Ecological trends in wood production dynamics of coniferous forest

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OUTLINE OF THE PRESENTATION

1. INTRODUCTION

2. MATERIAL & METHOD
   • GloboXylo Dataset presentation
   • Elaborated data computation
   • Basic model of wood production dynamics

3. RESULTS
   • Biogeographic patterns
   • Dynamics vs. phenology of growth
   • Biome and species strategies
   • Influence of environmental factors

4. DISCUSSION & PERSPECTIVES
Introduction

Earth Greening and Global Change?

- Recent global change induced an increase in:
  - Tree growth
  - Forest ecosystem NPP
  - Terrestrial biosphere carbon up-take
  - Forests are one of the largest C sink on earth

- These changes are attributed to rising temperatures by
  - Remote sensing
  - Direct observations
  - Eco-physiological models

- Scientific Questions:
  - Duration vs. rate of growth?
  - Effect of climatic factors
Wood formation monitoring and meteorological data

- > 50 study sites
- 3 continents
  - America
  - Europe
  - Asia
- 4 biomes
  - Boreal
  - Temperate
  - Mediterranean
  - Arid
- 15 conifer species
- 700 trees in total

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**Sampling Design and Anatomical Observations**

**Wood sampling**
- 3-15 trees/sites
- ~ Weekly microcores

**Developing xylem observations**
- Preparation of anatomical sections
- Observation under light microscope
- Classification and counting of differentiating tracheid along radial files:
  - Cambial cells
  - Enlarging cells
  - Thickening cells
  - Mature cells
**XYLOGENESIS DATA PROCESSING**

- Asses xylem phenology (dE)
- Assess xylem dynamics (r90)
- Basic Physical model: $RCN = dE \times r90$
- Sensitivity analysis
- Mixed model analysis

**What are the contributions of timings and rates?**

**What are the influences of climatic factors?**

**Check & format wood formation monitoring data**

**Basic Physical model:**

$$RCN = dE \times r90$$

**What are the contributions of timings and rates?**

**What are the influences of climatic factors?**
Huge range of climatic conditions

- Mean Annual Temperature:
  - From -8 °C in Siberia
  - To 18 °C in Spain

- Total annual precipitation:
  - From 30 cm in Tibet and Spain
  - To 180 cm in France and Slovenia
- **Four bioclimatic zones**
  - Mediterranean forests (M)
  - Temperate forests (T)
  - Boreal forests (B)
  - Arid forests (A)
- **Three elevation zones**
  - Low elevation (l)
  - Medium elevation (m)
  - High elevation (h)
- RCN: from 3 to 150 cells
- r90: from 0.1 to 1 cell/day
- dE: from 1 to 10 months
- bE: from Feb. to Jun.
- cE: from Jul. to Dec.
RESULTS

LENGTH OF THE GROWING SEASON

• **Clear biogeographic patterns**
  – Latitude
  – Elevation
  – Summer solstice
  – Upper limit at 40 days
  – No lower limit

• **Relationships between onset and cessation of cambial activity**
  – Similar range of variations
  – Similar contribution to dE
  – Similar importance

**Graphical Representation**

- **Onset of growing season & Cessation of growing season (Day of Year)**
- **Duration of growing season (days)**
- **Thermo–Med**: Red
- **Meso–Med**: Orange
- **Oro–Med**: Green
- **Low–Temp**: Light green
- **Mon–Temp**: Blue
- **Sub–Temp**: Cyan
- **Low–Bor**: Light blue
- **Mon–Bor**: Dark blue
- **Sub–Bor**: Purple
- **Low–Arid**: Light purple
- **Mon–Arid**: Light pink
- **Sub–Arid**: Pink

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**Validation of the Basic Physical Model**

- **The basic physical model** ($RCN = dE \times r90$)
  - Explains 80% of the variance
  - Exhibits no significant bias
  - Works also for Mediterranean and arid forests!

✓ **The model can be used for further investigations...**
CONTRIBUTION OF DURATION AND RATE TO TOTAL NUMBER OF XYLEM CELLS PRODUCED PER YEAR

Sensitivity analysis

- $r_mG$ varies, while $dE$ is kept constant
  - RCN: 18 → 59 (↗ 41 cells)

- $dE$ varies, while $r_mG$ is kept constant
  - RCN: 22 → 54 (↗ 32 cells)

- Resulting contribution to total variation:
  - $r_mG$: 55%
  - $dE$: 45%
ECOLOGICAL TRENDS BETWEEN BIOMES

- **Boreal forests**
  - short growing seasons
  - high growth rates
  - r90 contributes to 65 %, dE to 35 %

- **Temperate forests**
  - Medium growing season
  - Variable growth rates
  - r90 contributes to 60 %, dE to 40 %

- **Mediterranean forests**
  - long growing seasons
  - low growth rates
  - r90 contributes to 55 %, dE to 45 %

- **Standardised comparison (for 35 cells)**
  - Boreal: 70 days at 0.5 cells/day
  - Temperate: 100 days at 0.4 cells/day
  - Mediterranean: 130 days at 0.3 cells/day
**Species Specific Strategies?**

- **Scots pine across bioclimatic zones**
  - Boreal (B), Temperate (T), Mediterranean (M)
  - 13 sites
  - 168 trees
  - Same as global trends:
    - RCN \(\rightarrow\)
    - R 90 \(\downarrow\) from B to M
    - dE \(\uparrow\) from B to M

- **Norway spruce across altitudinal zones**
  - Low (l), Medium (m), High (h)
  - 17 sites
  - 246 trees
  - Same as general patterns
    - RCN \(\rightarrow\)
    - R 90 \(\uparrow\) from B to M
    - dE \(\downarrow\) from B to M

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** Mosque of the patron Saint Day**

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Effect of Mean Annual Temperatures on wood formation dynamics

- **Ring Cell Number (RCN)**
  - No effect

- **Mean cell production rate (r90)**
  - Small effect

- **Timings of enlargement (bE, cE, dE)**
  - Strong effect

- **Extend former results on cambium phenology**
  - Linear trend
  - Mediterranean area

**RESULTS**

**EFFECT OF TEMPERATURES ON WOOD FORMATION DYNAMICS**
**Effect of Water Availability on Wood Formation Dynamics**

**RESULTS**

Effect of total Growing Season Precipitations (GPS) on wood formation dynamics

- **Ring Cell Number (RCN)**
  - No effect

- **Mean cell production rate (r90)**
  - Moderate effect

- **Timings of enlargement (bE, cE, dE)**
  - Light effect

- New result showing the influence of water stress on cell production at global scale
**Global trends in wood production**
- Contribution of *growth rate* > growing season duration
- *Wood formation phenology* is mainly driven by temperature at global scale + species specific effect at local scale (global: 80 / local: 20)
- *Wood formation dynamics* is under the control water balance + local conditions (global: 20 / local: 80)

**Impact of global change**
- Extension of the growing season even in Mediterranean zone…
- …But strong modulation at site level…
- …Very uncertain outcomes!

**Future challenges**
- Deciphering the effect of site conditions and environmental factors on growth rate
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Herzlichen Dank für Ihre Aufmerksamkeit!