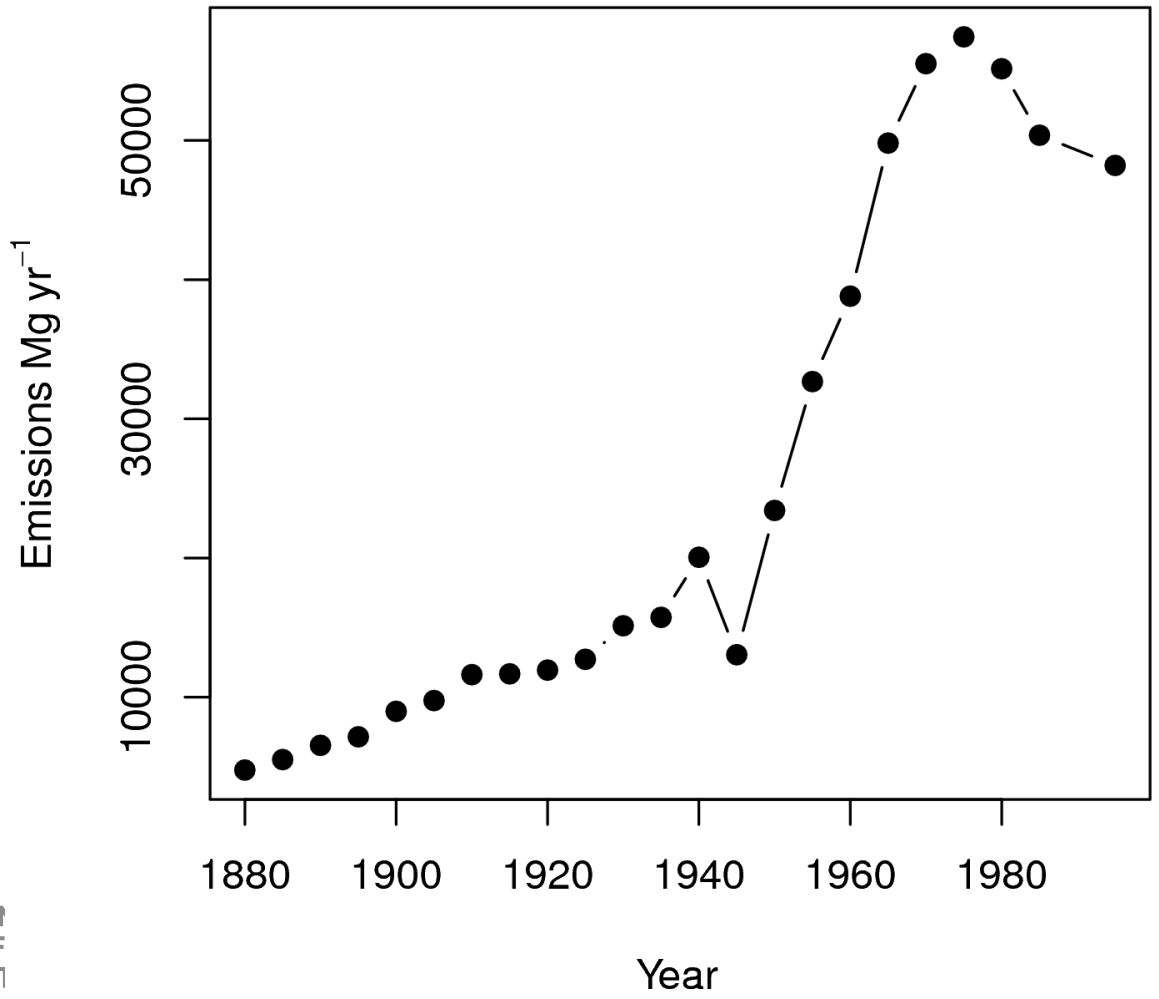
Using tree rings networks as detectors of environmental change

Frank Berninger

Why N and S deposition....
Don't we know the story already



Source
Emep

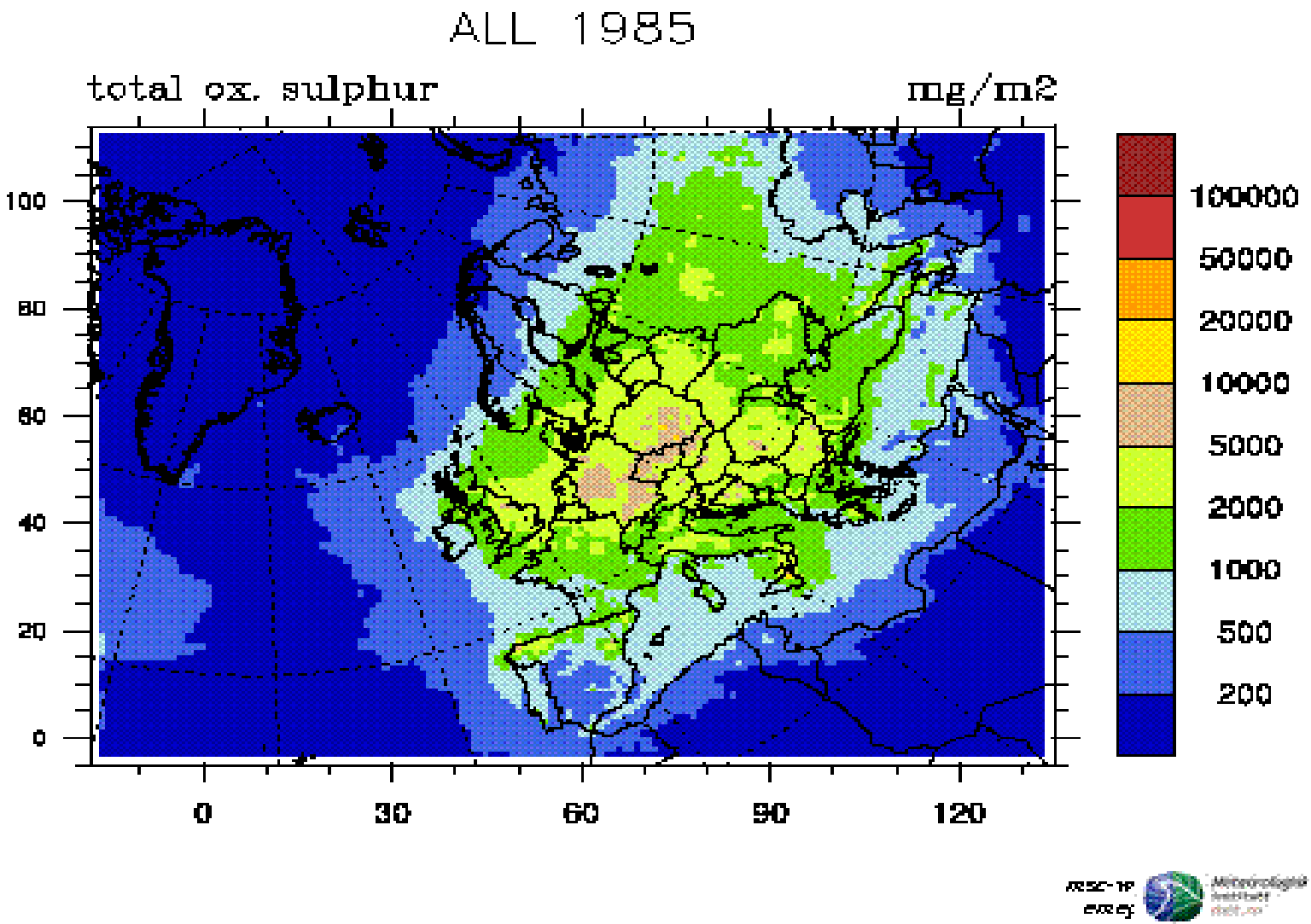

ALL 1985
total ox. sulphur
mg/m2
100
80
60
40
20
0
0
30
60
90
120
100000
50000
20000
10000
5000
2000
1000
500
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Photo BUND

