Wood phenology, not carbon input, controls the interannual variability of tree growth in a temperate oak forest

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Flux-growth correlations inter-biome

Tree growth is constitutively dependent on C inputs

Strong growth / C inputs correlations inter-biomes

Litton et al., 2007 GCB
Vicca et al., 2012 Ecol. Lett.
Flux-growth correlations

*inter-annual*

Annual wood growth is not systematically dependent on annual GPP / NPP

Rocha et al., 2006 *GCB*
Granier et al., 2008 *AFS*
Flux-growth correlations 
seasonal scale

Wood growth is a seasonal process

Seasonal C fluxes

FR-Fon Oak forest (2006-2015)

Delpierre et al., 2016, *Annals of Forest Science*
Objectives

- Assess the dependence of aerial wood growth on:
  - Carbon inputs (growth is \textit{source-limited})
  - Wood tissues activity, modulated by environmental drivers (growth is \textit{sink-limited})
FR-Fon research station

Fontainebleau-Barbeau forest (405 ha)

Sessile Oak (*Quercus petraea*) – 150 yr old
Hornbeam (*Carpinus betulus*)

Flux + growth measurements
2005 – ongoing

MAT=11.5 °C
MAP= 657 mm
Assessing stand wood growth

\[
\frac{dAWB}{dt} = \frac{dV}{dt} \times \rho
\]

\[\text{AWB} = \text{abv wood mass (kg C m}^{-2}\text{)}\]

\[V = \text{volume (m}^3\text{ m}^{-2}\text{)}\]

\[\rho = \text{volumetric mass (kg C m}^{-3}\text{)}\]
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\(\rho\) = volumetric mass (kg C m\(^{-3}\))
Does wood growth depend on C inputs?

GPP = 1931
NEP = 526
Does wood growth depend on C inputs?
Does wood growth depend on C inputs?

(a) Annual AWG vs GPP

(b) Annual AWG vs NEP

- GPP (gC/m²/y)
- NEP (gC/m²/y)

Correlation coefficients:
- GPP: $r = -0.09$, $p < 0.81$
- NEP: $r = -0.29$, $p < 0.42$
Does wood growth depend on C inputs?

see also Babst et al. 2014, *New Phytol.*
Does wood growth depend on C inputs?

$r^2 = 0.41$, $p < 0.05$
Intrinsic determinants of wood growth

« critical periods » after Le Maire et al., 2010 JGR

Critical period #1

Halt date

Start

Halt

r-Pearson (seasonal, annual)

AWG (gC/m²/d)

Day of Year
Intrinsic determinants of wood growth

1. Scatter plot showing the relationship between \(\text{AWG}_{\text{start}}\) (DoY) and annual \(\text{AWG} (\text{gC/m}^2\text{yr})\). The correlation coefficient is \(r = -0.02, p < 0.96\).

2. Scatter plot showing the relationship between \(\text{AWG}_{\text{halt}}\) (DoY) and annual \(\text{AWG} (\text{gC/m}^2\text{yr})\). The correlation coefficient is \(r = 0.89, p < 0\).

3. Scatter plot showing the relationship between growth during CP1 and annual \(\text{AWG} (\text{gC/m}^2\text{yr})\). The correlation coefficient is \(r = 0.89, p < 0\).
Intrinsic determinants of wood growth

End date + growth during CP1 explain 91% of the IAV of wood growth
Intrinsic determinants of wood growth

- Date of growth halt depends on SWC

See also Mund et al. (2010) Beech, Lempereur et al. (2015) Holm Oak
Intrinsic determinants of wood growth

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Intrinsic determinants of wood growth

Growth during CP1

- Not strongly dependent on C fueling
- Constrained by water shortage
Wood growth more sensitive to water shortage than GPP
(see Hsiao et al., 1976)
Conclusions

- No dependence of annual wood growth on GPP / NEP

- Annual wood growth correlates with:
  - the date of growth halt
  - growth during a « critical period » (DoY 172-186)

- Clear dependence of wood growth on water shortage...
  whilst GPP is not water-limited (mesic site)
Analysis over 49 French forests, 941 site-years

Source-limitation dominates in temperate conditions

Sink-limitation dominates in montaneous / Mediterranean conditions

Guillemot et al., 2015 Biogeosciences
“Environmental control of carbon allocation matters for modelling forest growth”

Guillemot et al., in revision, *New Phytol.*

- Incorporating sink-limitation in the *CASTANEA* process-based model reduced wood growth RMSE by 20-50%
Thank you for your attention

www.barbeau.u-psud.fr
Intrinsic determinants of wood growth

See also:
- Mund et al. (2010): Beech
- Lempereur et al. (2015): Holm Oak
Microcoring @ FR-Fon

WoodCap project
INRA-Nancy, Univ. Paris-sud, TU Dresde
Microcoring @ FR-Fon

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Guillemot et al., in revision, *New Phytol.*