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the contribution of forest scientific knowledge
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Long-term growth changes of temperate lowland forests:
a retrospective analysis of tree rings

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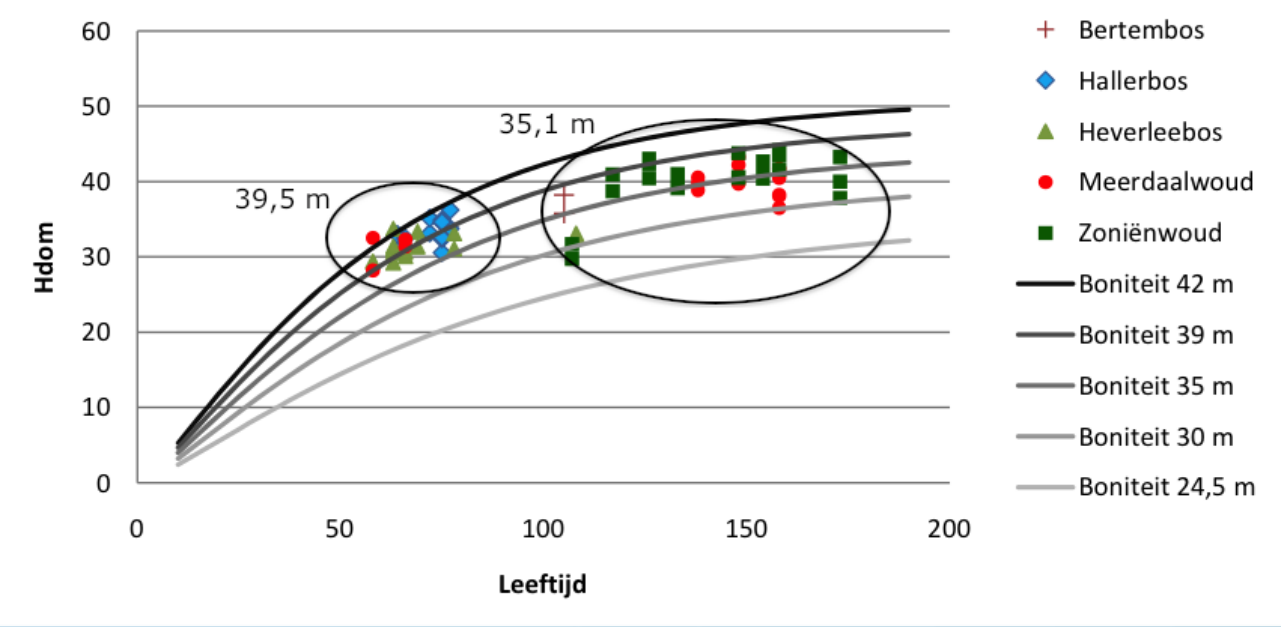
With contributions of Ellen Janssen, Bart Muys, Jos Van Orshoven, Jean-Daniel Bontemps, Matteo Campioli, Dries Vansteenkiste, Andy Delcloo and others

Context

- More and more recent research indicate an increased growth of European forests over the past century