Source
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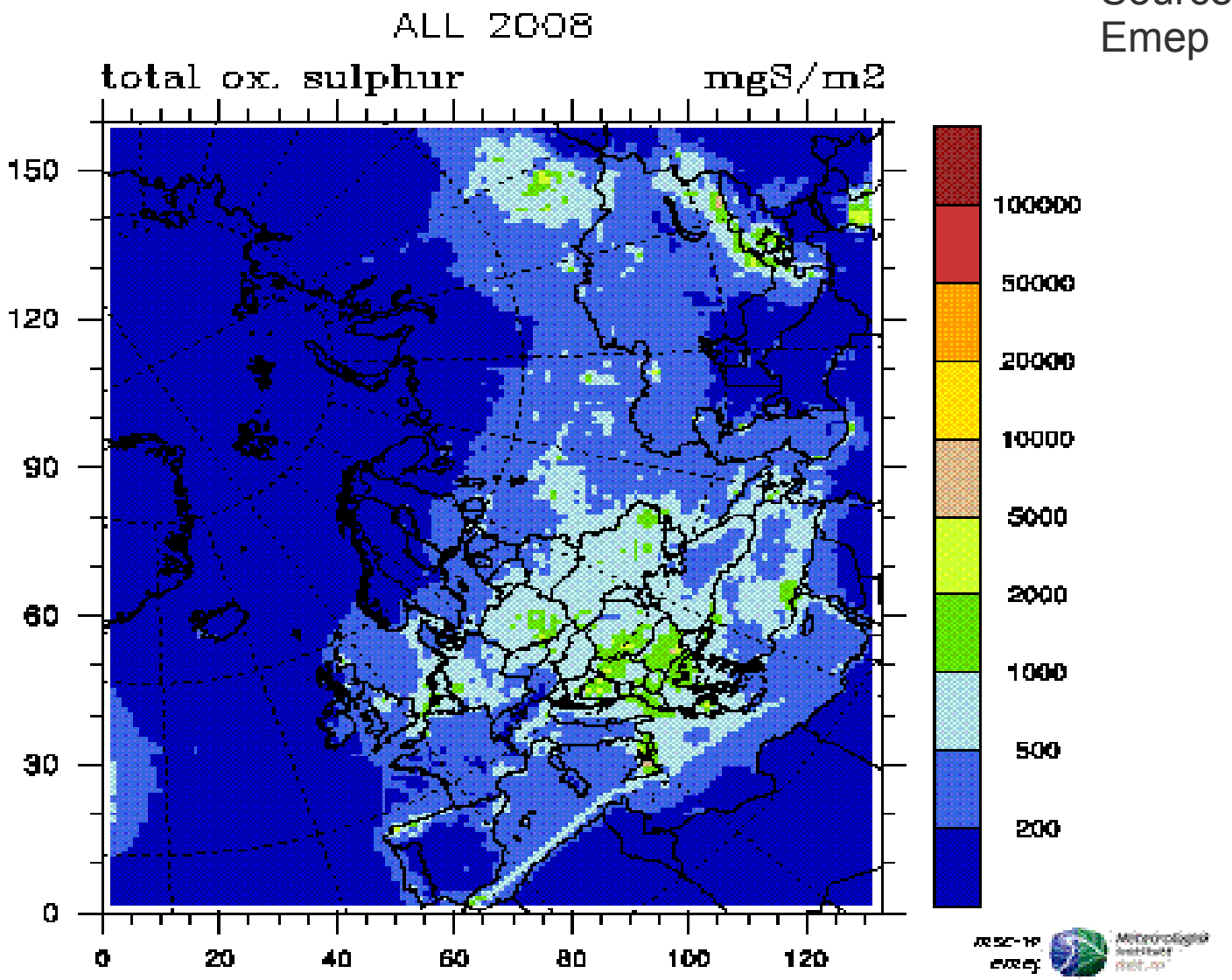
ALL 2008
total ox. sulphur
mgS/m2
150
120
90
60
30
0
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80
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120
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50000
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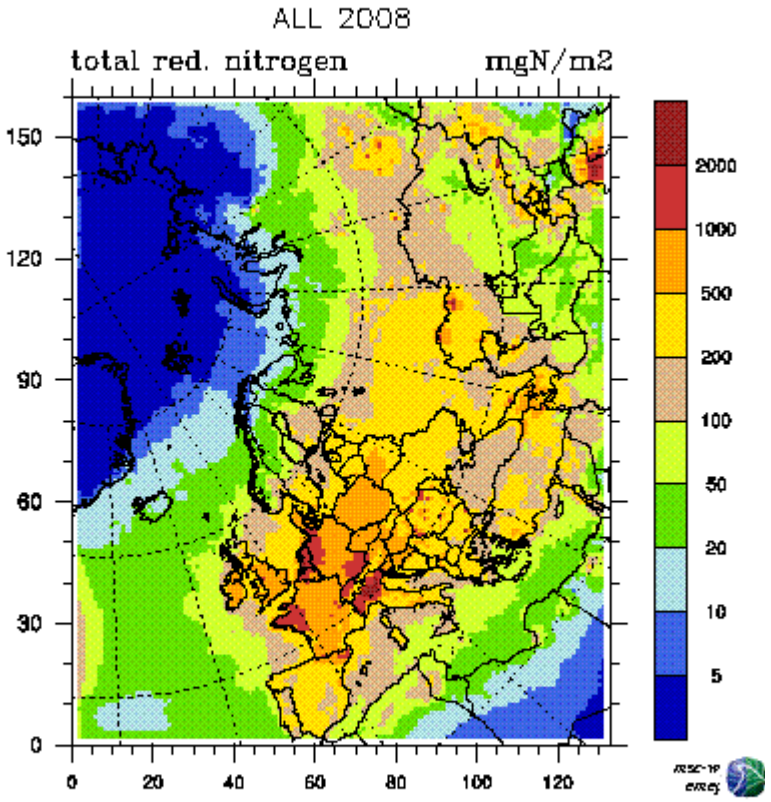
ALL 2008
total red. nitrogen
mgN/m2
150
120
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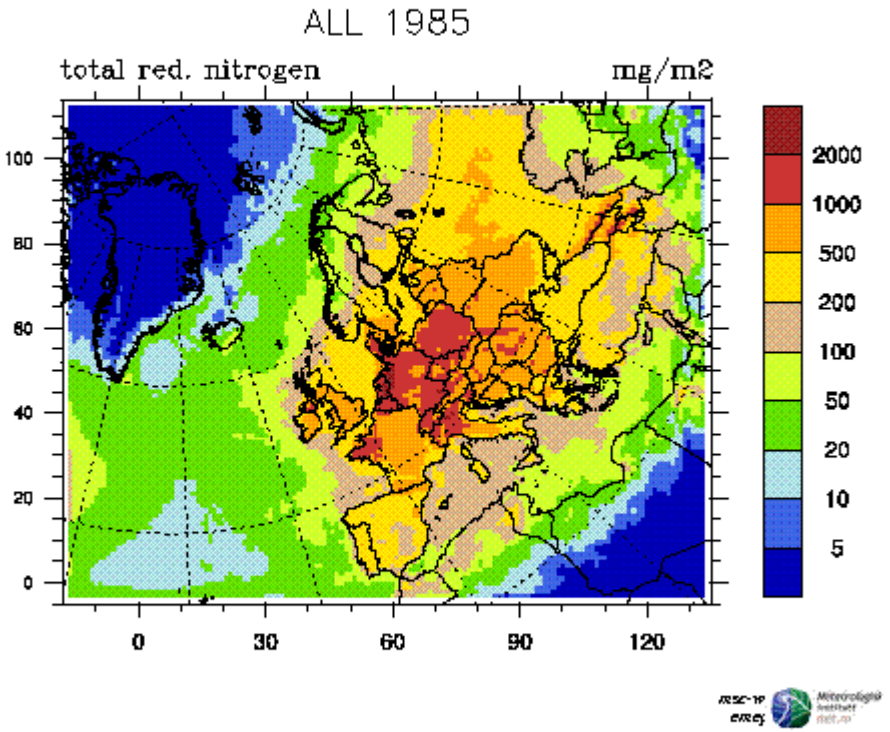
10
5


ALL 1985
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100
80
60
40
20
0
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30
60
90
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2000
1000
500
200
100
50
20
10
5

Two theories (not exclusive)

- **Direct toxicity of SO_2**
- Rapid reaction
- Not accumulative
- More rapidly reversible

- **Acidification**
- Slow effects
- Accumulative
- Slowly reversible

Both are interacting...

