Environmental control of growth variation in Norway spruce in Finland

Harri Mäkinen
Outline

• Annual growth variation
  – Transect from northern to southern Finland
  – Damaged spruces in southern Finland
  – Norway spruce: European view

• Intra-annual increment
  – Drought
  – Soil frost
  – Nutrient availability
  – Provenance
Annual growth variation

Future?
Sampling: ring-widths from old trees, sensitive sites
Data preparation: removing disturbing signals

Age trend

Climate
Norway spruce in Finland: latitudinal transect
Correlations with weather variation

- Precipitation
- Temperature

Correlation values for:
- Northernmost Finland
- North Finland
- Central Finland
- Southern Finland
Damaged spruces in southern Finland
Damaged spruces in southern Finland

Damaged trees

Healthy trees

Healthy stands

Peatlands
Damaged spruces in southern Finland

![Graph A: Ir–index over years for damaged trees.](image)

![Graph B: Ir–index over years for healthy trees.](image)
Norway spruce: European view
Correlations with temperature

(A) March
(B) April
(C) May
(D) June
(E) July
(F) August

Correlation vs. Mean temperature, °C
Correlations with precipitation

March A
April B
May C
June D
July E
August F

Correlation

Mean precipitation, mm

Mean precipitation, mm

Mean precipitation, mm

Mean precipitation, mm
Correlations with precipitation
Correlations with temperature sum

![Graph showing correlation between temperature sum and year.](image)
Annual growth variation

• Factor limiting growth depends on geographical location, altitude, site properties, etc.
• Northern Finland; temperature enhances tree growth
• Southern Finland; mixed effect of several factors
• On dry sites, prolonged drought may induce mortality
Intra-annual increment
Girth band; changes in stem circumference

**ELPA-93**
A. band, stainless-steel  
B. rotating potentiometer  
C. fastening arm  
D. adjustable foot  
E. cable  
F. spring

- resolution 0.01 mm  
- recording automatically to a datalogger  
- powered by a battery

(Pesonen et al. 2004)
Water availability

Norway spruce, central Finland

Radius increase, mm

May June July August
Microcoring
Preparation of the samples in the lab:

- dehydration of the samples in ascending ethanol series
- clearance by Tissue-Clear, immersion into liquid paraffin
- embedding into parafin blocks
- sectioning of the samples with microtome
- staining (safranin and alcian blue), mounting into Canada balsam
- measurement using microscope and image analysis system
Dynamic wood formation

Cell division
Cell enlargement
Cell wall deposition
Mature cells
Dynamic wood formation

Figure: Saranpää & Piispanen
Drought stress and fertilisation
Drought stress and fertilisation

Norway spruce, southern Finland

Number of tracheids / year

Drought stress

Fertilisation

D0

D1

F0

F1
Drought stress and fertilisation

- Tracheid diameter (µm)
- Wall thickness (µm)

Drought stress
- D0
- D1

Fertilisation
- F0
- F1
Drought stress and fertilisation

- **Drought**
  - reduced tracheid formation rate
  - no effect on tracheid size

- **Fertilisation**
  - increased tracheid formation rate
  - no effect on tracheid size

- **No drought-fertilization interaction**
Artificial soil frost

- Norway spruce stand in eastern Finland (47 yrs)
- 3 treatments (3 plots each):
  - Control (CTRL)
  - Snow clearing (CLEAR)
  - Snow clearing + insulation (INSUL)
Artificial soil frost

- Deep soil frost and delayed thawing
  - minor delay in the onset of tracheid formation
  - reduced tracheid formation rate
  - no clear effect on the cessation of tracheid formation
  - no effect on tracheid size
Nutrient availability

An unfertilised control plot (left) and a stand subjected to optimised fertilisation for 20 years (right).

• Norway spruce in northern Sweden (50 yrs)
• 2 treatments (2 plots each): control
  optimal nutrition + irrigation
Nutrient availability

MAIN EFFECTS OF NUTRIENT OPTIMISATION
- Drastic increase in volume production > 300%
- Slightly earlier onset and later cessation of tracheid formation
- Higher tracheid formation rate, especially in late summer
- Slightly wider tracheids
Provenance trial
Provenance trial

Year 2004

Year 2005

Year 2006

Cumulative no. of tracheids

Julian day

Cumulative no. of tracheids

Julian day

Cumulative no. of tracheids

Julian day
Provenance trial

Year 2007

2007: Total cell no

Cumulative no. of tracheids

Julian day

Year 2008

2008: Total cell no

Cumulative no. of tracheids

Julian day
• The German and Hungarian provenances seemed to initiate the cambial growth slightly later than the Finnish ones

• The total no. of tracheids in German and Hungarian provenances was somewhat smaller than in Finnish ones

• Between-tree and between-year variation in the timing of tracheid formation is high compared with the provenance effect
Effects of climate change?

- Increasing temperature enhances tree growth, especially in northern Finland
- Drought may reduce growth; spruce, sensitive sites
- Trees capable for adapting to changing conditions
- No major changes in wood properties
Thanks to

- **Metla**: Pekka Nöjd, Tuula Jyske, Tuomo Kalliokoski, Kari Mielikäinen, Tapani Repo, Ilari Lumme
- **U Freiburg**: Heinrich Spiecker, Hans-Peter Kahle
- **U Dresden**: Heinz Röhle, Ulrich Neumann
- **NFRI**: Björn Tveite
Thank you