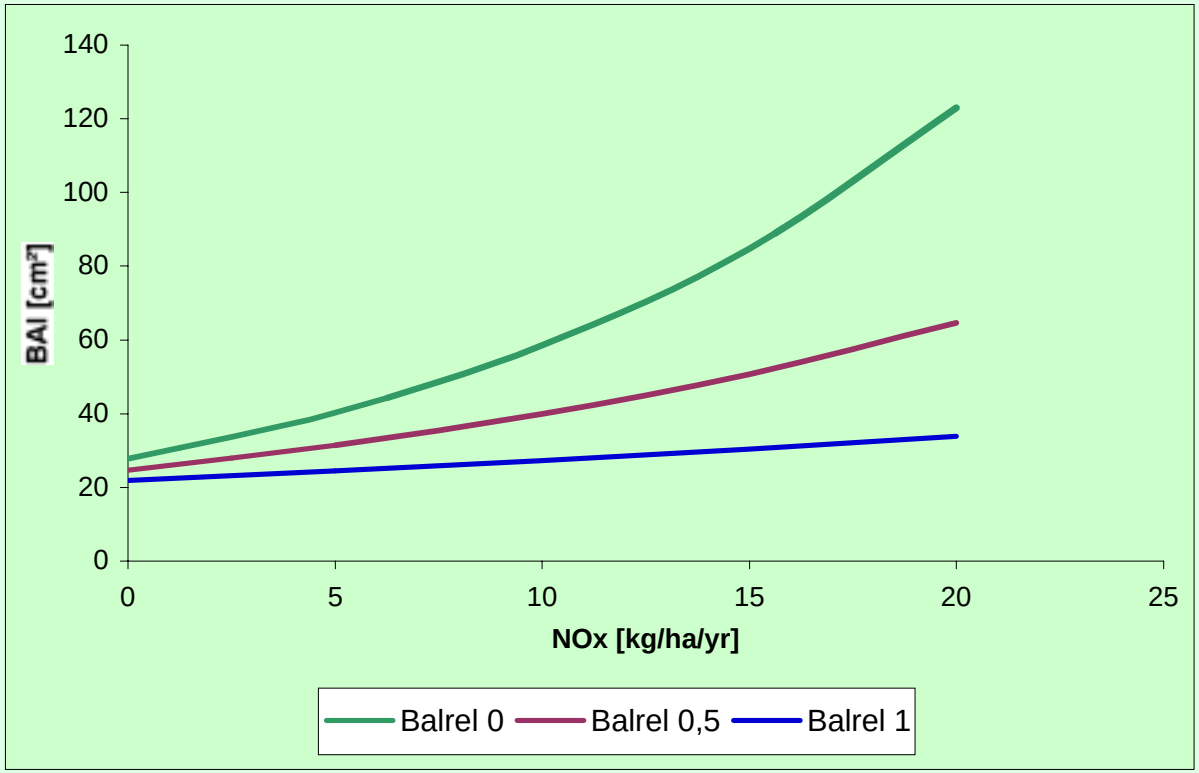
- Results not conclusive yet
- N mainly responsible for increased tree growth (RECOGNITION Project, Solberg et al. 2005, Laubhann and Sterba pers. comm.)
- N saturation causing partially reduced tree growth (Nelleman and Thomson 2001 , Braun et al. 1999)

The positive effect of NOx deposition on the increment of beech increases with decreasing nitrogen content of the organic soil.



Laubhann and Sterba 2006, pers. comm.

The effect of NOx deposition on Scots pine increment decreases with increasing competition.