Tree rings as indicators of environmental change

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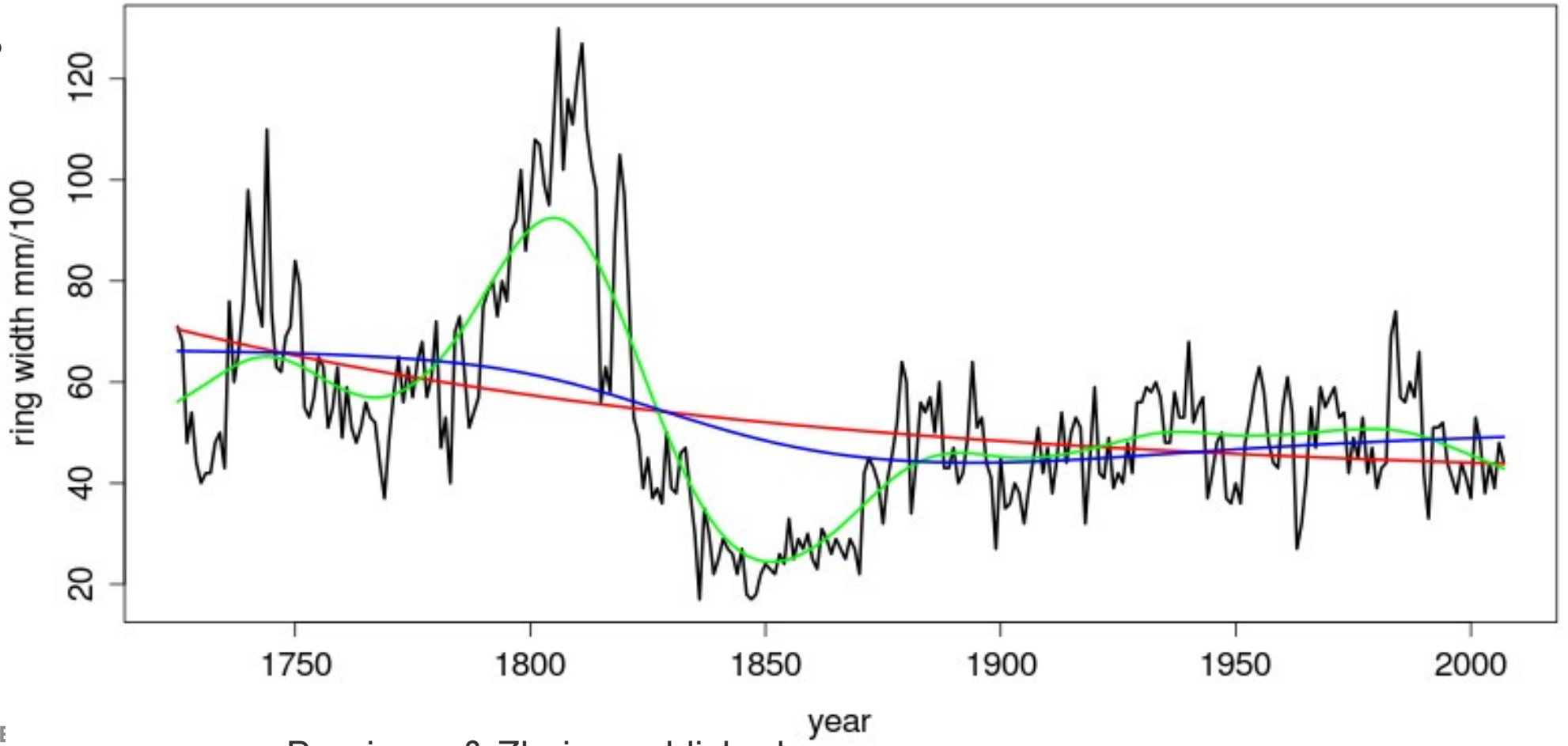

Berninger & Zhai unpublished

Analysis of tree rings

- Tree growth series contain several superimposed processes.
- Autocorrelation reduces our possibilities for statistical inference.
- Fit with traditional carbon or nutrients is relatively poor.

Cook & Kariutskis “model”

- **G = f(age) x f(disturbances) x f(climate) x ….**

- Decomposes growth to different parts
- Assumes that different parts of growth have different time frequencies
- Detrending might removes “the right frequencies” from the data.

Tree rings as indicators of environmental change

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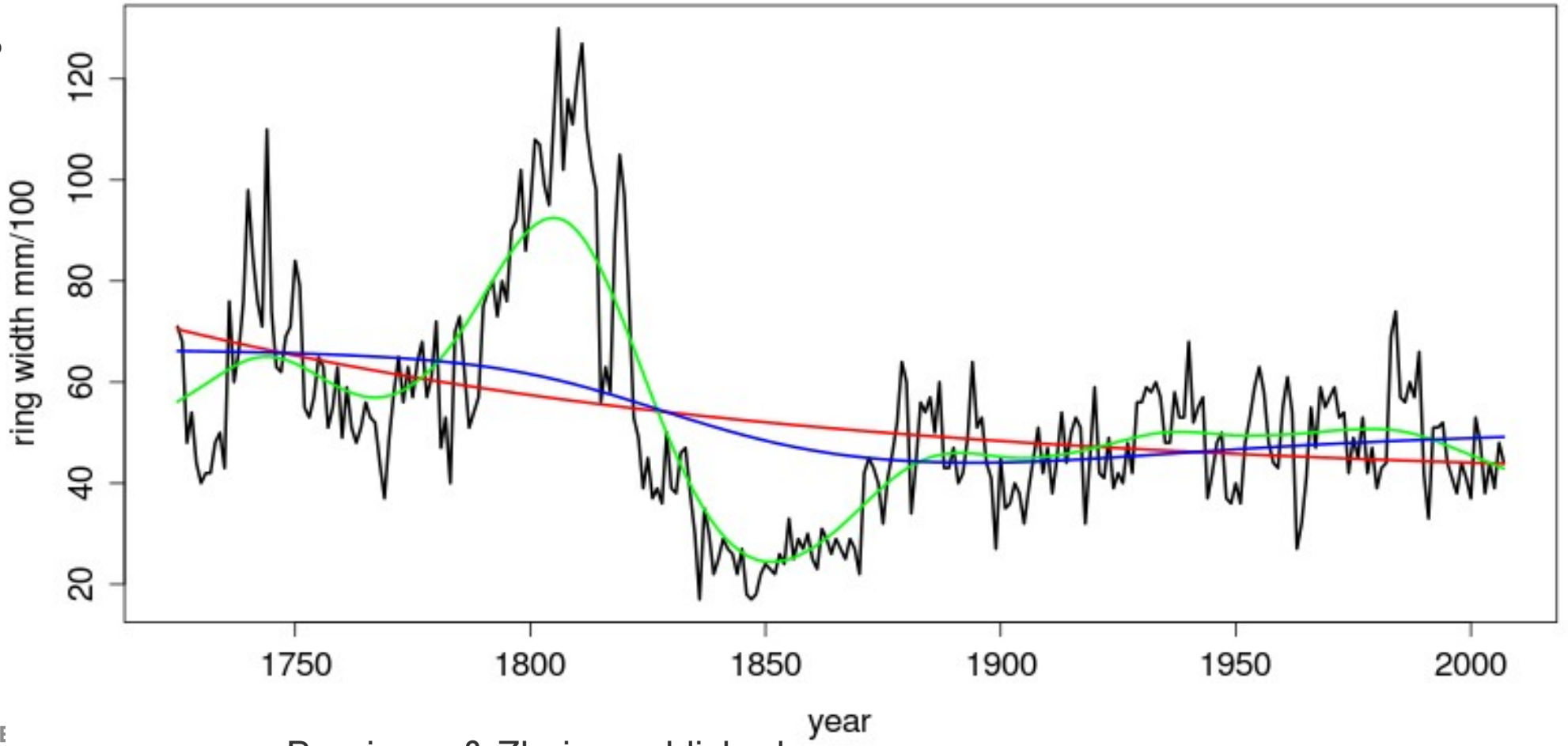
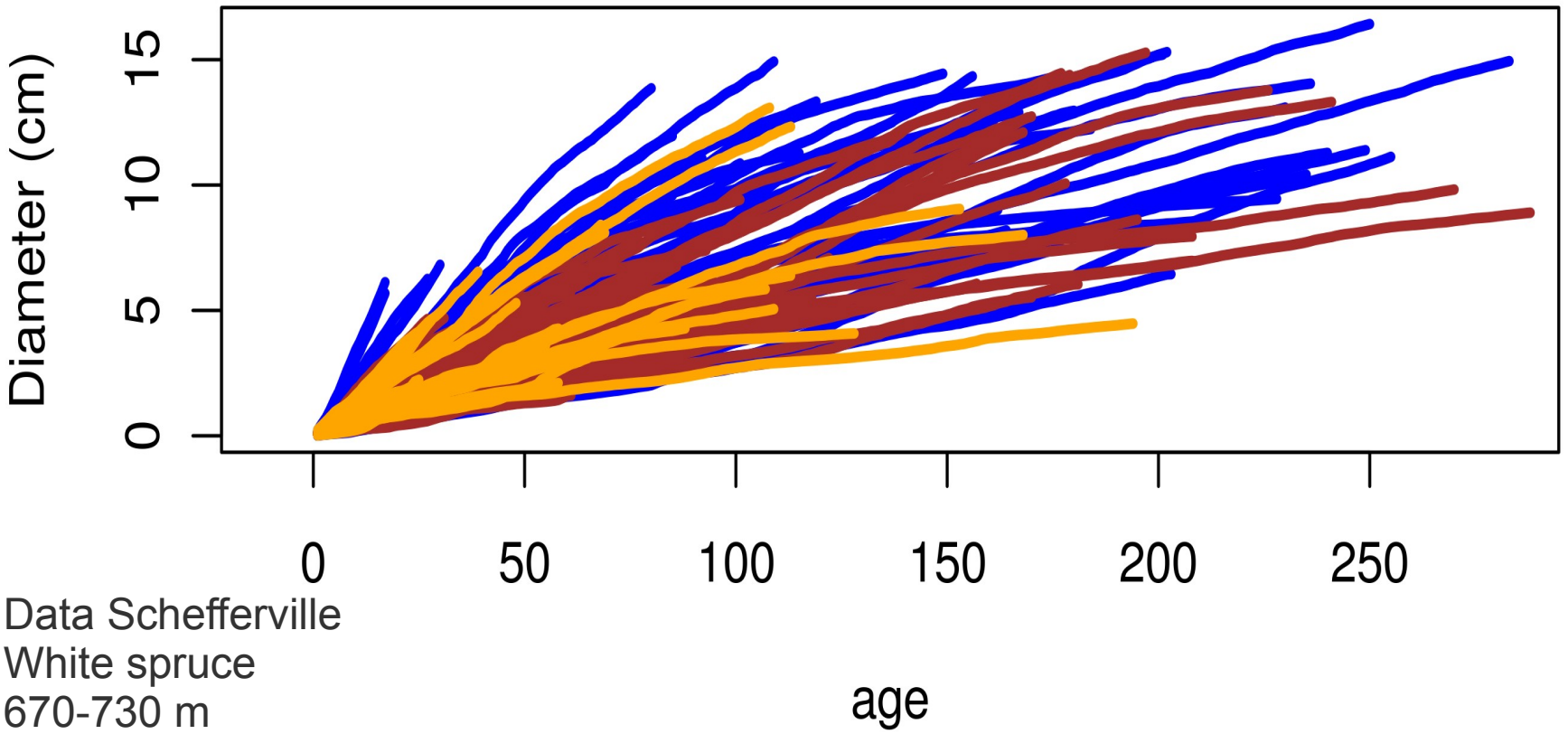