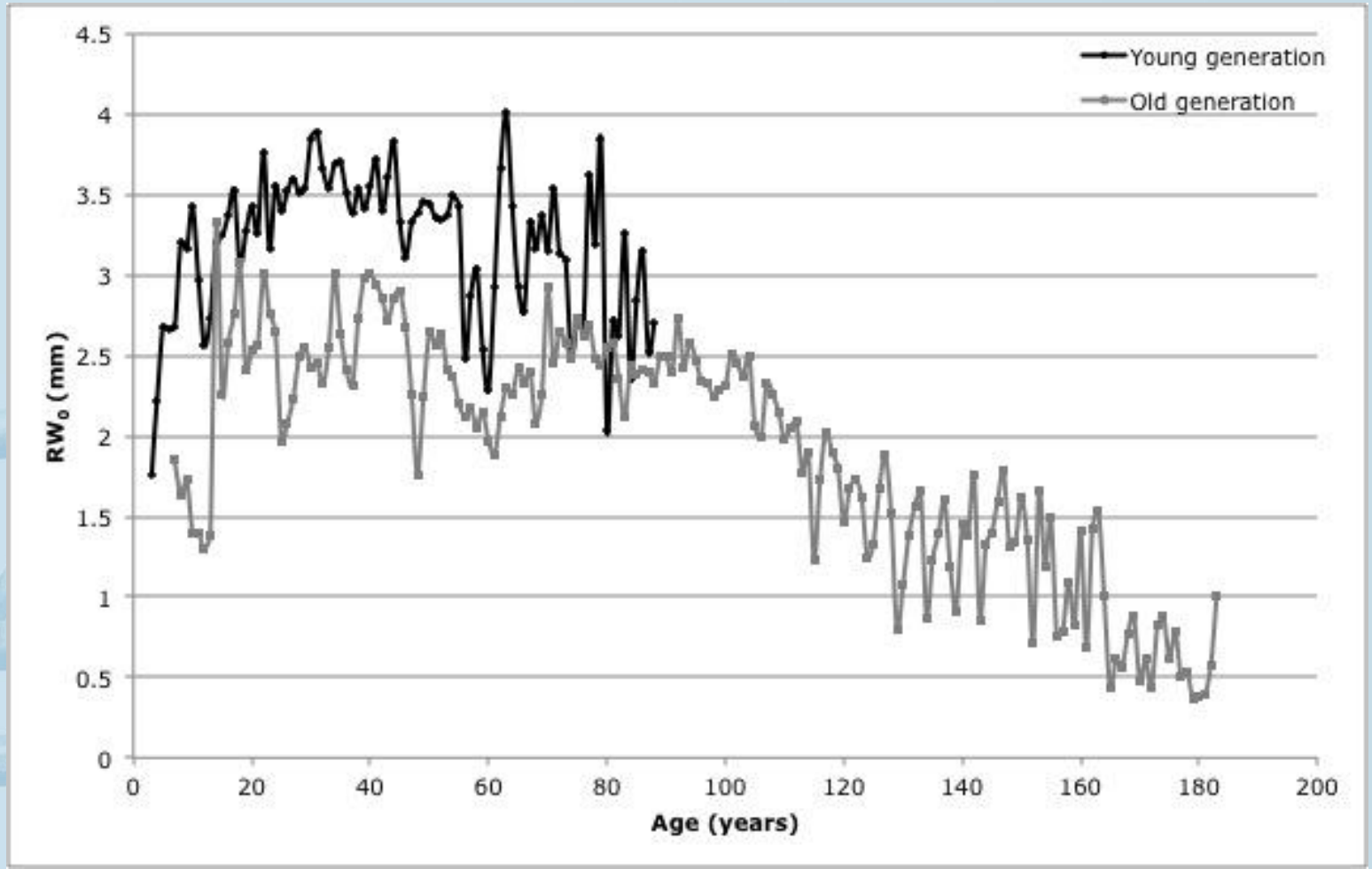
- Similar indications were found in our dataset for forests of Flanders

- Can we confirm these trends for Flanders (or more locally the Flemish loam belt) and what are the driving factors?



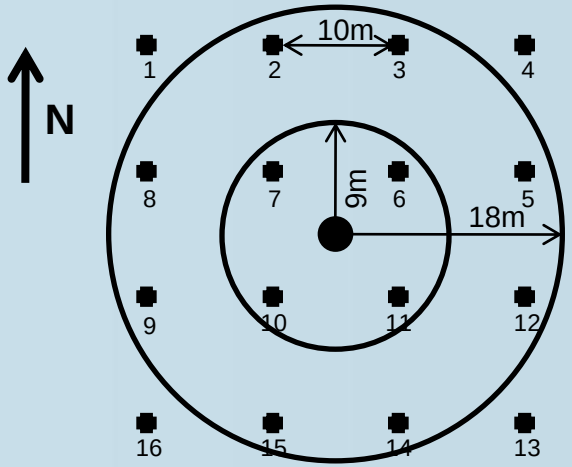
Context

- Tree ring analysis
  - Meerdaalwoud-Heverleebos (2 generations)