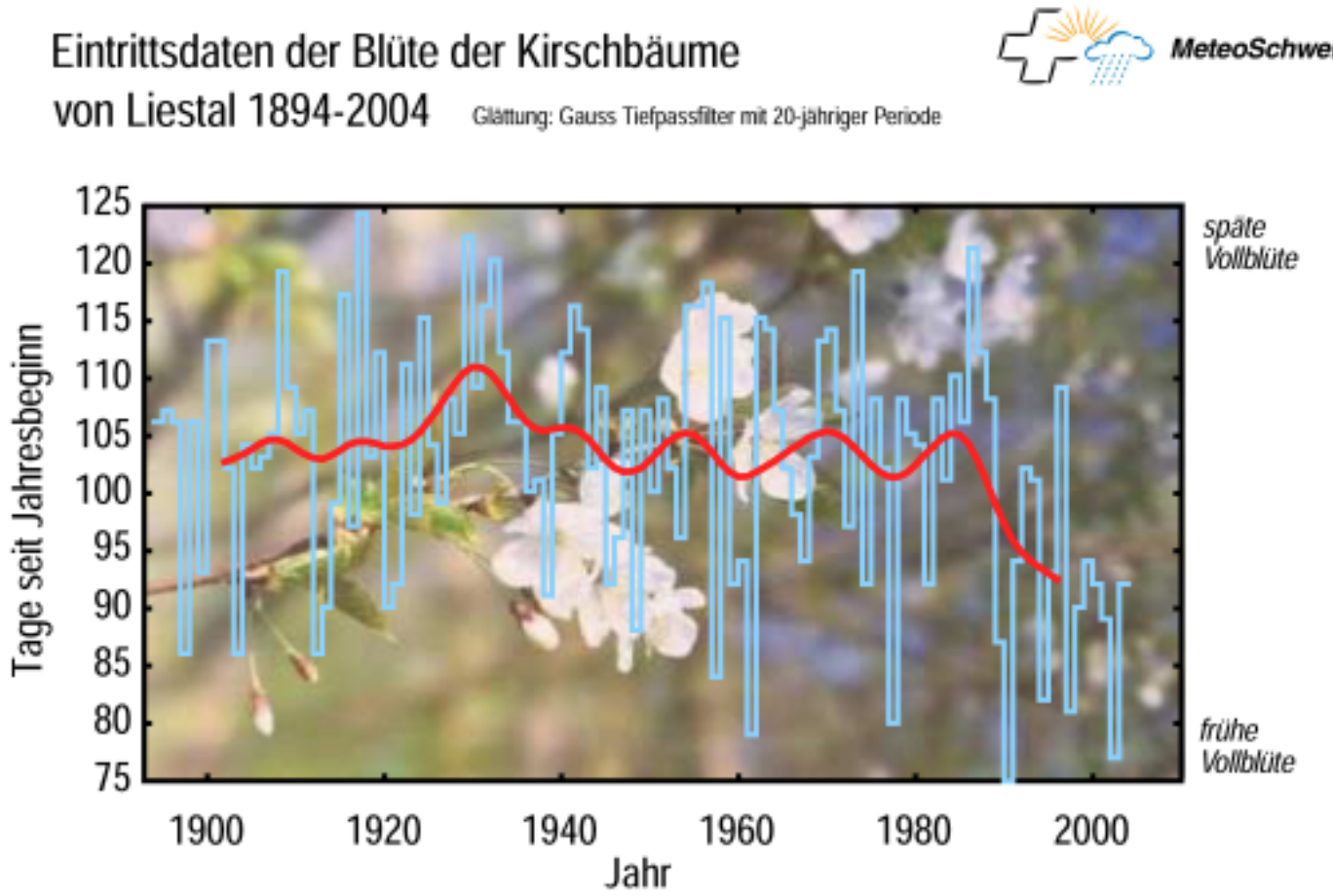


Laubhann and Sterba 2006, pers. comm.

