Relationship between above and belowground phenology: meta-analysis and case study

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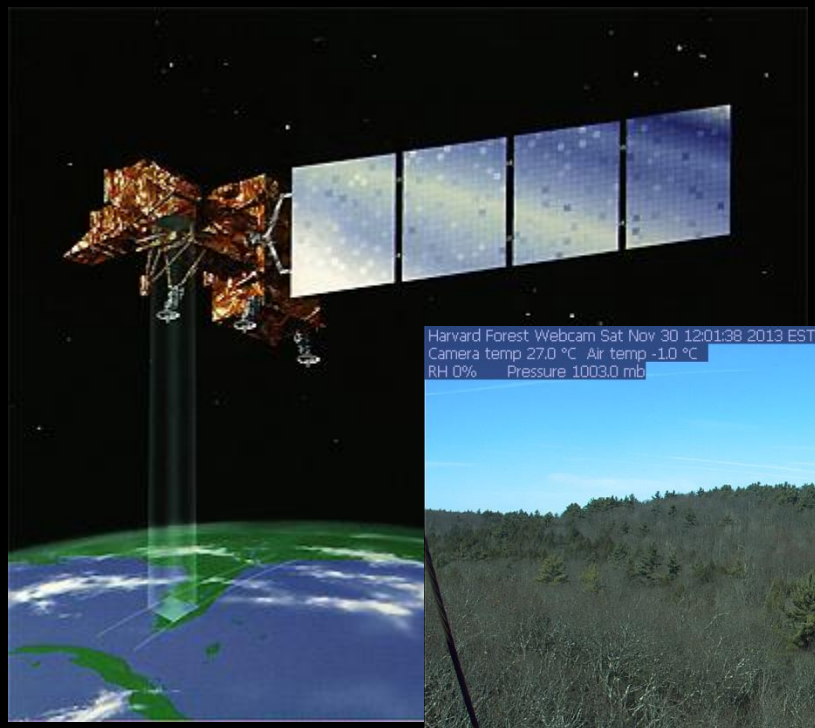
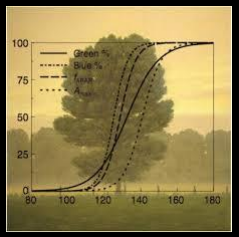
Boston University

Aboveground phenology = big data



neon
National Ecological Observatory Network

USA npn National Phenology Network



Project BudBurst
www.budburst.org

Model	Aboveground Phenology	Belowground Phenology	C allocation	Citation
TRIFFID	Temperature	n/a	Allometric equations and partitioning into 'spreading' and 'growth' based on LAI	Cox 2001
Hyland	n/a	n/a	Allometric equations	Friend et al. 1997, Friend and White 2000, Levy et al. 2004
PnET-BGC	Temperature GDD	Monthly turnover rate	Fixed site-specific ratios	Kram et al. 1999
ORCHIDEE	Temperature and soil moisture GDD	n/a	Resource optimization	Krinner et al. 2005
IBIS	Temperature Productivity threshold	n/a	Fixed annually for leaf:stem:root	Mcguire et al. 2001
TEM	Evapotranspiration	n/a	Not explicit	Mcguire et al. 2001
ED2	Logistic functions derived from MODIS data	n/a	PFT-dependent allocation relationships, root:leaf allocation determined by optimization	Medvigy et al. 2009
CLM 4.0	GDD Temperature and soil moisture Daylength	n/a	Allometic equation based on fixed ratios of fine root:leaf and coarse root:stem	Oleson et al. 2009, Thornton and Zimmerman 2007
LPJ	GDD Temperature and soil moisture	n/a	Allometric equations	Sitch et al. 2003
BIOME-BGC	Optimized from satellite observation	n/a	Allometric equations	White et al. 1997
Sheffield- DGVM	Temperature and soil moisture	n/a	Based on demand by different plant organs LAI>roots>wood	Woodward et al. 1995, Woodward and Lomas 2004

Abramoff and Finzi *(in revision, New Phytologist)*

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Objectives

- Are root and shoot phenology in sync?

- What are the drivers of root phenology?
    1) On a biome scale?
    2) On a local scale?