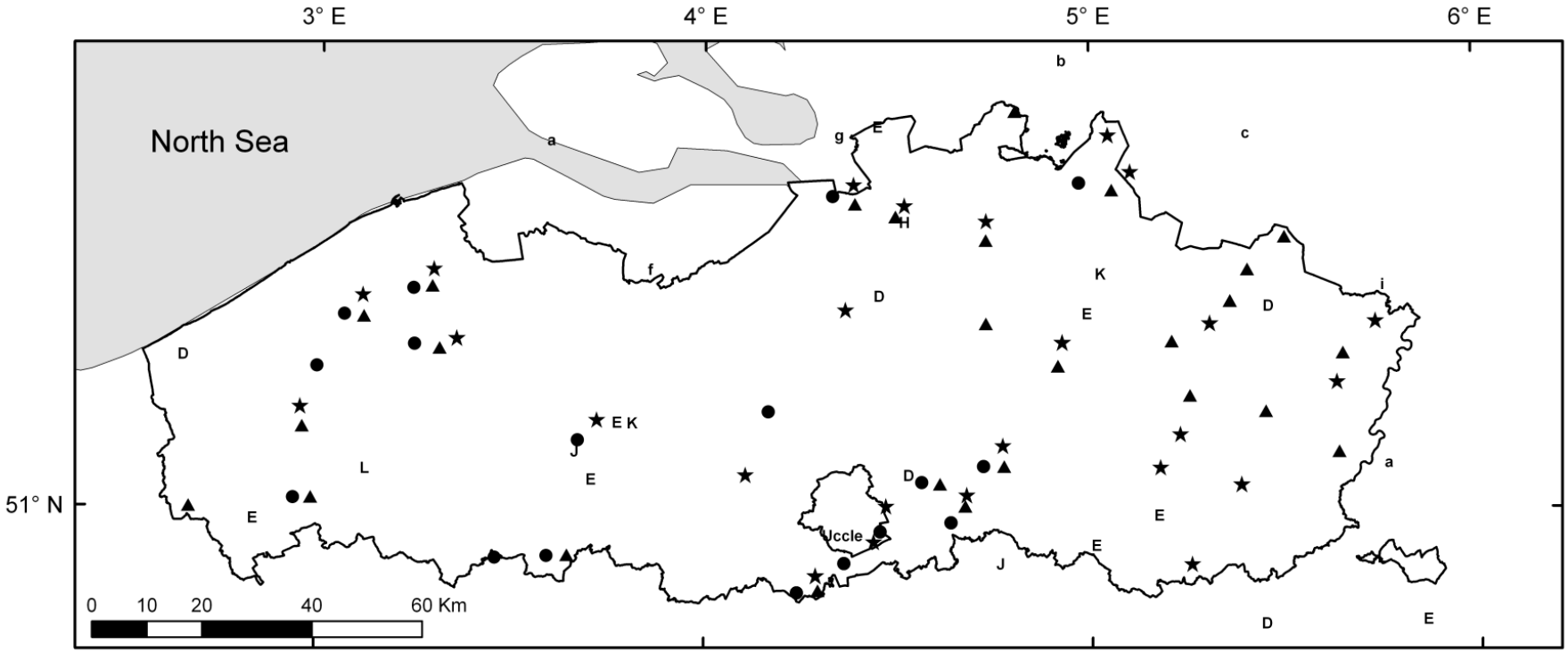
Material and methods

235 study plots,
3 species,
all productivity classes,
homogeneous stands



- **Plot-level data**: vegetation survey , soil analysis, humus classification, dendrometrical measurements (FieldMap)
- **Tree-level data** (central tree): tree ring analysis of central tree (age, ring widths)
- **Meteo data 1901-2008**: temperature (min, max, average), precipitation, RH, wind speed → bi-monthly values per plot
- Other: incoming radiation, CO_2, N deposition, PBL ozone

Material and methods



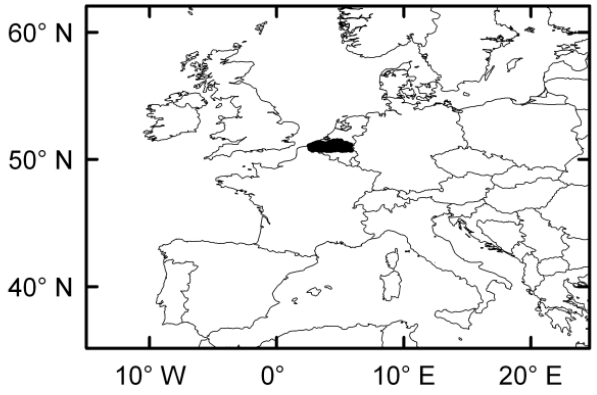
Research plots

- ★ Pedunculate oak
- ▲ Scots pine
- ● Beech

Climate stations

Temperature / Precipitation / Relative humidity & wind speed available since:

Uccle	1901/1901/1901	g	1996/na/1995
a	1910/1957/1910	H	1997/1997/1997
b	1951/1976/1971	i	1999/1999/1999
c	1951/1984/1971	J	na/na/1985
D	1954/1954/1985	K	na/na/2002
E	1954/1954/na	L	na/na/2003
f	1991/1993/1993		



Material and methods

- Develop linear mixed models for basal area increment (BAI) to detect growth changes during the period 1901-2008 and identify driving factors
- *Individual tree growth* is modelled by adopting a meaningful relation between tree growth and a sensible metric for time (e.g. cambial age or tree size) and fitting this relation to each individual in the sample while taking into account time-invariant characteristics of the individual
- *Growth change*, on the other hand, is defined as the component of growth that results from time-variant exogenous factors operating at a regional scale, i.e. affecting all trees in a broad geographic area in the same way (so only depending on time, not on location).