Berninger & Zhai unpublished

Trees still follow a common growth curve

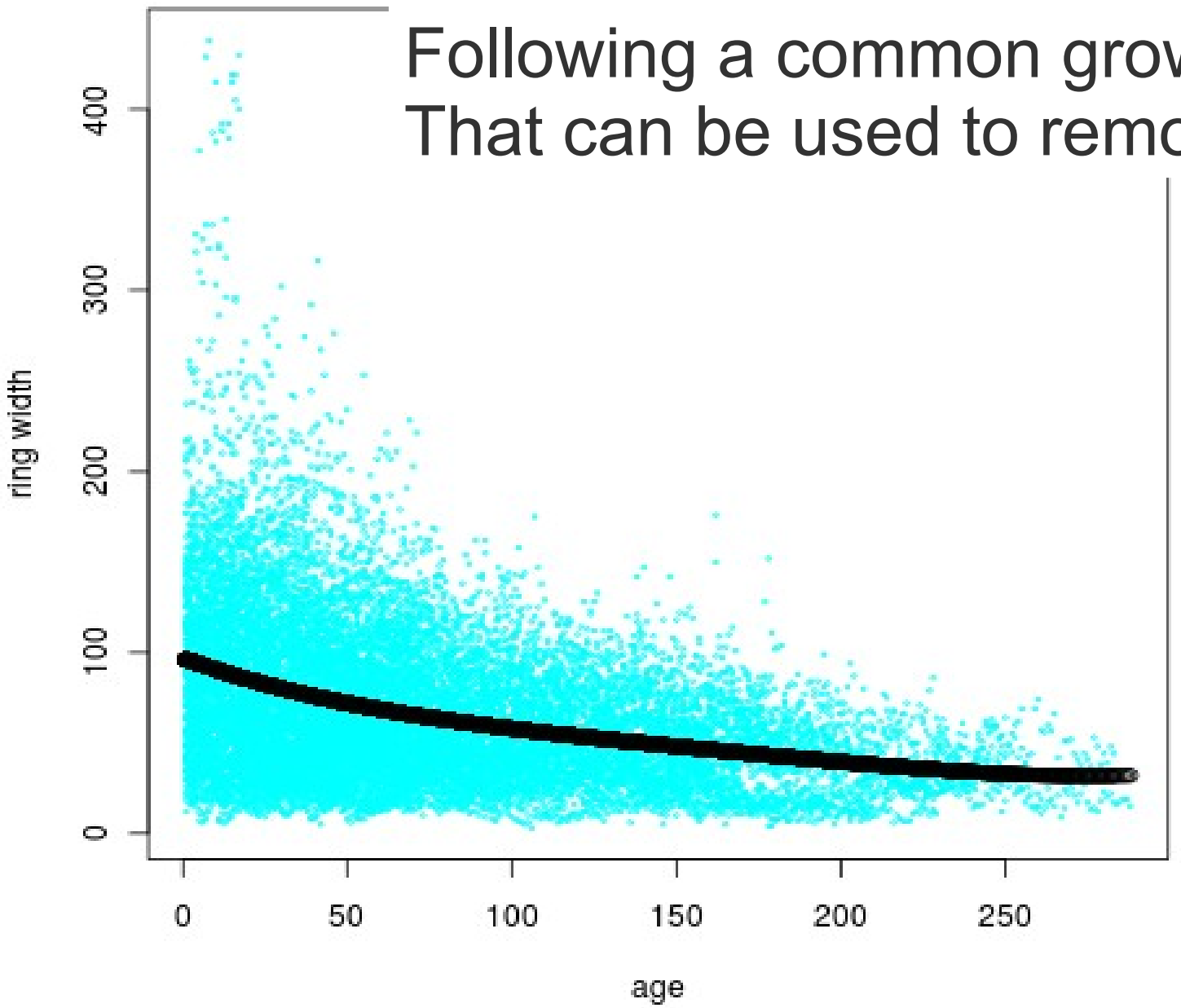
Blue closed forest
Red intermediate zone
Orange treeline



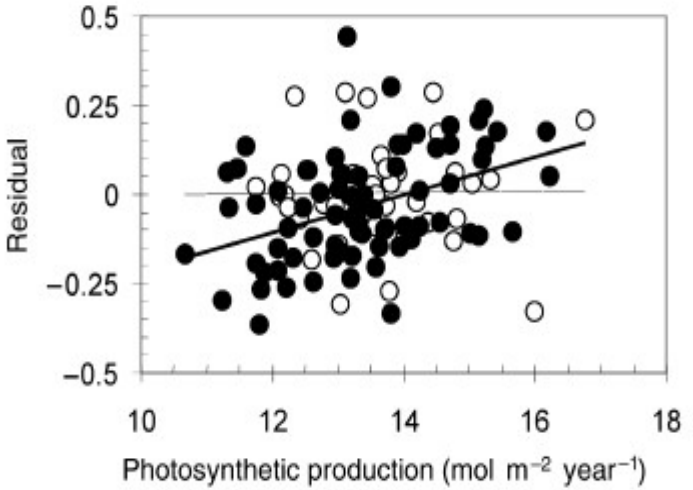
Data Schefferville
White spruce
670-730 m

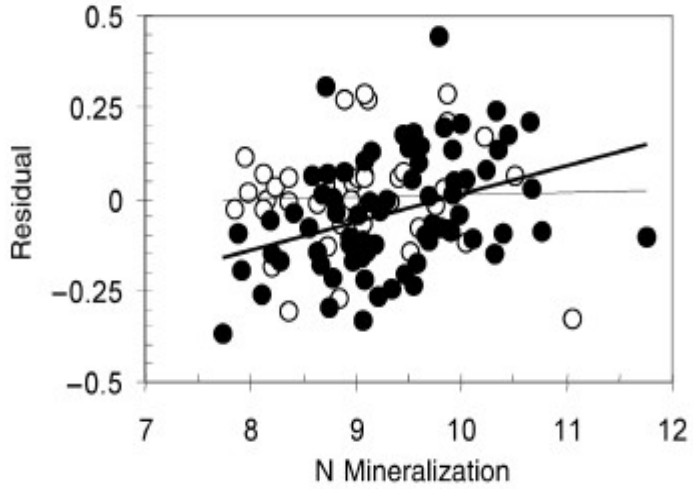
Berninger unpublished

RCS assumes that trees are Following a common growth curve That can be used to remove age trends

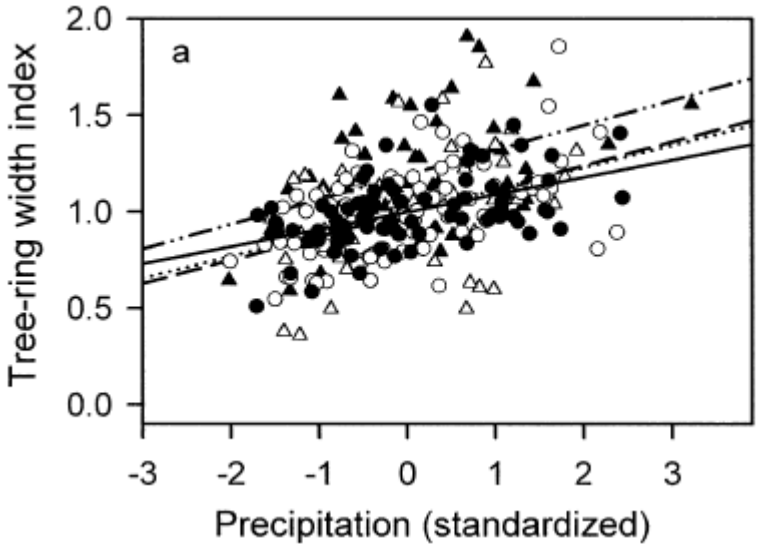


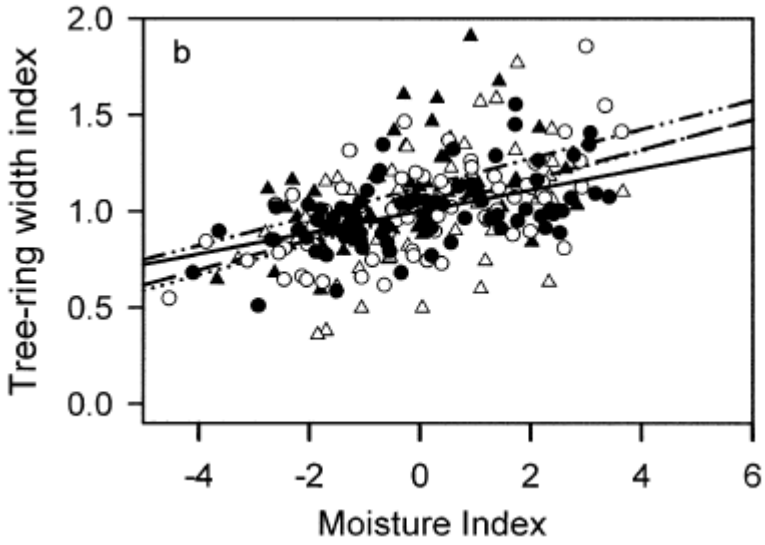
Advantages and limitations of tree ring based environmental research





Berninger et al. 2004





Morales et al J Ecol

Two examples!