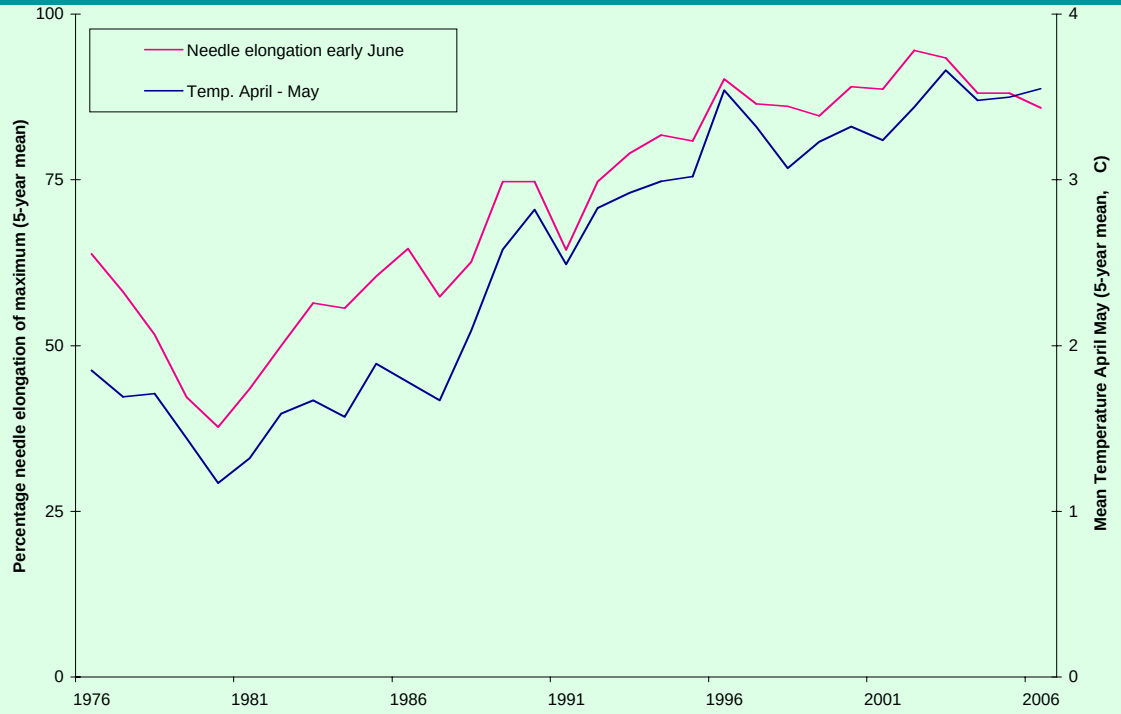
Effects of Climate change on Forests

- Change in Vegetation period
  - Earlier leaf unfolding, later or earlier leaf fall
- Change in tree growth
  - Increase if low temperature is limiting and other factors not
  - Decrease if drought/heat stress increases
- Change in tree mortality
  - Directly due to change in stressed trees (drought or wind)
  - Change in insect/pathogen populations
- Change in extreme damaging climatic events
  - Frost, snow, wind, fire conditions