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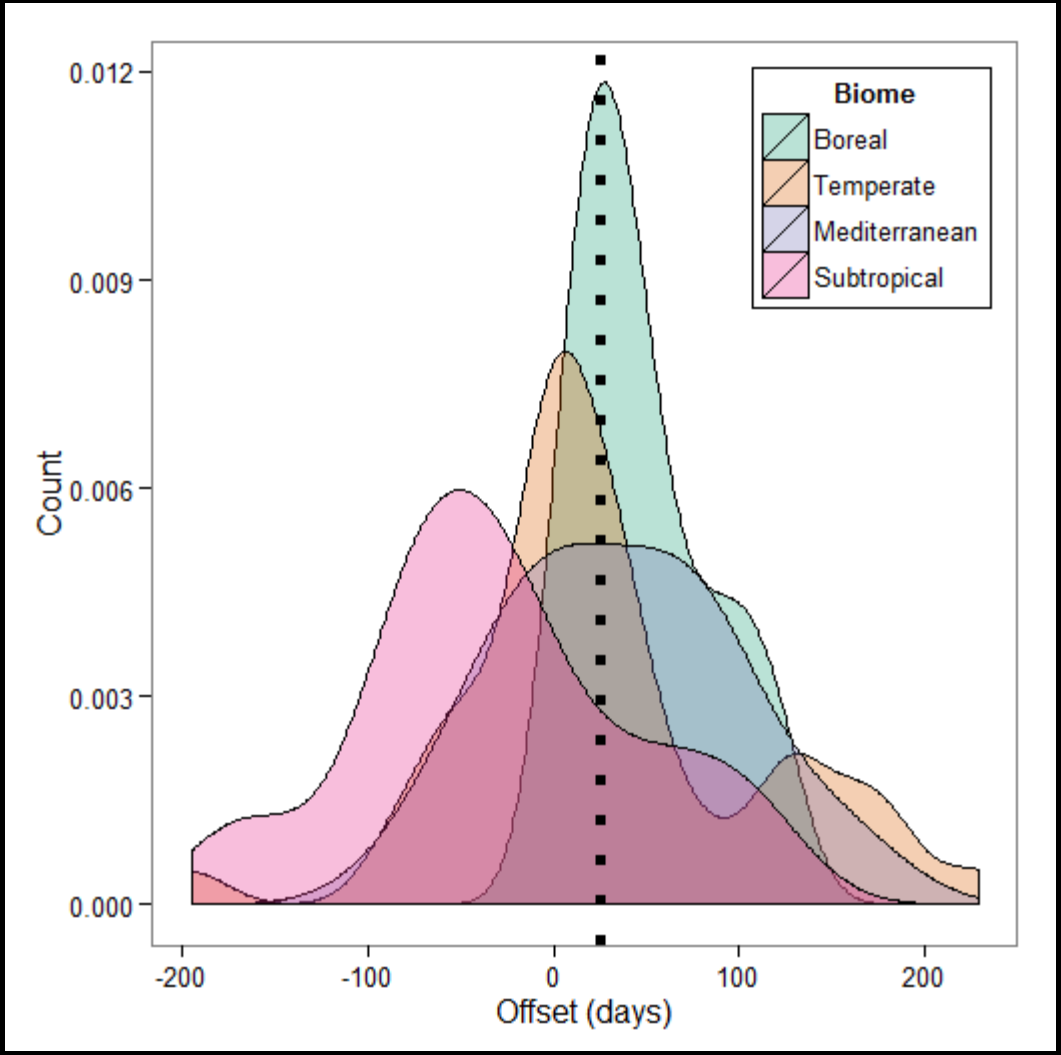
Meta-analysis

