Tree Radial Growth Response to Climate
A Synthetic Study of Pointer Years in French Forests

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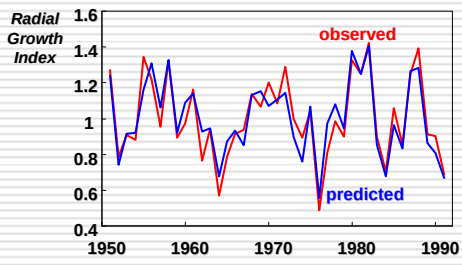
How to analyse the climate-tree-growth relationships
An example for beech

Fagus sylvatica - calcareous plateau - 1 025 trees (Badeau, 1995)



Most explanatory variables

June precipitation

23%

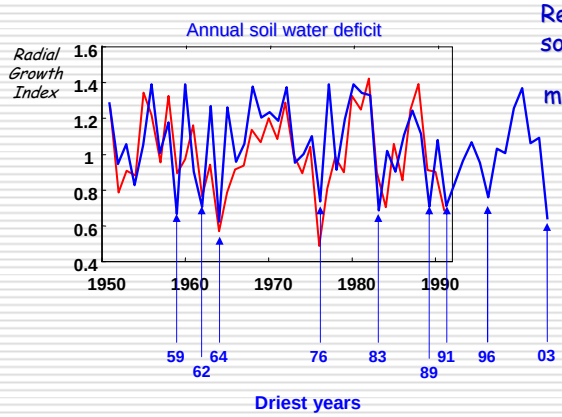
July soil water deficit

56%

Soil water deficit (june + july + august)	year n	58%	71%
Soil water deficit (june + july + august)	year n-1	13%	
Max. temperatures (march & april)	year n	7%	
Min. temperatures (september)	year n	7%	
Min. temperatures (september & december)	year n-1	2%	

How to analyse the climate-tree-growth relationships
An example for beech

***Fagus sylvatica*, calcareous plateau (Badeau, 1995)**



Relationship between growth and soil water deficit …

mostly driven by extreme years

(=concept of pointer years)

Why analyse only pointer year ?

- A pointer years are small (or wide) tree-rings

  present on (almost) all the individual chronology of a study

$$F_{(year\ n)} = \frac{\text{Number of } \begin{matrix}\text{negative}\\\text{positive}\end{matrix} \text{ change}}{\text{Total number fo ring width}}$$

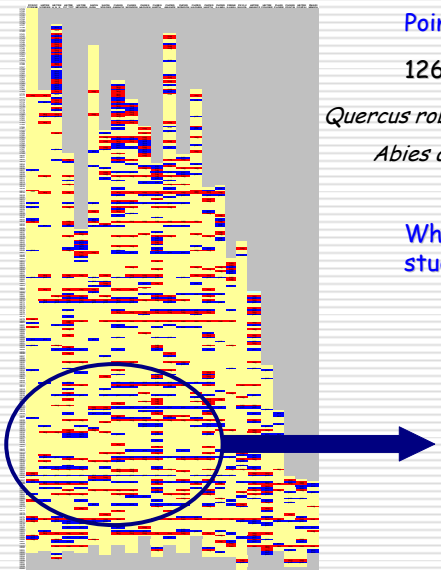
- Pointer years are a tree-growth response to very particular environmental conditions

  - at a local scale (e.g. cutting, insect outbreak, …)
  - at a regional (national) scale very particular climatic conditions

- Pointer years can be used to analyse the climate-tree-growth relationships

- Pointer years can be used to compare the reactions of several species in several regions