Change in timing of flowering of cherry trees in Switzerland



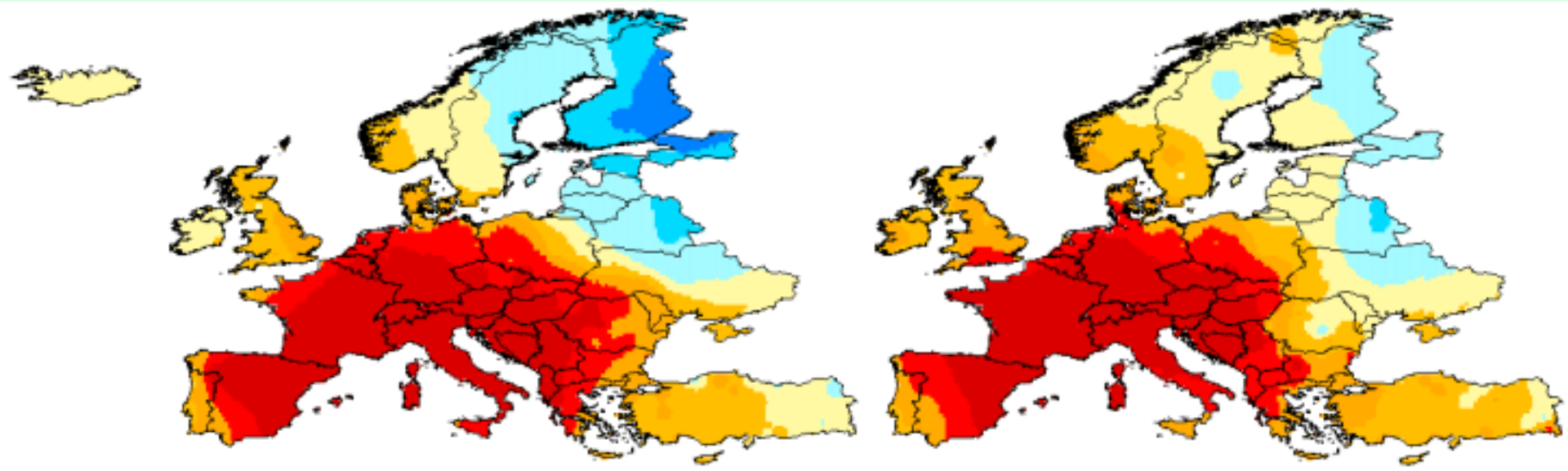
Needle elongation and Temperature



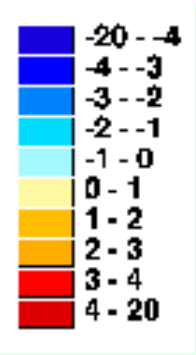
Needle elongation of European larch in the Swiss Alps has advanced by 8 to 10 days or 200 m in the past 20 years

Dobbertin et al. in prep.