- 40 studies
- 87 datasets
- 63 species

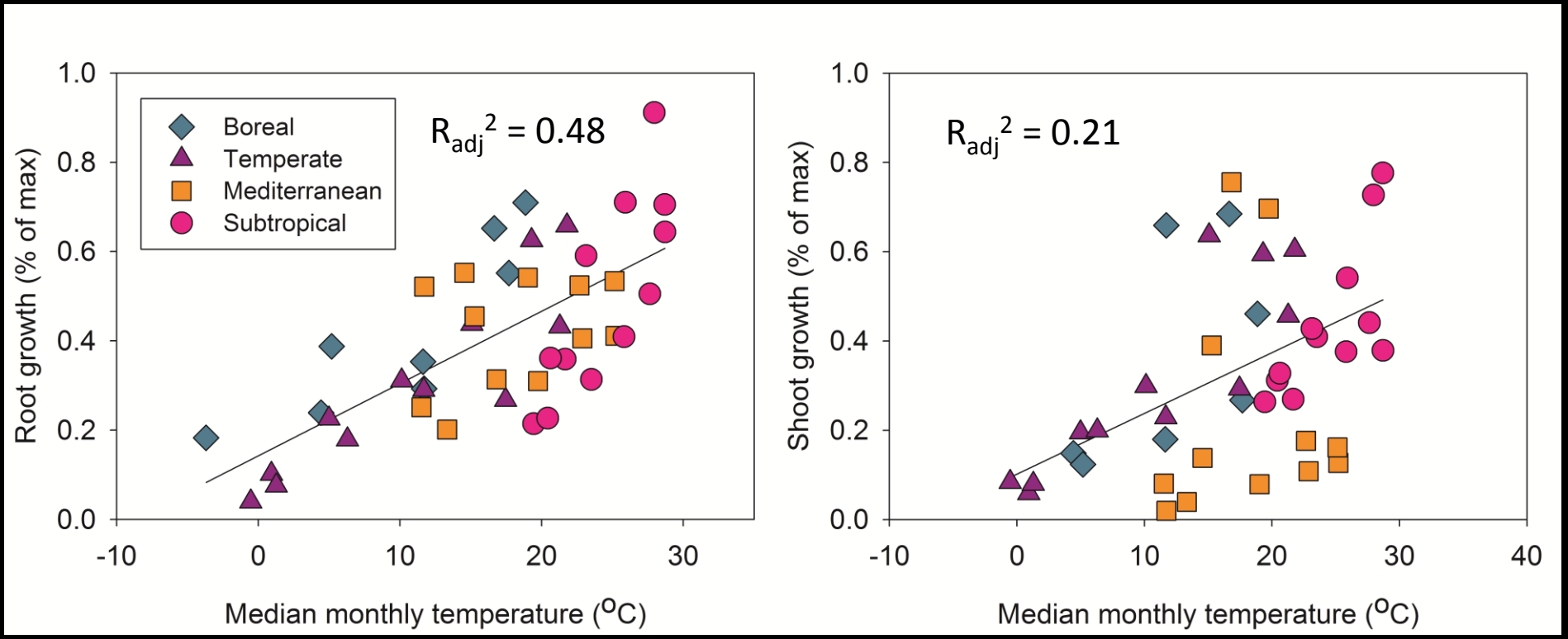
- 4 biomes
  1. Boreal (N=20)
  2. Temperate (N=45)
  3. Mediterranean (N=11)
  4. Subtropical (N=11)

- Shoot phenology
  - Shoot/stem elongation
  - Leaf elongation/production
  - Diameter increment
- Root phenology
  - Root elongation/production
- Root methods
  - Soil coring
  - Minirhizotron
  - Field rhizotron
  - Soil CO_2 efflux