Use of pointer years



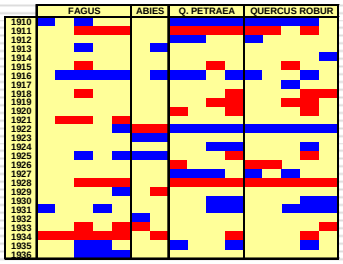
Pointer Years Atlas

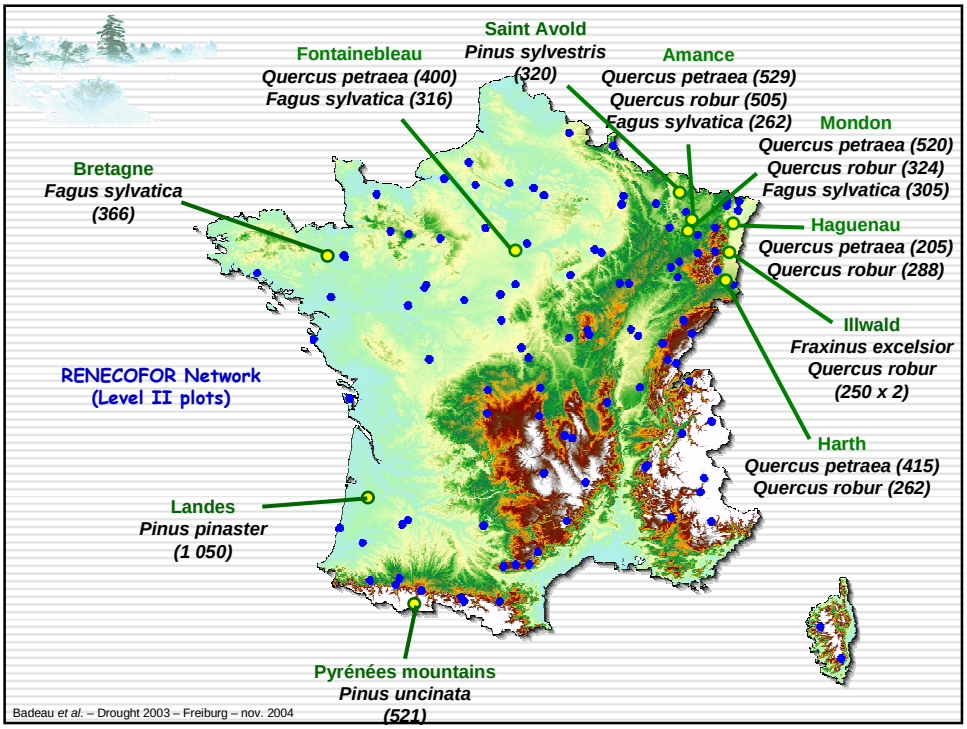
126 sites – 8 species

Quercus robur - Quercus petraea - Fagus sylvatica

Abies alba – Picea abies – Pinus sylvestris

What are the relationships between studied areas, species and climate ?





Preliminary results

Frequency of pointer years

Examples of growth change in 1976 and 1989

Pointer years in the North East of France

Factorial analyses

Preliminary results

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Frequency of pointer years

20 studies

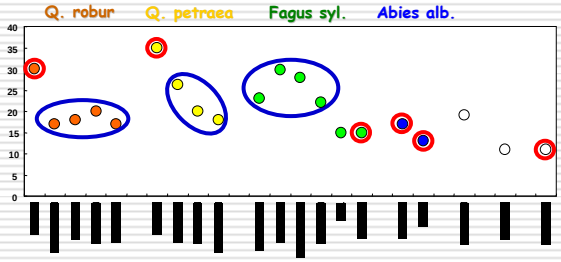
Period 1908 – 1984

(77 years)

Driest conditions

Q. robur Q. petraea Fagus syl. Abies alb.

Number of P.Y.
(1908 – 1984)



Fagus ≥ Q. petraea > Q. robur
at low altitudes

Montainous area

Preliminary results

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Factorial analyses

Relative Change of Growth (pointer year *vs* previous year)

$$RGC_{(year\ n)} = \frac{Ring\ Width_{(year\ n)} - Ring\ Width_{(year\ n-1)}}{Ring\ Width_{(year\ n-1)}}$$