Material and methods

$$\mathrm{BAI}_y = \pi\left(R_y^2 - R_{y-1}^2\right)$$

3 models:

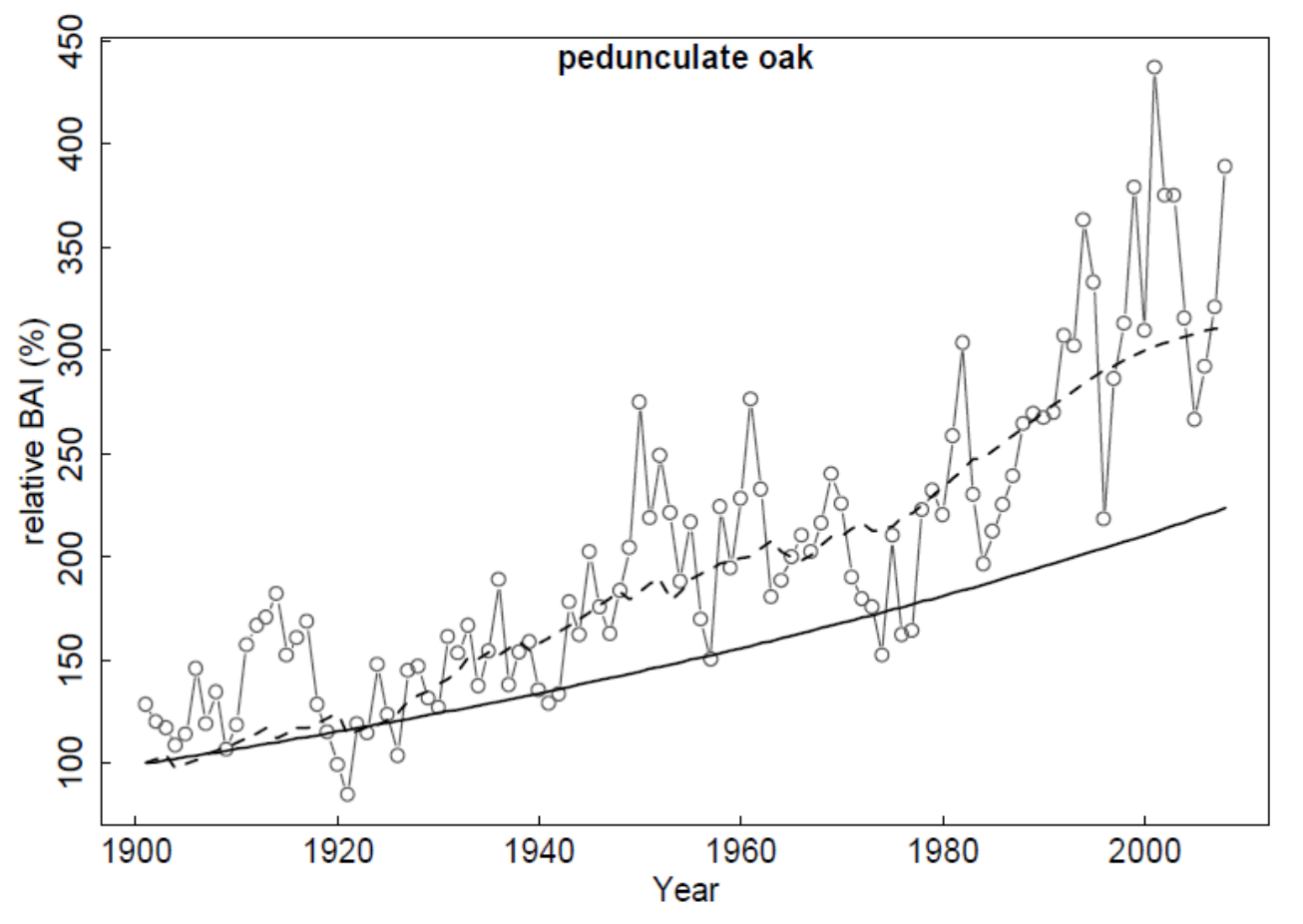
$$\mathrm{M_b} : \ln\left(\mathrm{BAI}_{i,y}\right) = \alpha + \beta\mathbf{T}_{i,y} + \gamma\mathbf{F}_i + \delta\mathbf{S}_i + \mathrm{a}_i + \mathbf{b}_i\mathbf{T}_{i,y} + \varepsilon_{i,y}$$

$$\mathrm{M_d} : \ln\left(\mathrm{BAI}_{i,y}\right) = \mathrm{M_b} + \lambda\mathbf{y}_i$$

$$\mathrm{M_e}: \ln\left(\mathrm{BAI}_{i,y}\right) = \mathrm{M_d} + \mu\mathbf{C}_{i,y} + \theta\mathbf{Ct}_y + \vartheta\mathbf{O}_{i,y}$$