- Productivity Case

  Savva & Berninger Global Biogeochemical Cycles 2010

- Water use efficiency case
  - Berninger et al. Unpublished...

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 24, GB3002, doi:10.1029/2009GB003749, 2010

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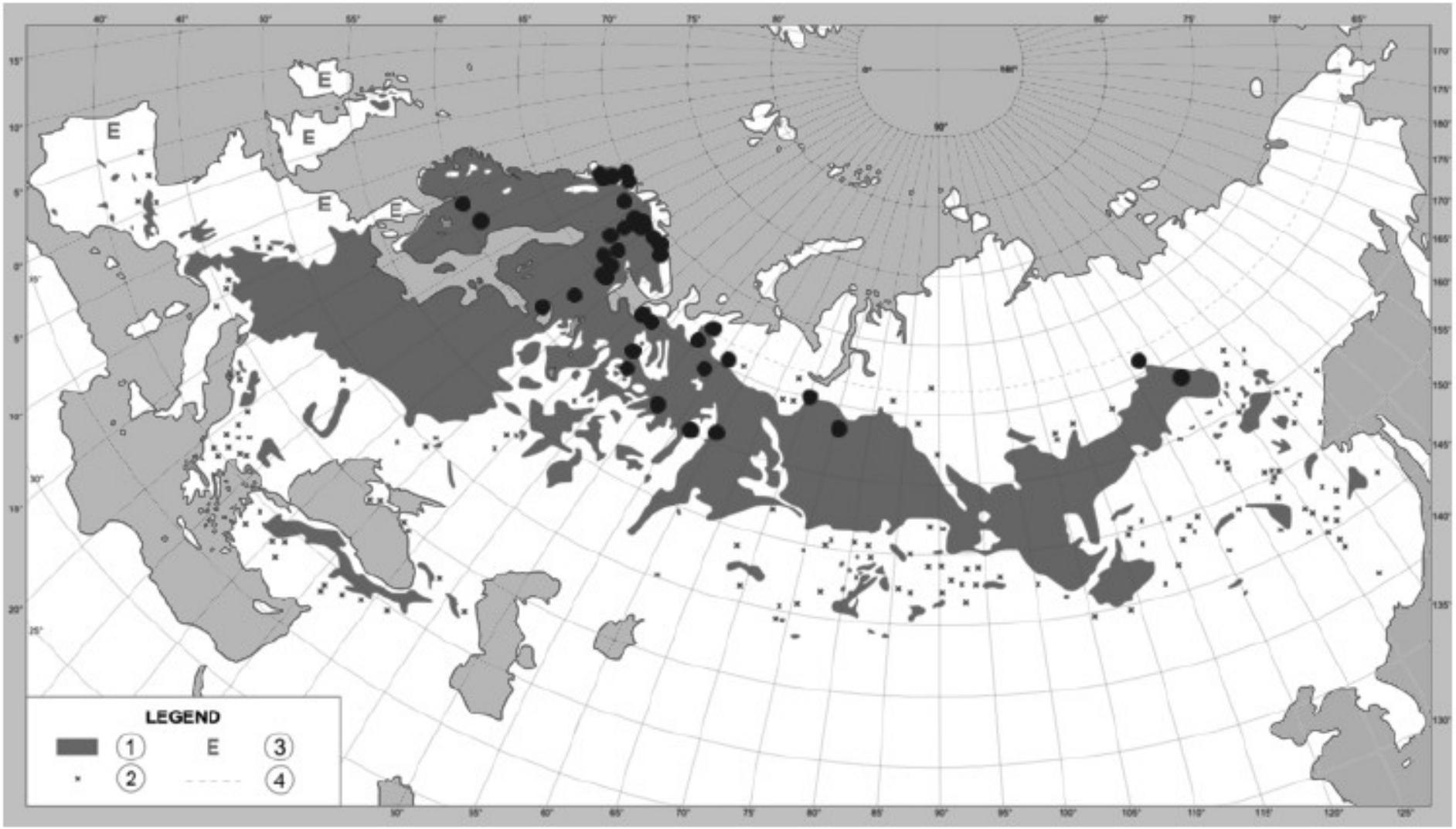
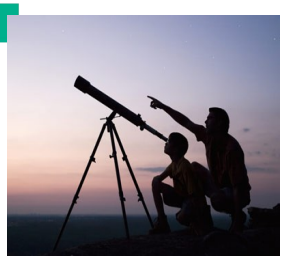
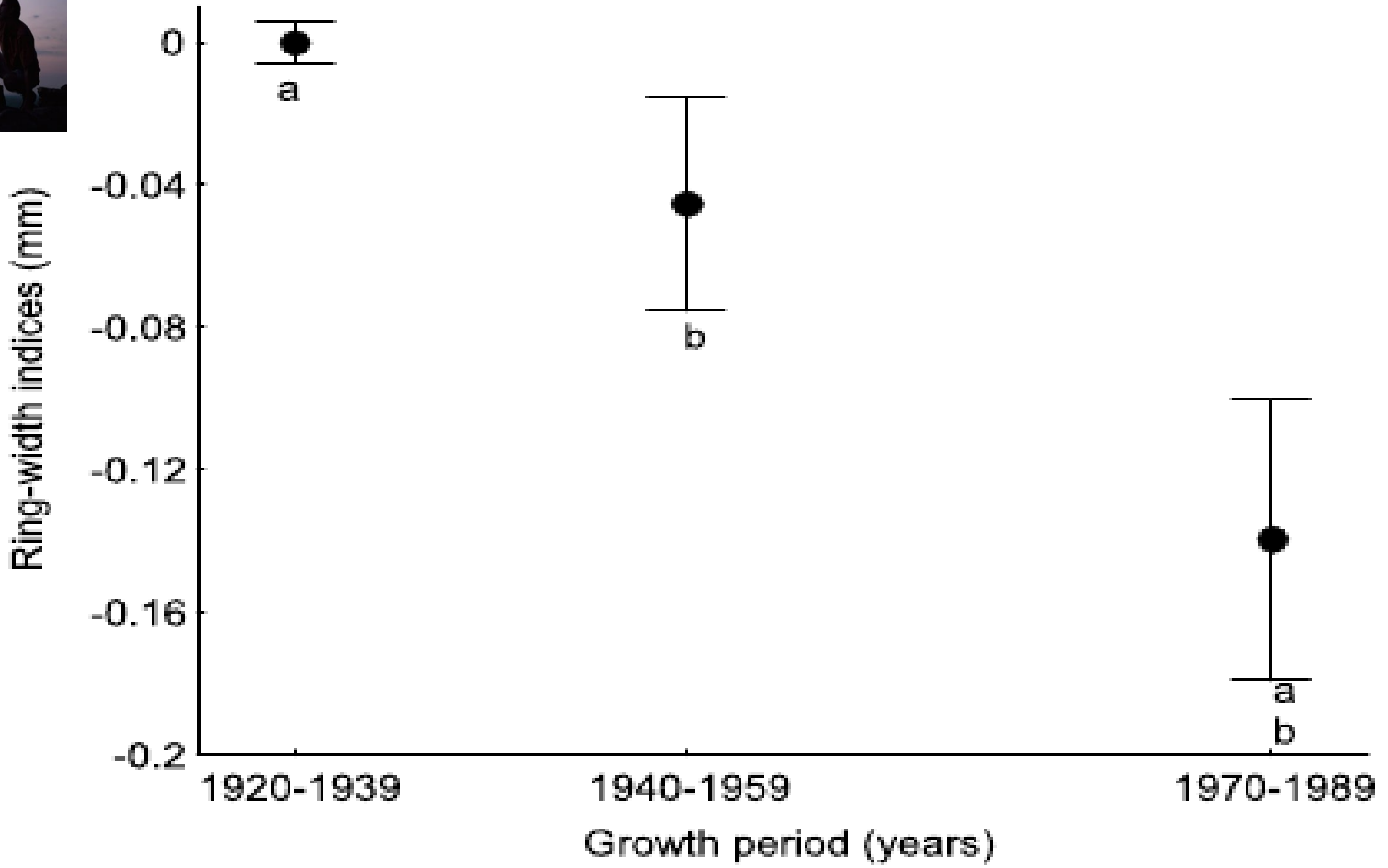
Sulphur deposition causes a large-scale growth decline in boreal forests in Eurasia