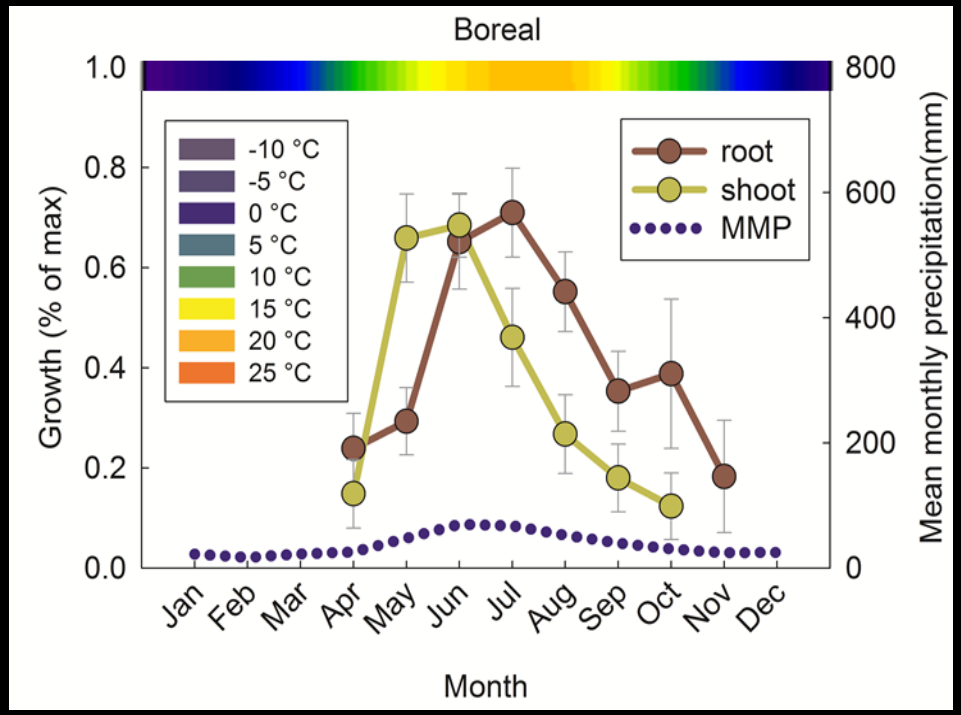
(offset = $DOY_{maximum\ root} - DOY_{maxium\ shoot}$)