Results

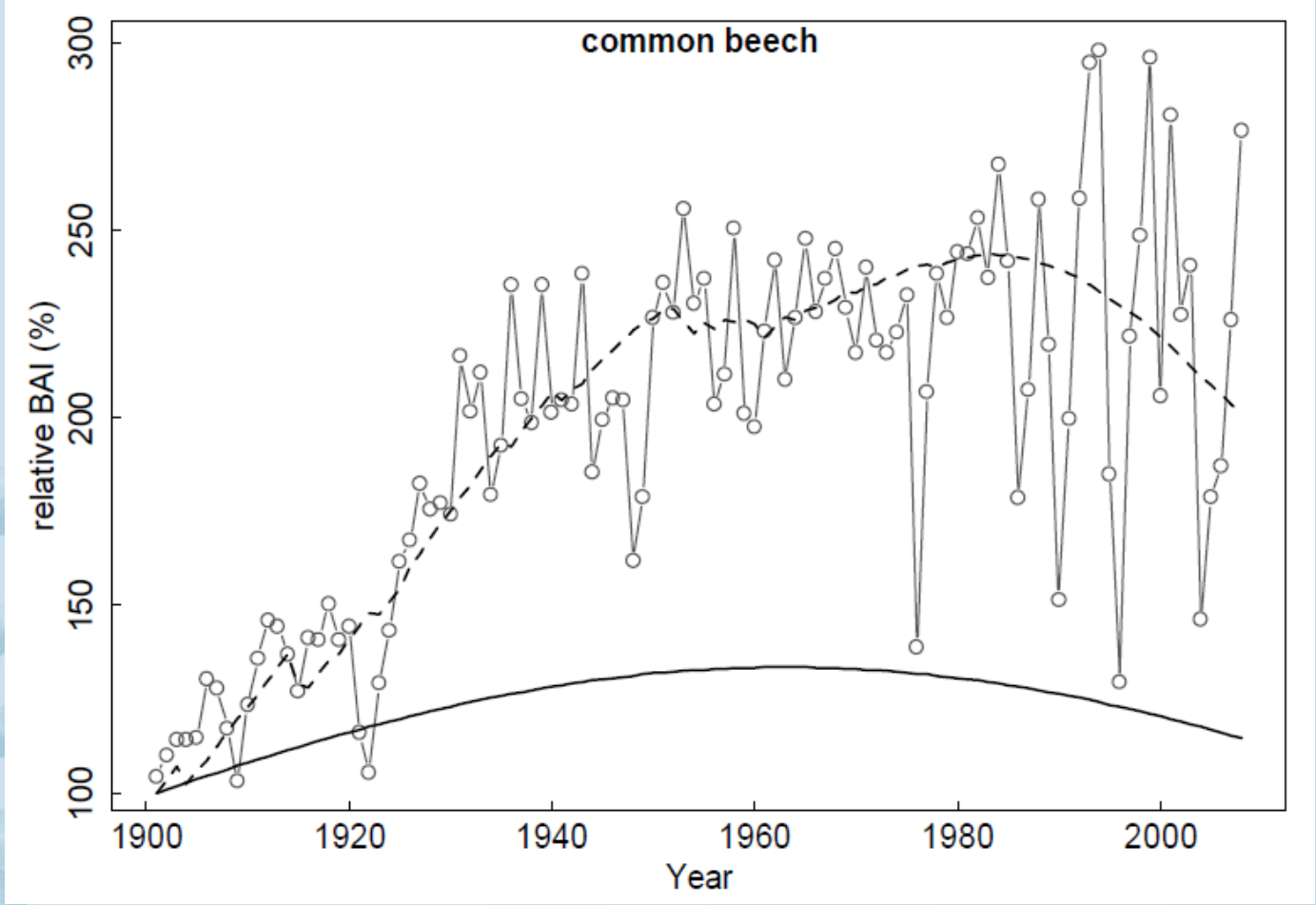
- **Radial growth (BAI) 1901-2008 in Flanders**
  - Increasing growth trend of pedunculate oak: +123%



Source: Kint et al. 2012, Climatic Change

Results

- **Radial growth (BAI) 1901-2008 in Flanders**
  - Quadratic growth trend for common beech: netto +15%