Deviation of Maximum Temperature 2003



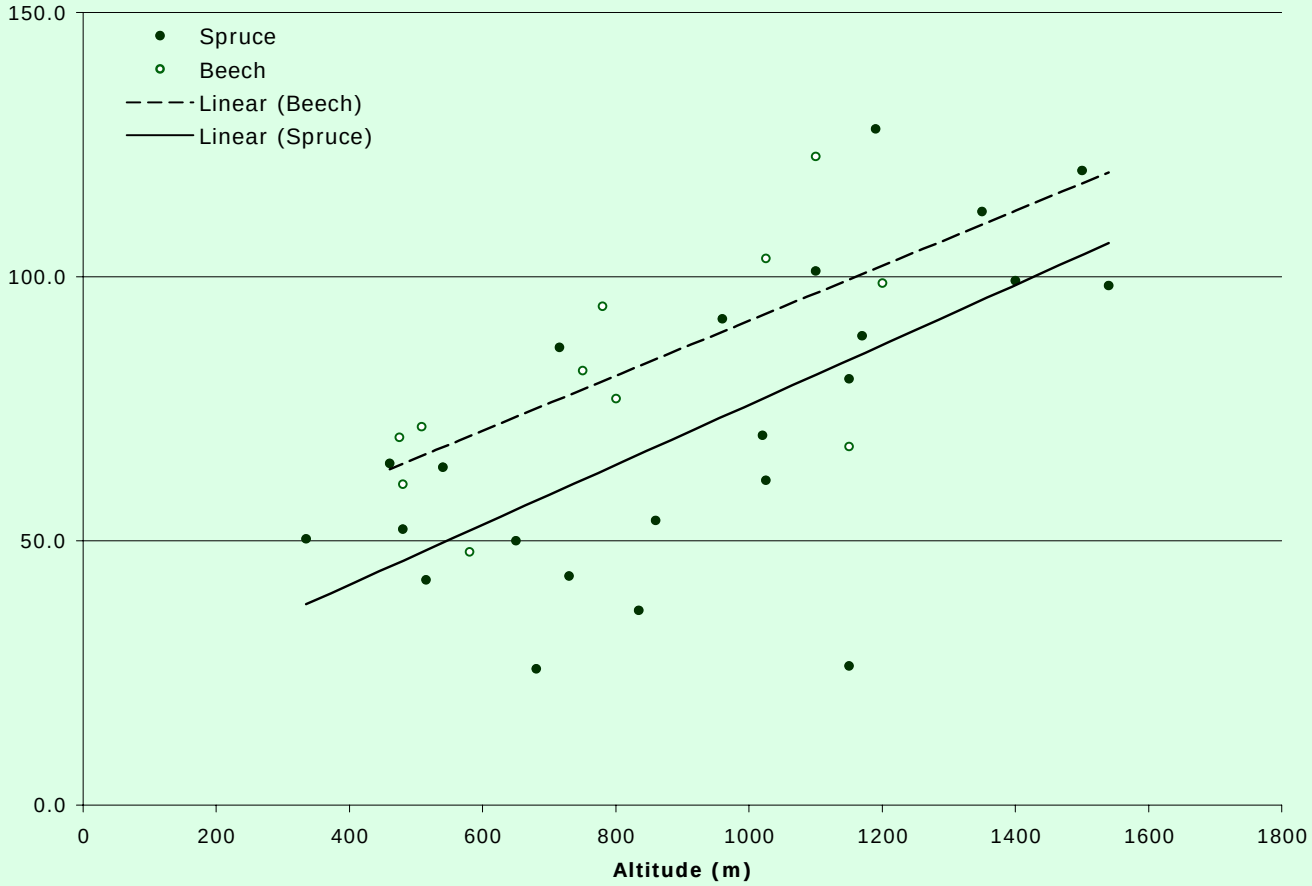
June



August

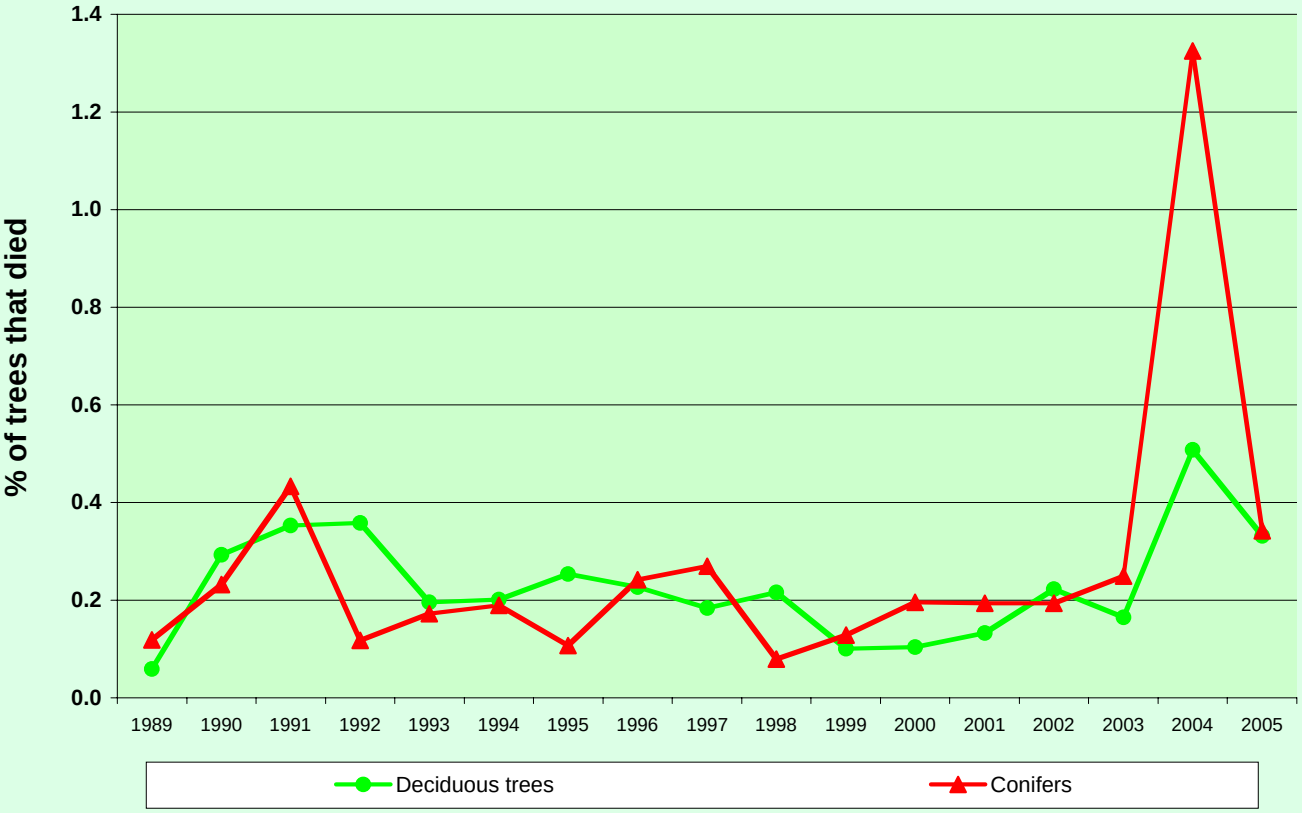
(Rebetez et al. 2006)