Yulia Savva[1] and Frank Berninger[1]



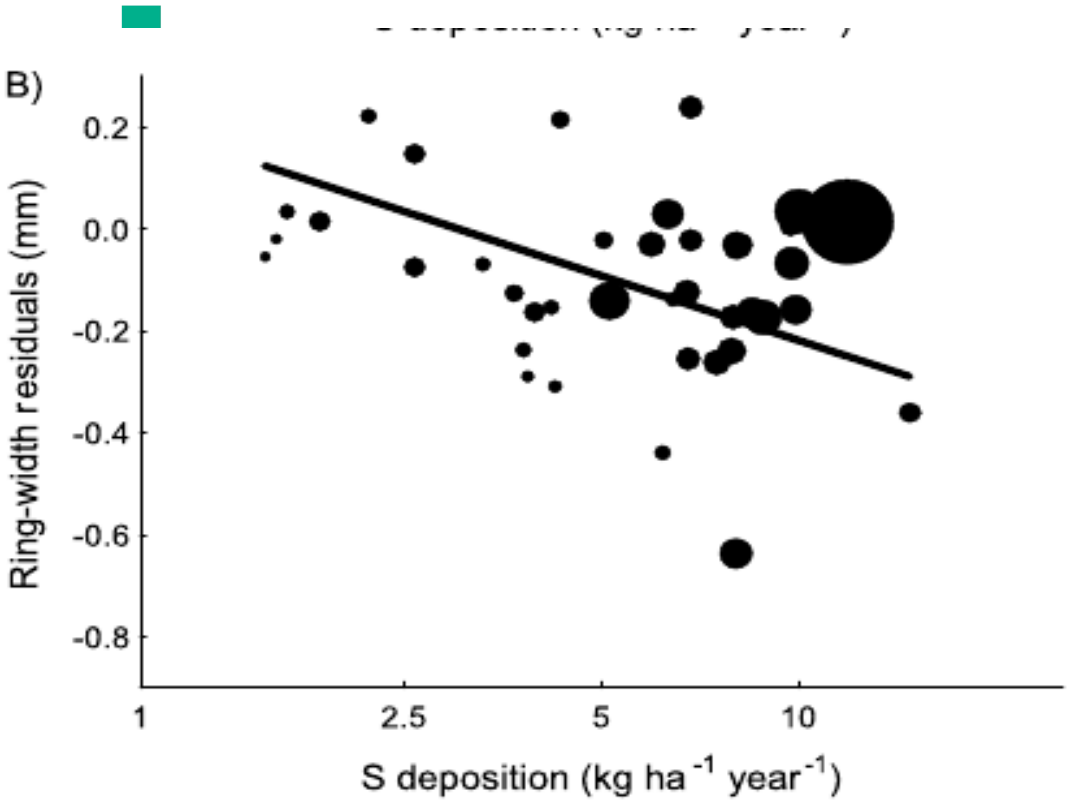
Looking for the CO_2 fertilisation effect