Source: Kint et al. 2012, Climatic Change

Results

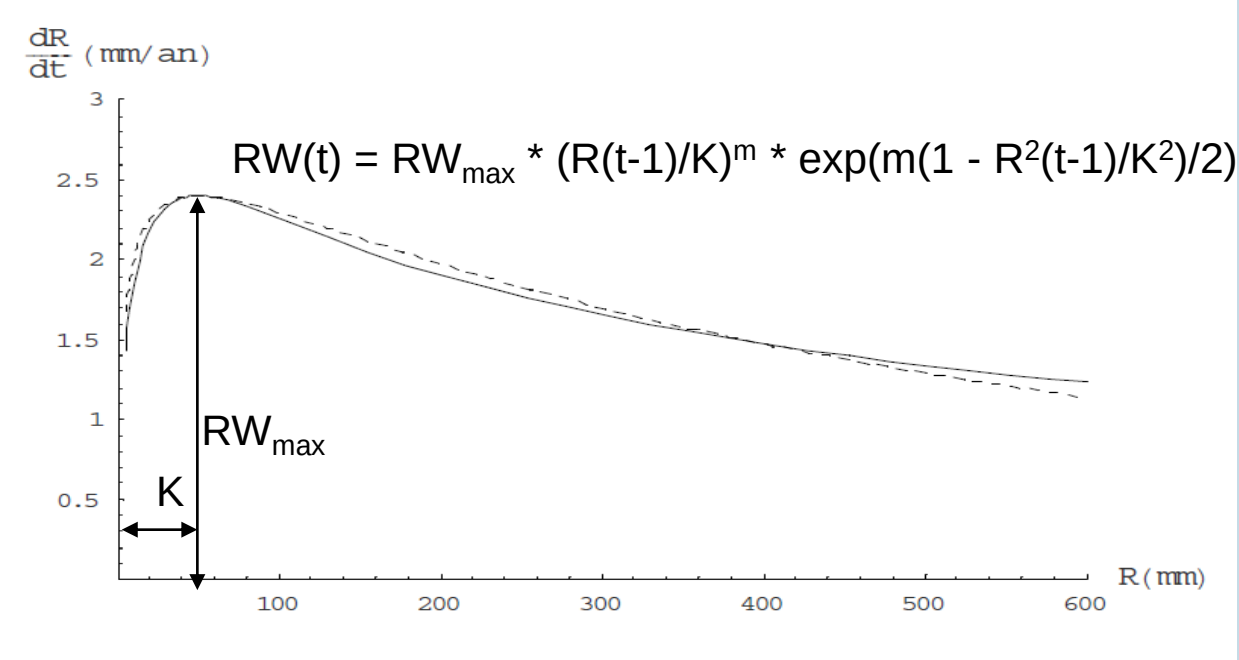
- **Remaining methodological uncertainties:**
  - **Unbalanced design (site quality)**
  - **Youth growth could not be included in this methodology**
  - **No clear seperated generations**

-> common beech in the Flemish loam belt

  - Restricted dataset, to exclude site and management effects
  - Three well seperated generations (10-30 years, 50-88 years and 136-188 years), to identify long-term trends

Results

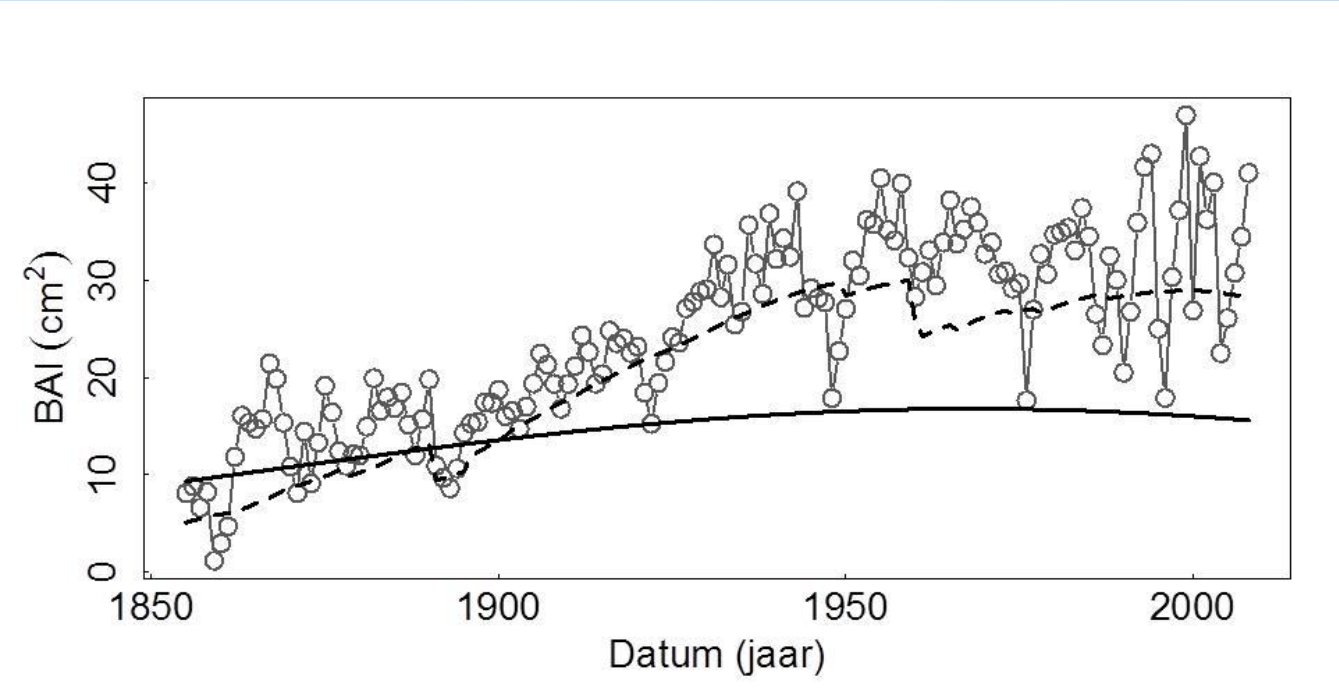
- Two modelling approaches are applied and compared:
  - A linear mixed model with BAI as response variable (similar to the previous models)
  - A non-linear mixed model with ring width (RW) as response variable