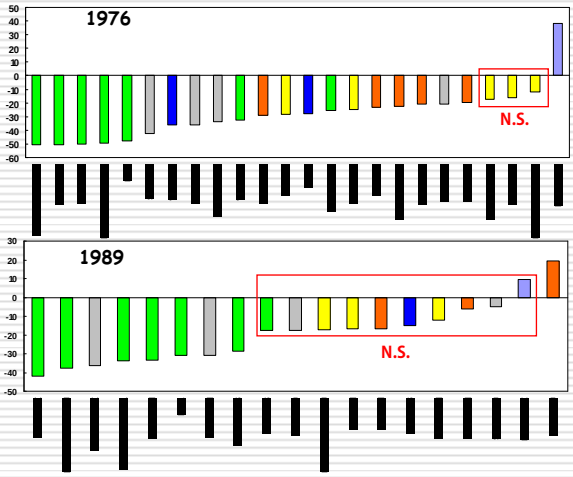
N.S. = not a pointer year at the level of 70%

Fagus sylvatica

Quercus petraea

Quercus robur

Abies alba



Preliminary results

Frequency of pointer years

Examples of growth change in 1976 and 1989

Pointer years in the North East of France

Factorial analyses

Negative Pointer years (Top 11 between 1908 and 1991)

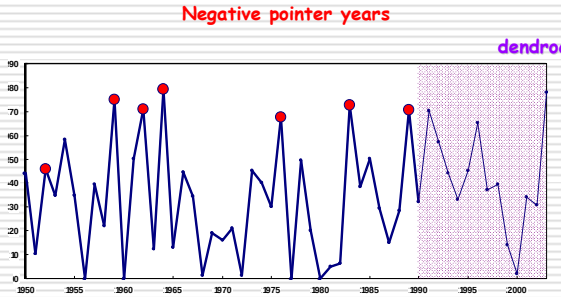
		1976	1928	1983	1911	1947	1952	1962	1964	1934	1959	1989
Q. robur	Amance	■	■	■	■		■		■	●	●	
	Mondon	■	■			■		●	■	●	●	●
	Haguenau	■	■			■					■	
	Harth	■	■	■	■	■	■	■	■	■		
	Illwald	■	■								■	
Q. petraea	Amance	■	■	■	■	■	■	■	■	●	●	
	Mondon		■	■	■	■	■	●	■	●	●	●
	Haguenau		■	■	■	■						
	Harth	■	■	■	■	■	■	■		■	■	
Fagus	Amance	■	■	■	■	■	■	■	■	●	●	
	Calcar. Plat	■	■	■	■	■	■	■	■	■	■	■
	Mondon	■	■	■	■	■	■	●	■	●	●	●
	N.E.	■		■			■		■	■	■	■
	Vosges	■		■						■	■	
Abies	Vosges	■						■		■		
	Jura	■						■				
Fraxinus	Illwald	■		■			■					■
Pinus	St Avold	■			■	■	■					
	Nb P.Y.	16	12	12	11	11	11	9	9	8	8	5
	Total	18	18	18	18	18	18	18	18	18	18	13
	Freq.	**89%**	**67%**	**67%**	**61%**	**61%**	**61%**	**50%**	**50%**	**44%**	**44%**	**38%**

Badeau *et al.* – Drought 2003 – Freiburg – nov. 2004

Negative Pointer years *vs* water stress

Soil Water Deficit

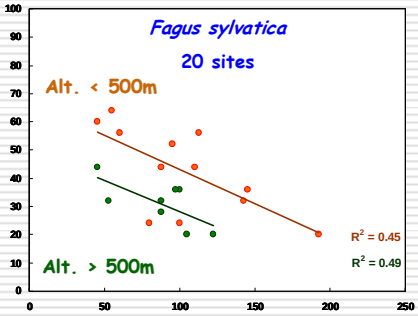
(Granier *et al.*,99)



Badeau *et al.* – Drought 2003 – Freiburg – nov. 2004

Pointer years *vs* soil water content (Level II plots)