Differing response in tree growth in the Alps during the drought of 2003



Stem growth on level II plots in 2003 in percent of the growth of 2002 in the Alps

Increasing tree mortality in France following the drought/heat of 2003

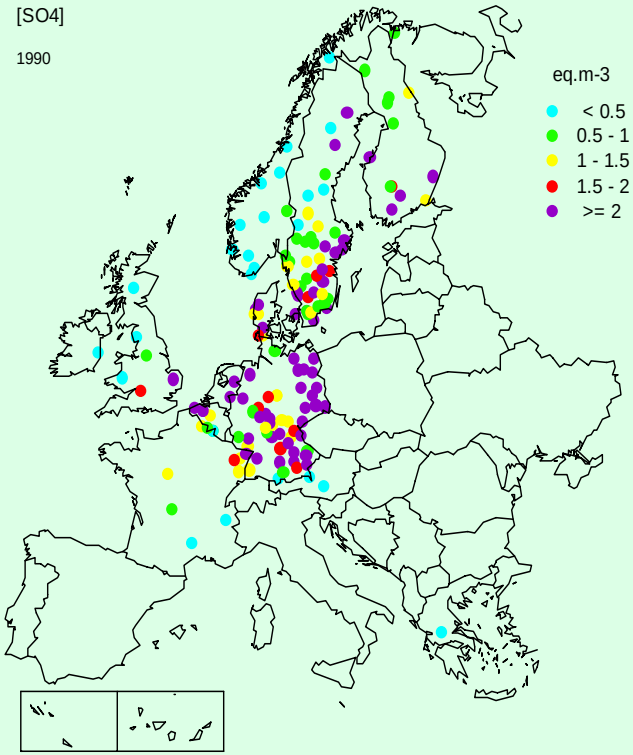


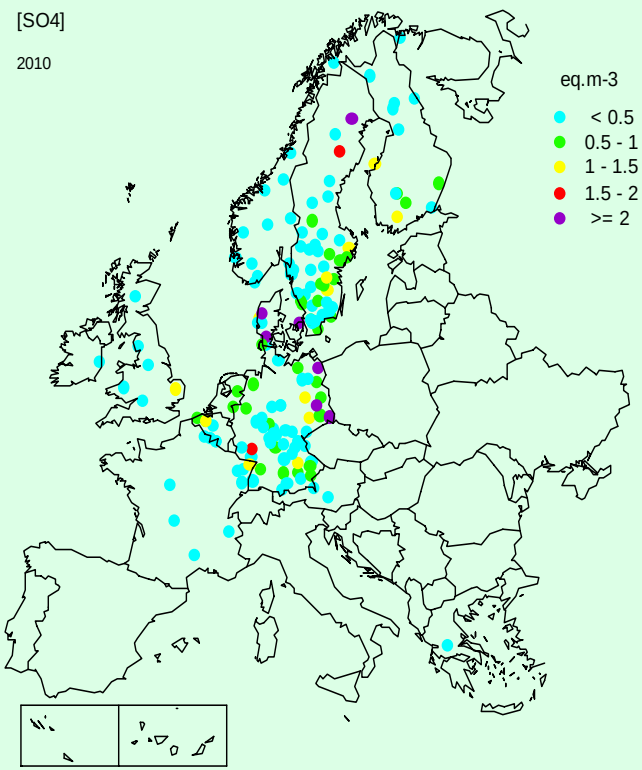
Mortality rates between 1989 et 2005 in the French level I plots (Nageleisen and Renaud 2006)