Source: Janssen, 2011

Results

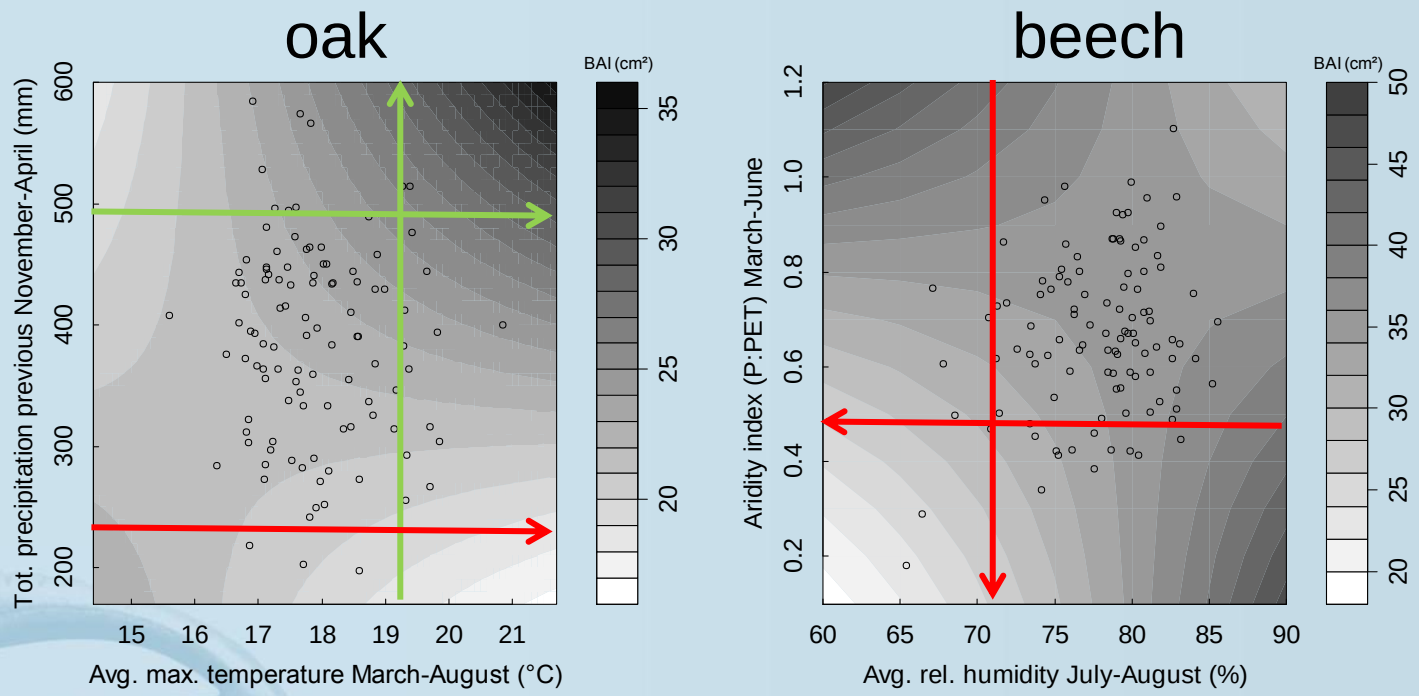
- **Radial growth of different generations of common beech in the Flemish loam belt**
  - Consistent results based on a linear and a non-linear modelling approach (after inclusion of young generation for NLMM)
  - The same long-term growth changes are observed as for the whole of Flanders