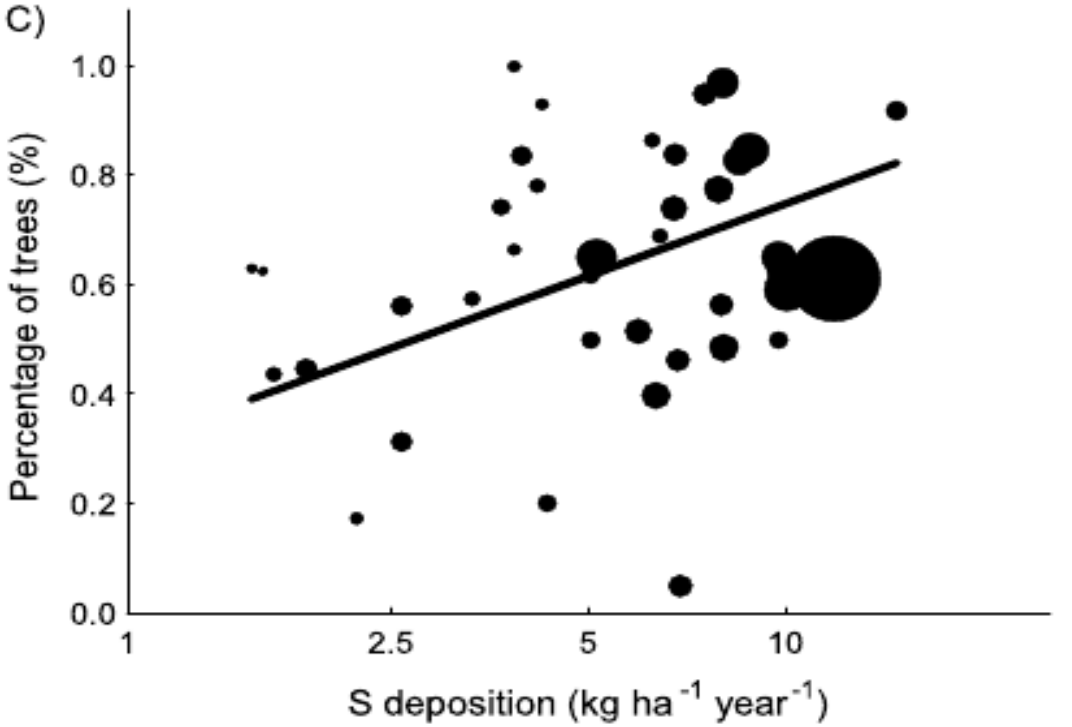




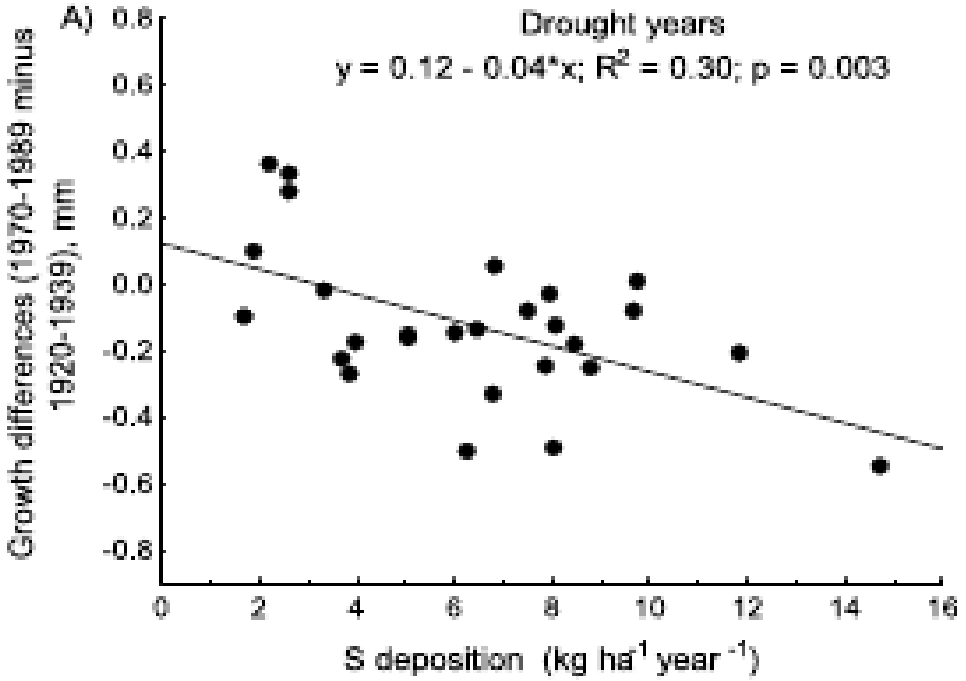
Results are actually quite typical

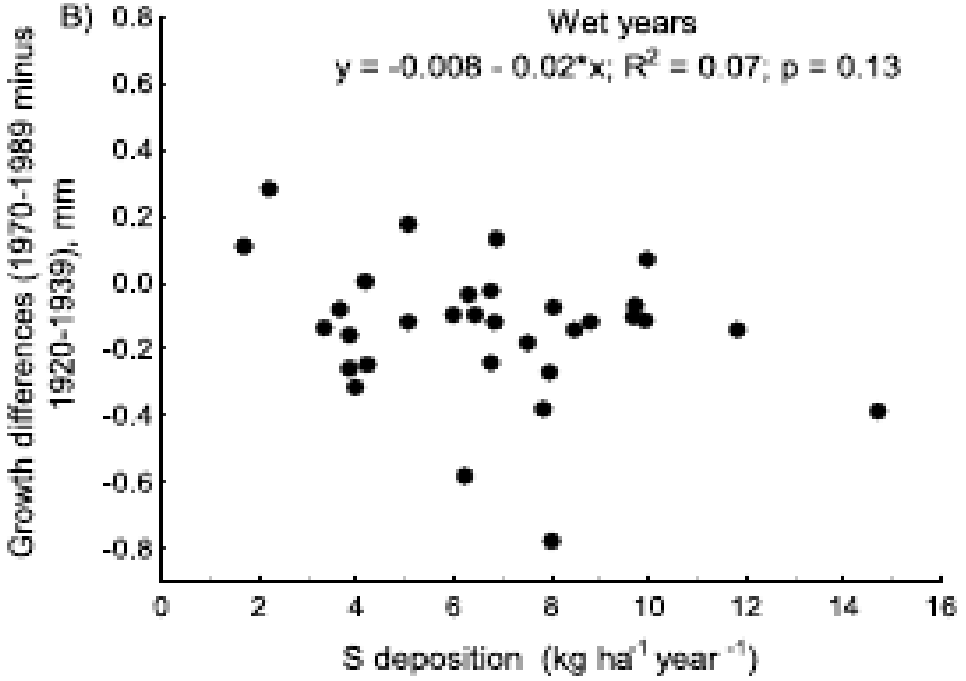
- In a recent review (Huang et al. 2008) we found that positive responses of tree growth to CO_2 was pretty much restricted to dry ecosystems
- Varying results have been published... Including no changes in growth, growth decrease and growth increases.





Sulphur deposition described
Growth decreases.
Nitrogen deposition increases growth
Both significant



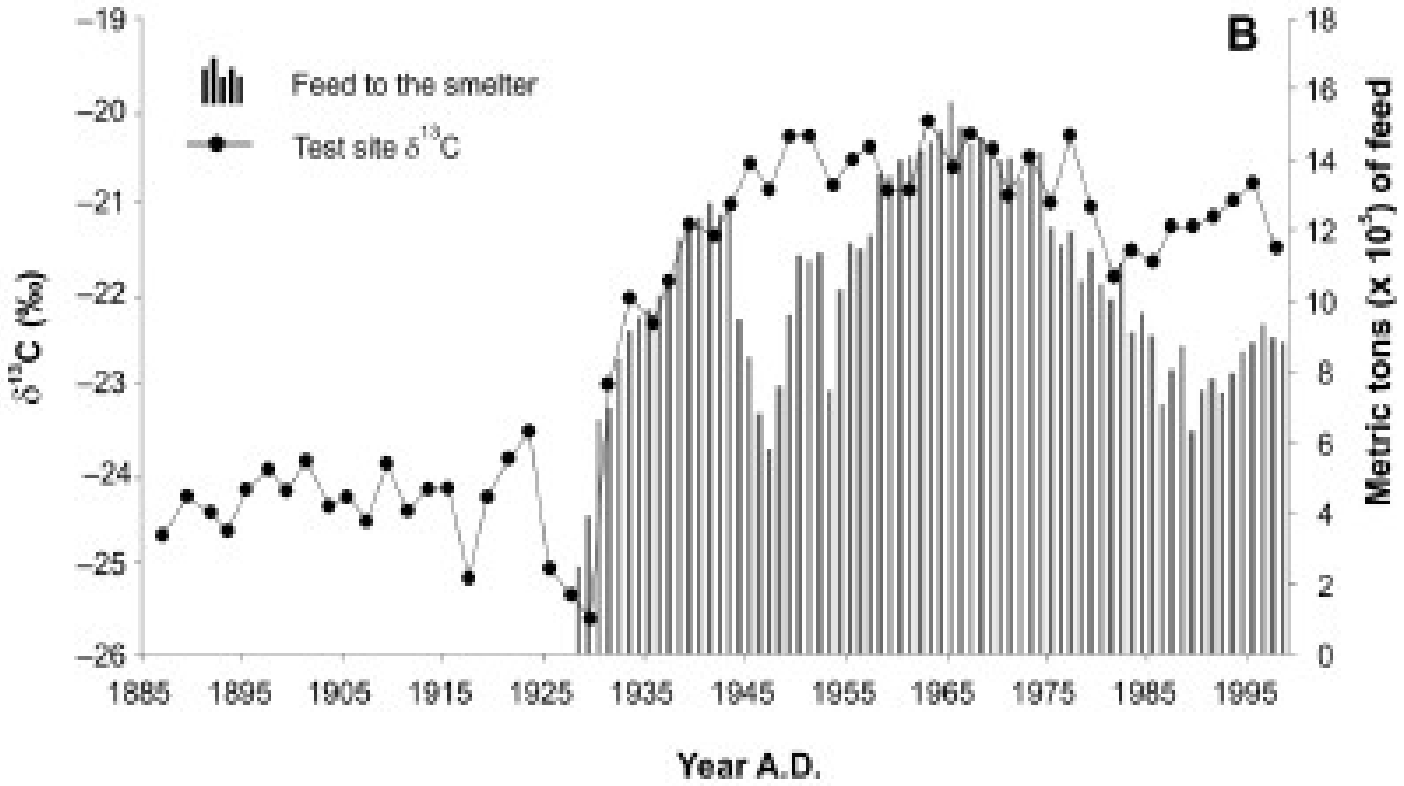


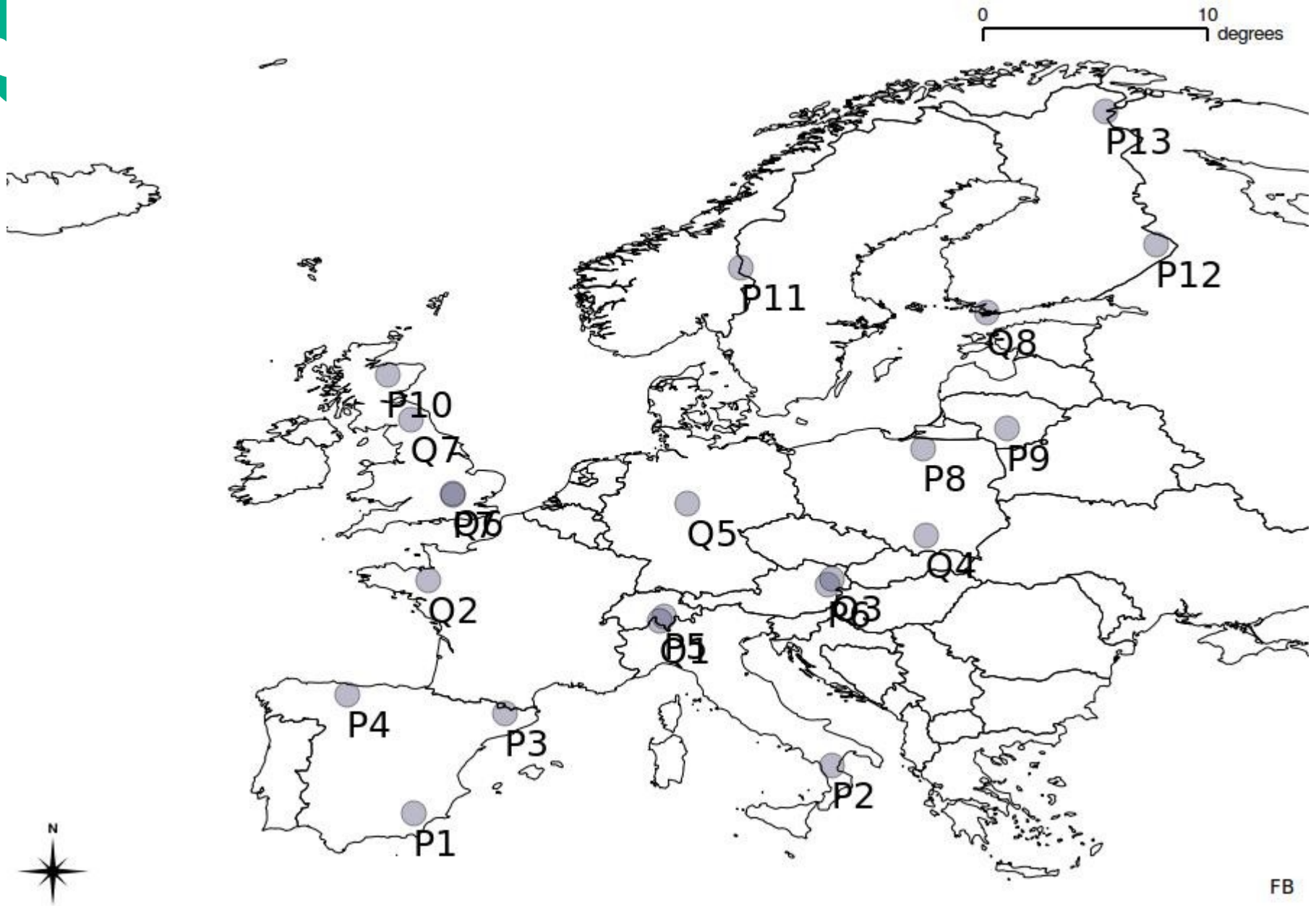
Effects of drought accentuated effects of Sulphur.