Conclusions Tree responses

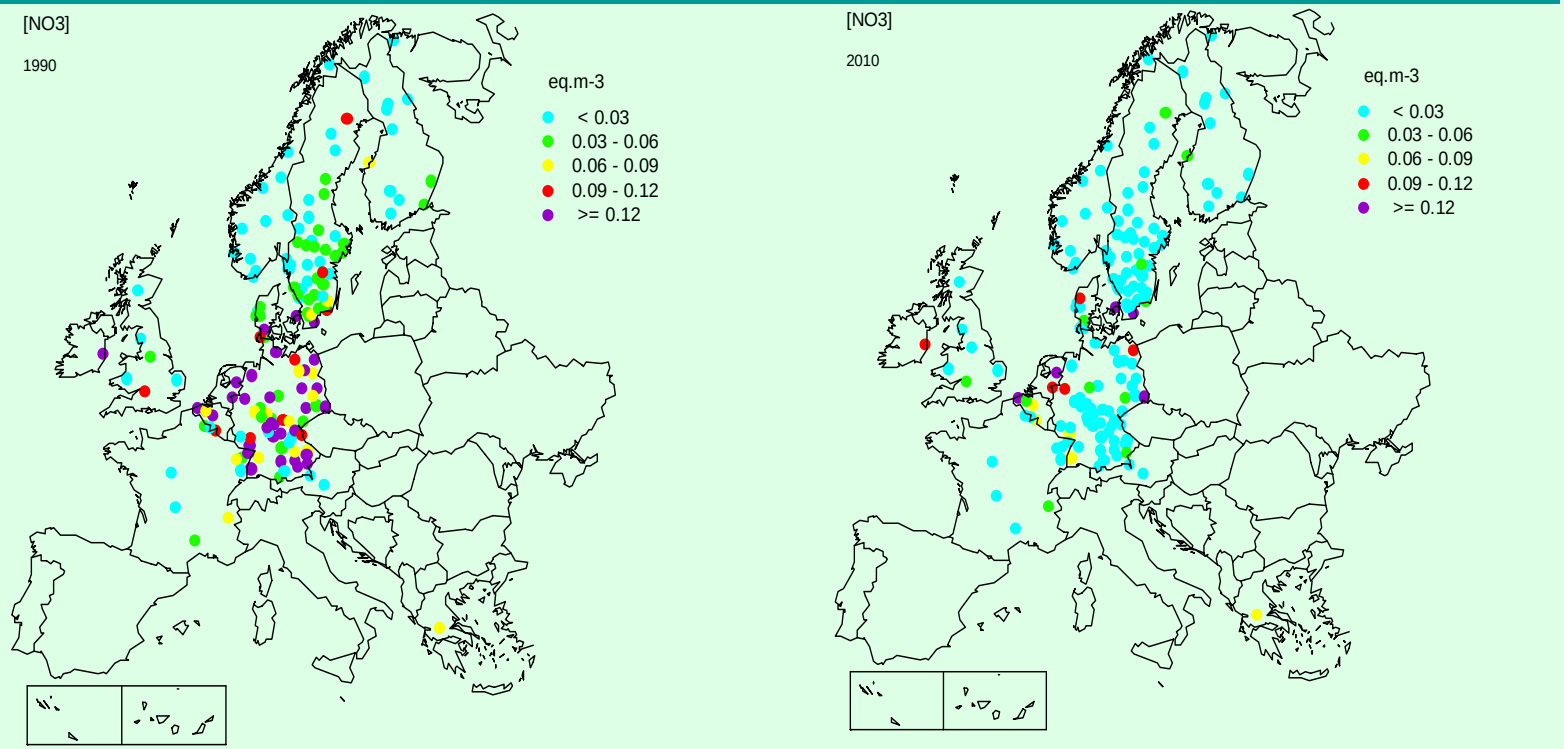
- Trees have reacted with increased growth to N deposition and partially to warming
- However, recent drought has caused substantial growth reduction and increased tree mortality

Modelled concentration of $[SO_4]$ at Level II sites





Modelled concentration of $[NO_3]$ at Level II sites



Conclusions (1)

- Current emission reduction protocols have and will lead to strong reductions in deposition of N and especially S in Europe

- Still, part of the ecosystems remain at risk because the current reduction plans do not reduce the area with critical load exceedances to zero but only reduces it by 50 %.....

- For Nitrogen reduction percentages are lower than for S and large parts of the reduction still need to be achieved in the coming 10 years.

Conclusions (2)

- Carbon dioxide will further rise depending our efforts in emission reduction
- Temperature will further rise by between 1.5°C and > 5.5°C by the end of this Century
- Extreme events (heat, drought, precipitation) will increase
- Phenology, tree growth and mortality pattern will be altered
- At the limit of their geographic distributions tree species shifts are already occurring and changes will be more rapid in the future

Thank You for Your Attention!!