Frequency (%) of P.Y.
Period 1970 - 1994



Preliminary results

Frequency of pointer years

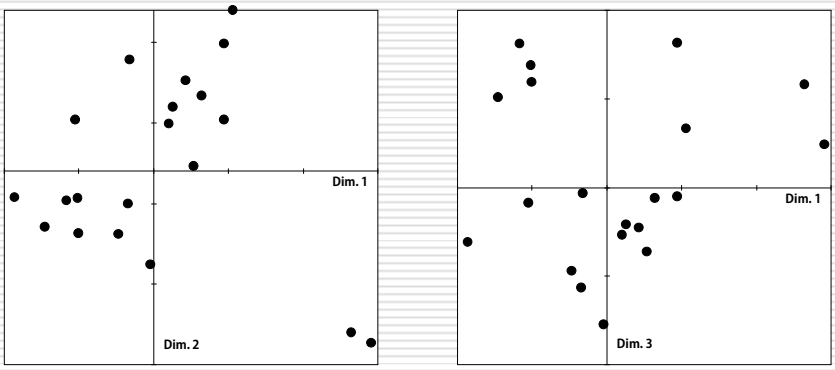
Examples of growth change in 1976 and 1989

Pointer years in the North East of France

Factorial analyses

Factorial analysis (Phytoecology data)

20 studies – 7 species – period 1908-1984 – presence/abscence of P.Y.

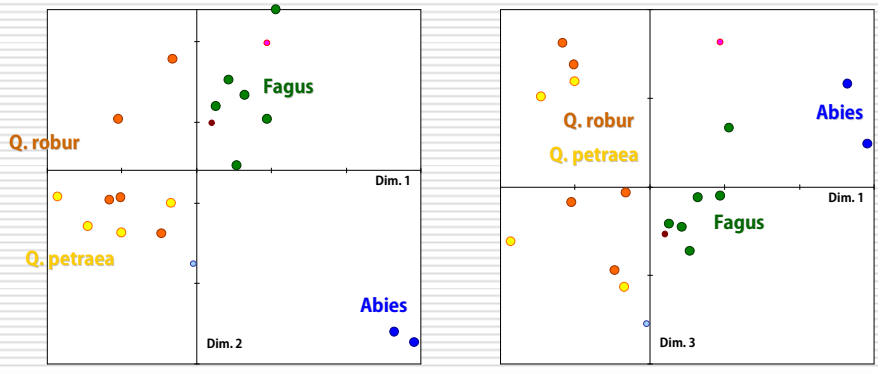


Dim. 1 = 13.8% of total variance

Dim. 2 = 11.8%

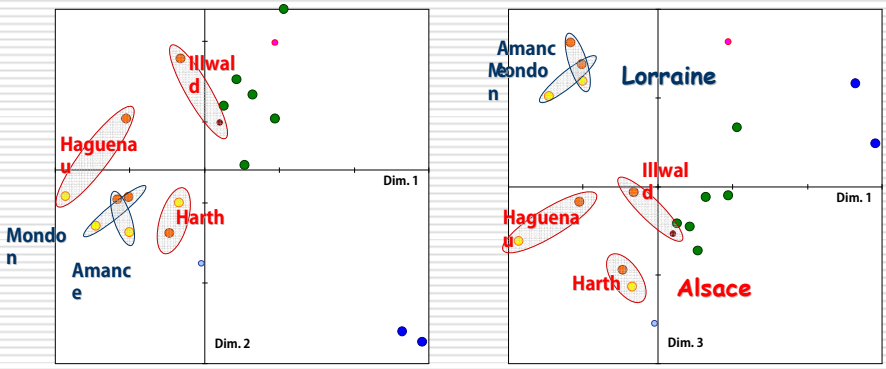
Dim. 3 = 9.3%

Factorial analysis (Phytoecology data)



A species effect

Factorial analysis (Phytoecology data)