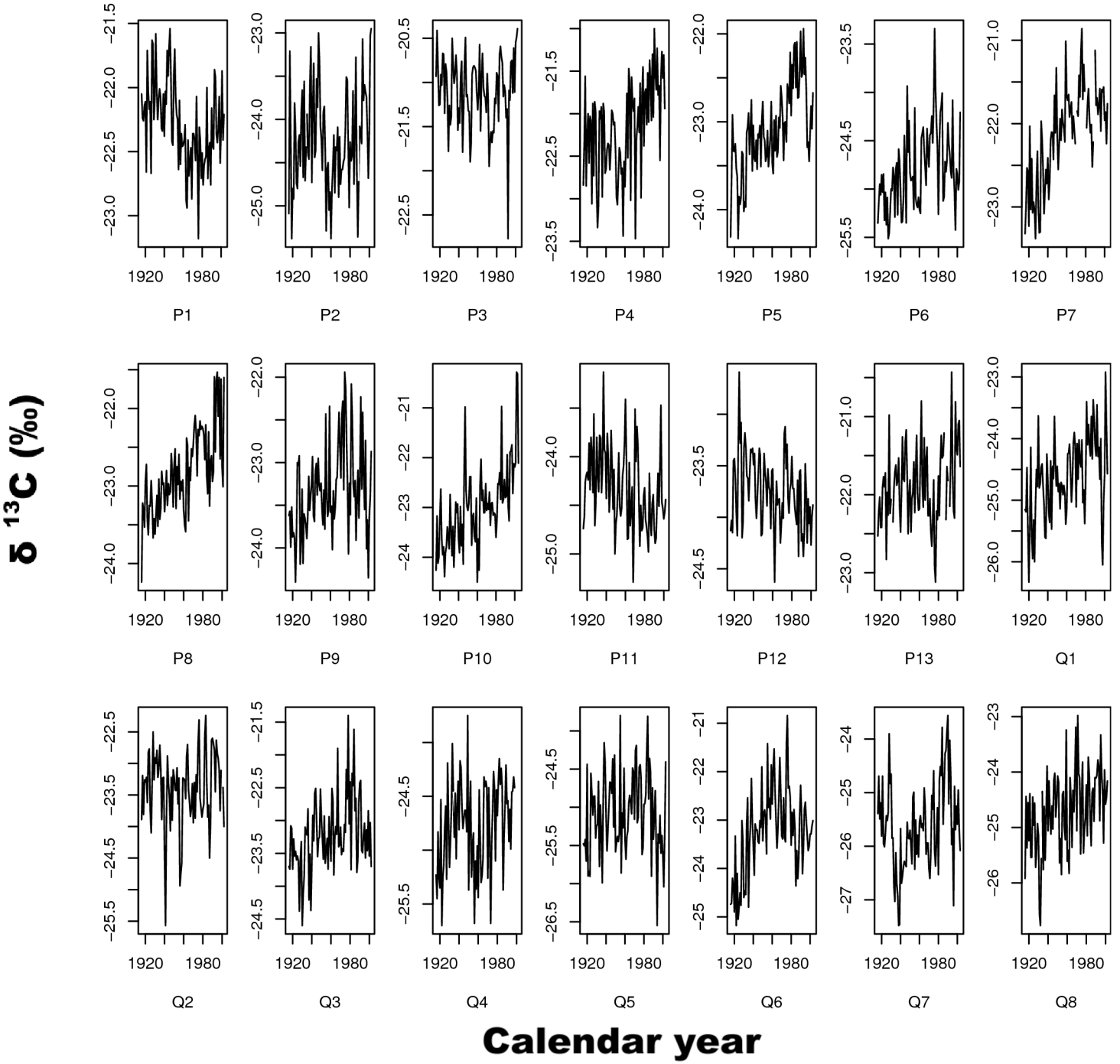
Water use efficiency responses to acid depositon

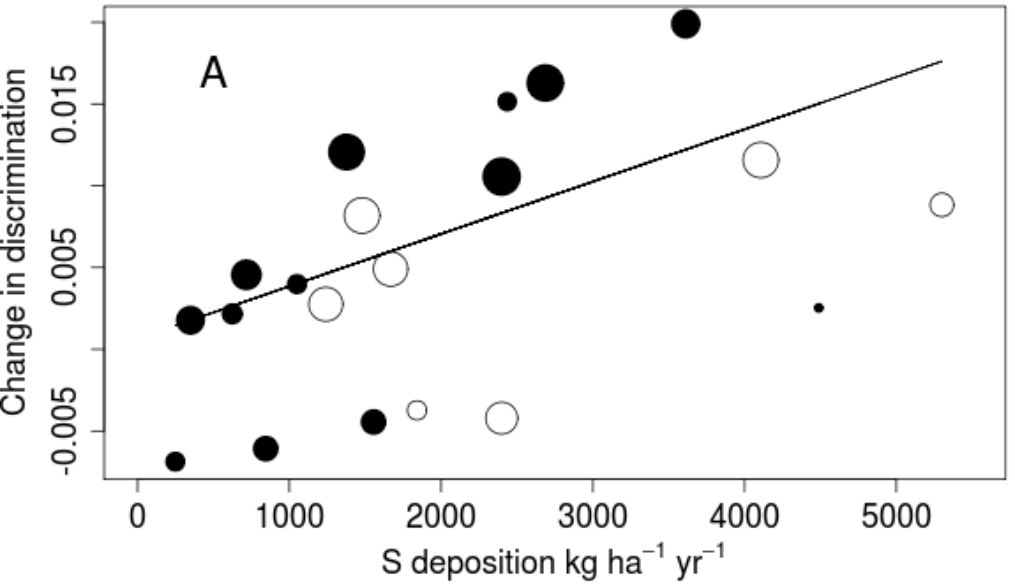
- Carbon isotopes
- Measure of rate of photosynthesis weighted rates ratios of Ci / Ca.
- Less negative values (higher values)
-
- Oxygen isotopes measure of relative humidity
-

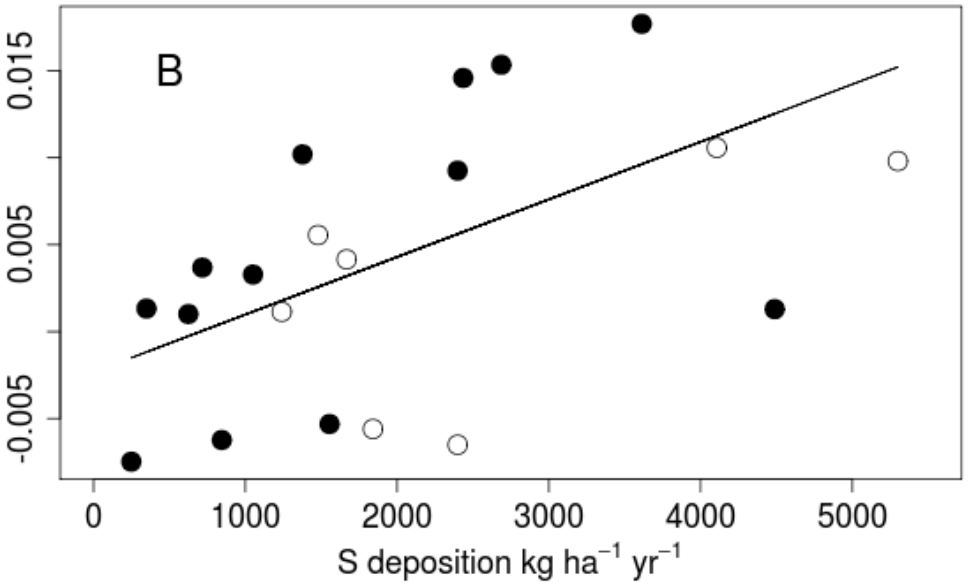
Savard et al. Geology




0
10
degrees
P13
P12
P11
Q8
P10
Q7
P9
P8
Q5
Q4
Q2
P4
P3
P2
P1
N
FB


δ 13C (‰)
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
1920
1980
Calendar year


A
Change in discrimination
-0.005
0.005
0.015
0
1000
2000
3000
4000
5000
S deposition kg ha^{-1} yr^{-1}


B
-0.005
0.005
0.015
0
1000
2000
3000
4000
5000
S deposition kg ha^{-1} yr^{-1}

Summary

- Tree rings provide strong evidence for long term effects of SO_2 deposition on tree growth in Europe.
- Decreases are associated with changes in WUE (stomatal closure)
- There is a positive effect of N deposition on growth

Iceland extra

Pinatubo (an islandic volcano) erupted in 1991

- Emmitted 17 000 tons of SO2 in the earth. Equals 0.16 kg of S per ha....
- Results into a growth reduction of 0.0282 mm.
- Low impact into growth.

And and Icelandic explosion

- Laki fissure 100 000 tn SO_2. 6 x Pinatubo
- Would result into a reduction of growth of 0.17 mm yr^{-1}. (One third of the industrially caused decline).
-
- However, effects in Island were quite dramatic. (25 of the human population died).