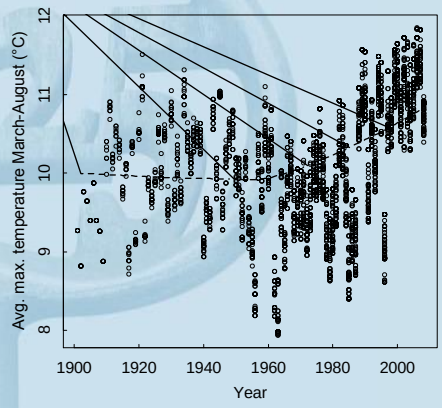


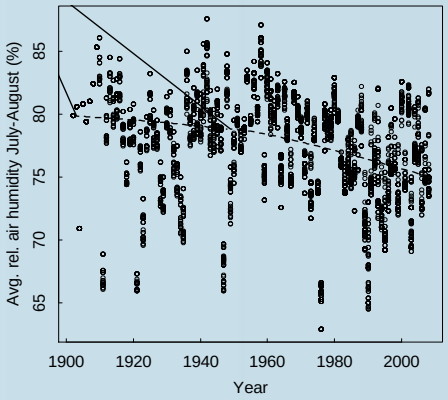
Source:
Janssen, 2011

Results

– **Growth changes are mainly climate driven**



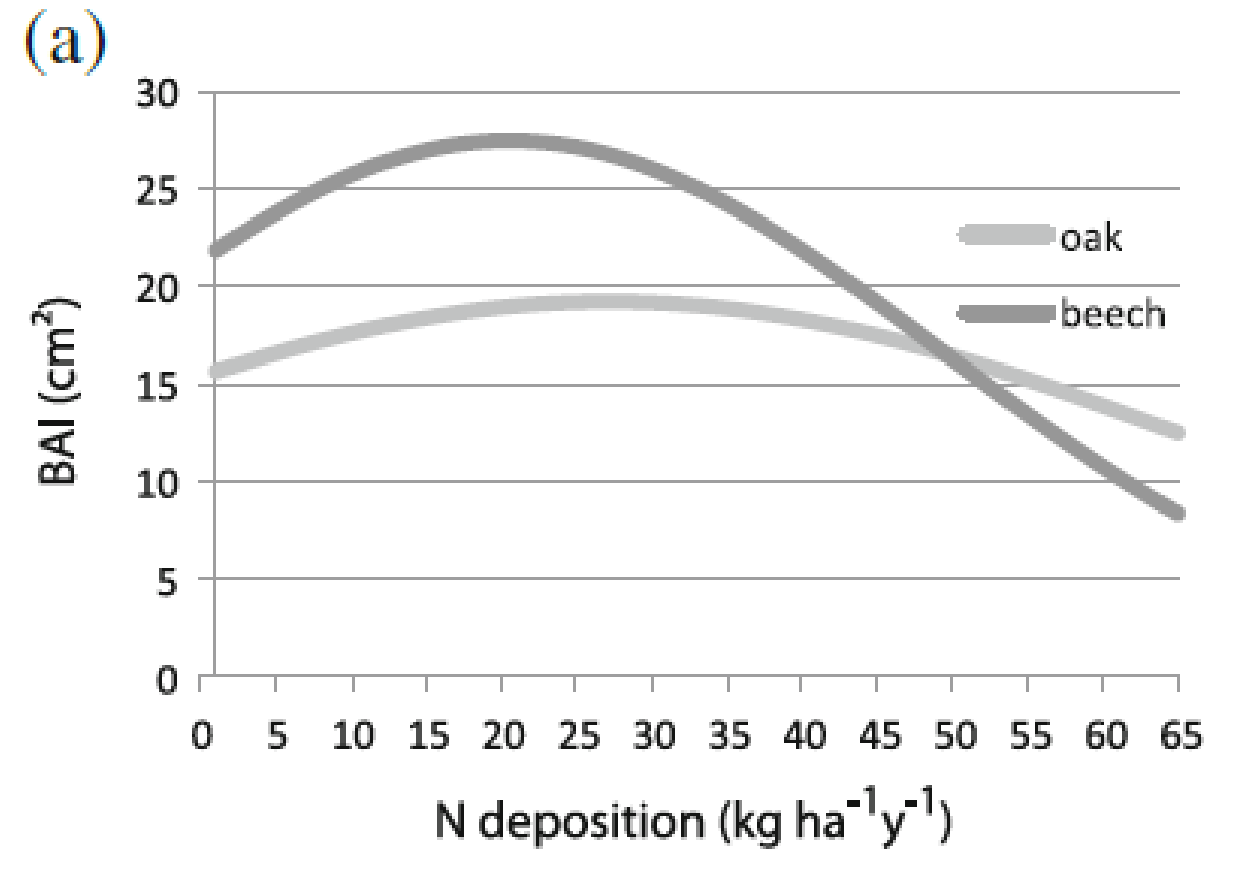




Source: Kint et al. 2012, Climatic Change

Results

- Additionally, a N-deposition effect was found



Source: Kint et al. 2012, Climatic Change

Conclusions

- Long-term growth changes were observed for both pedunculate oak and common beech in Flanders
- Similar observations were made applying linear and non-linear modelling approaches
- Important differences were found in growth changes between oak (increase) and beech (initial increase followed by growth decline since the 1960s)
- Growth change could be related to climate time series and N-deposition trends


Thank you !!!
Special thanks to all contributors !!
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