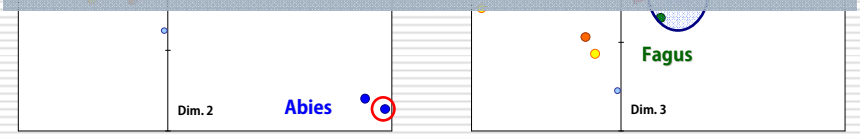


A regional effect

The case of the beech

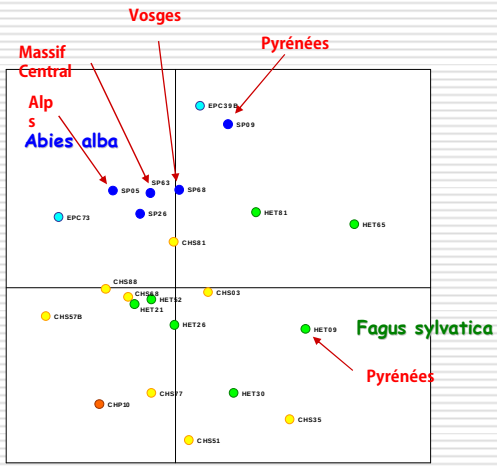
The beech of the Vosges mountains is closer to the beech of Brittany than to the silver fir of the Vosges mountains !

Abies alba Vosges vs Jura	50% of common pointer years
Fagus syvatica Vosges *vs* Brittany	26%
Fagus Vosges *vs* Abies Vosges	19%



Vosges mountains
Lorraine
Brittany

Factorial analysis (Level II plots)



23 sites – 5 species

1908 – 1994 (87 years)

Conclusions

Pointer years depends on:

1 - mainly species

2 – bioclimatic regions

3 – site characteristics

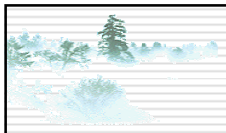
Beech is the most reactive species

- number of pointer years
- relative growth change levels from one year to the other

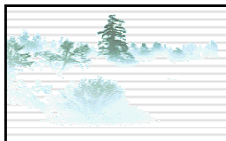
Pointer years analysis provides information on an individual year basis and can be considered as a supplement to the calculation of dendroclimatic models

In addition pointer years are the basis of all dendrochronological datations

Towards an European Atlas of pointer years for the major tree species ?



To be continued …

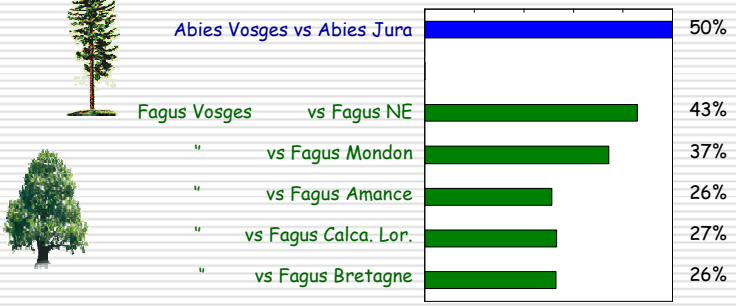


Pointer years *vs* soil water content

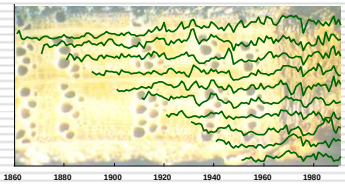
Abies Alba	Jura mountains	13
	Vosges mountains	17
Fagus sylvatica	Vosges mountains	15
	Northeastern plains	14
	Mondon	22
	Amance	29
	Calcareous Lorraine	28
	Fougères (Bretagne)	23

Number of pointer years

Period 1908 – 1984 (77 years)



How we compute pointer years ?



Individual chronologies
***i* trees x *j* sites x *k* forests**

For each individual chronology and each year

Relative Growth Change

$$RGE_{(year\ n)} = \frac{Ring\ Width_{(year\ n)} - Ring\ Width_{(year\ n-1)}}{Ring\ Width_{(year\ n-1)}}$$

If RGE < -10% then « negative change »
If RGE > +10% then « positive change »
Else « no change »

For each year with all chronologies

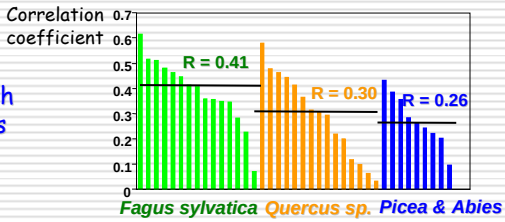
Frequency of the changes

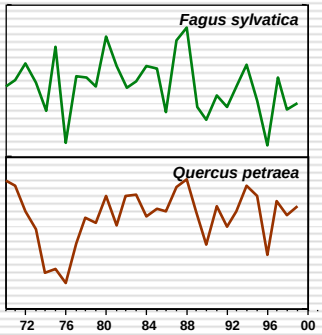
$$F_{(year\ n)} = \frac{Nbr\ of\ \begin{matrix}negative\\positive\end{matrix}\ change}{Total\ number\ fo\ ring\ Width}$$

If F > 70% then « $\begin{matrix}negative\\positive\end{matrix}$ pointer year »

How to analyse the climate-tree-growth relationships
An example for beech

Ability of models to explain growth varies according to species & sites





Autocorrelation within chronological series

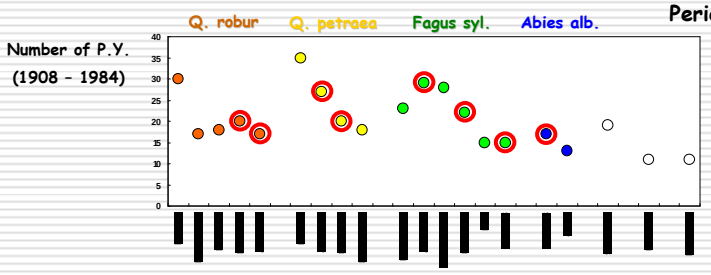
Badeau *et al.* – Drought 2003 – Freiburg – nov. 2004

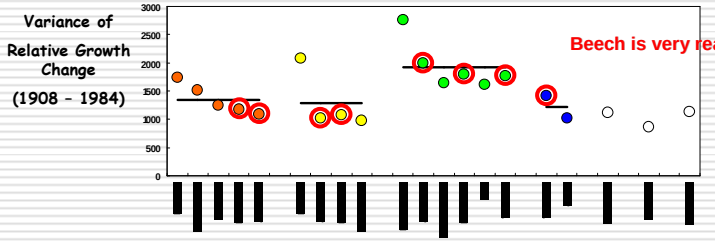
Frequency of pointer years
(Phytoecology lab.)

20 studies

Period 1908 – 1984

(77 years)

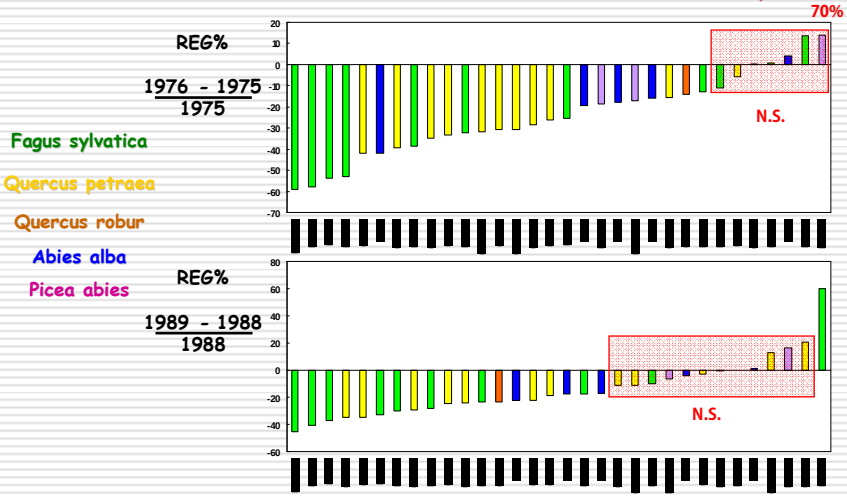




Badeau *et al.* – Drought 2003 – Freiburg – nov. 2004

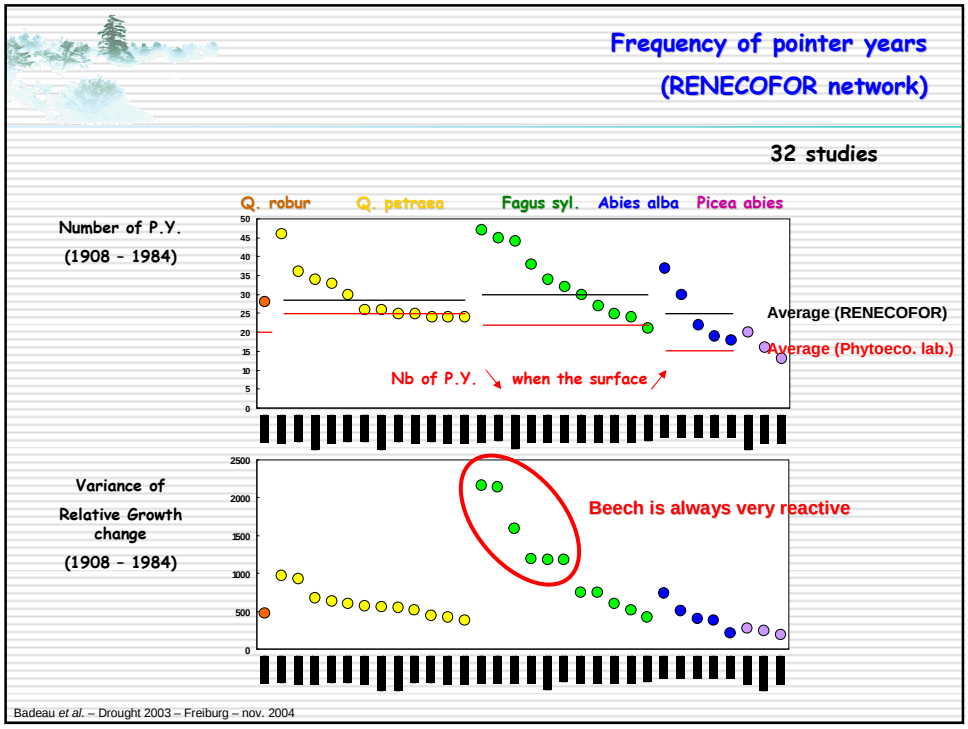
Relative change of Growth (RENECOFOR network)

N.S. = not a pointer year at the level of 70%



Sampling

- **A long story of dendrochrological studies at regional scales in our laboratory since the early 80's**
  - Long-term growth trends
  - Fertilization
  - Pollution
  - Forest decline …
- **And a huge database**
  - 24 studies (one species in one location)
  - between 1 200 000 and 1 300 000 ring width
  - *Quercus robur - Quercus petraea - Fagus sylvatica - Abies alba*
- **ICP Forest Level II Monitoring Network (RENECOFOR)**
  - 102 sites x 30 trees
  - *Quercus robur - Quercus petraea - Fagus sylvatica*
  - *Abies alba – Picea abies – Pinus sylvestris – Pinus pinaster*


Frequency of pointer years
(RENECOFOR network)
32 studies
Q. robur
Q. petraea
Fagus syl.
Abies alba
Picea abies
Number of P.Y.
(1908 – 1984)
Average (RENECOFOR)
Average (Phytoeco. lab.)
Nb of P.Y. ↘ when the surface ↗
Variance of
Relative Growth
change
(1908 – 1984)
Beech is always very reactive
Badeau et al. – Drought 2003 – Freiburg – nov. 2004