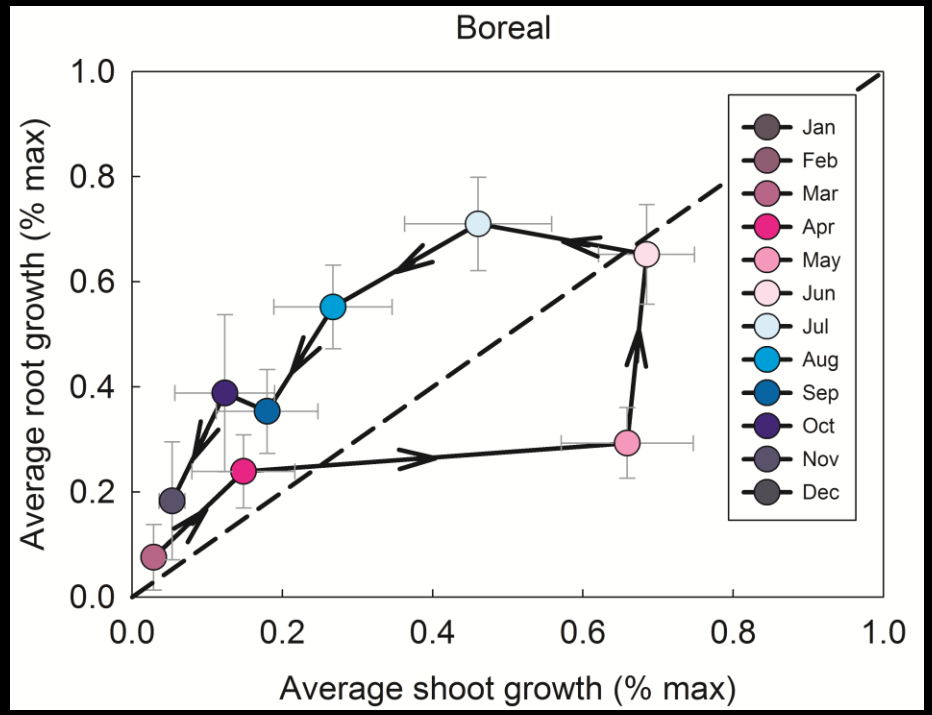


Correlation with temperature

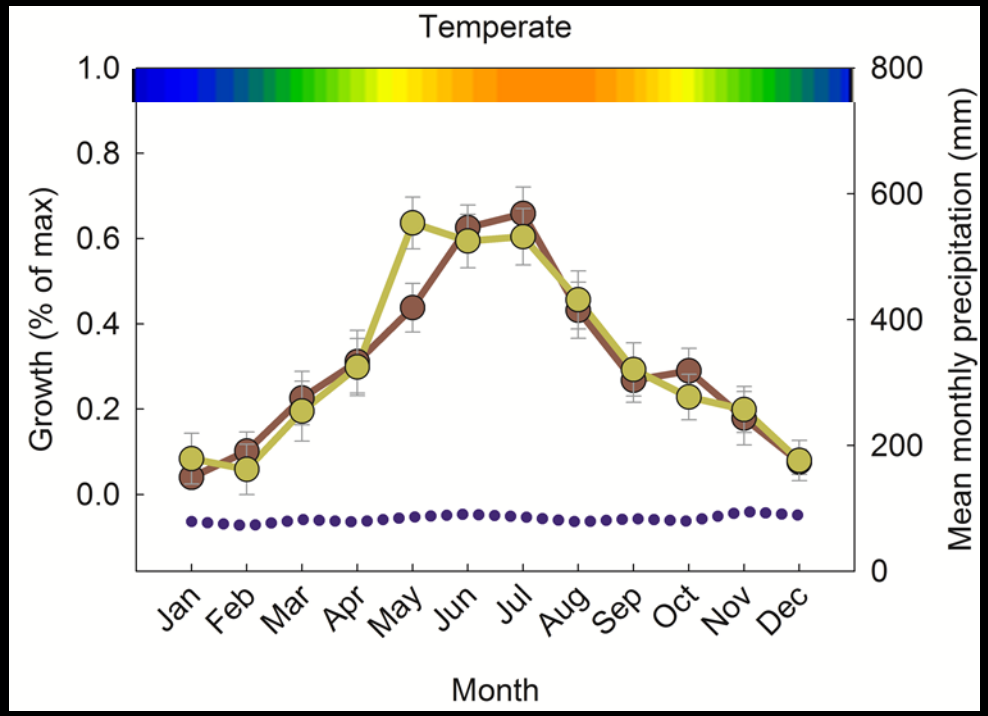


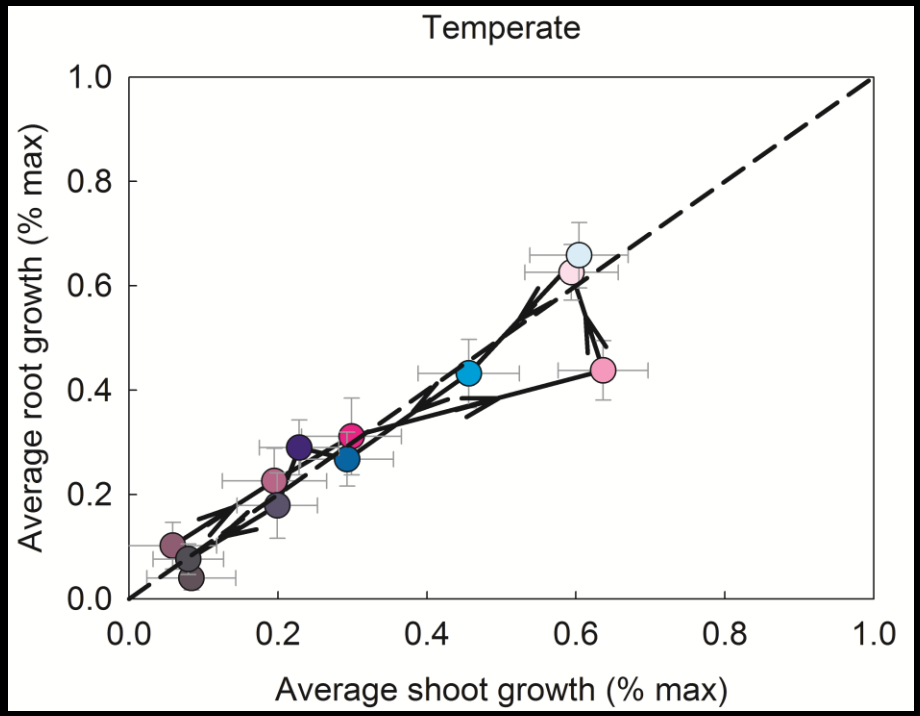
Boreal


Boreal
Growth (% of max)
Mean monthly precipitation(mm)
Month
-10 °C
-5 °C
0 °C
5 °C
10 °C
15 °C
20 °C
25 °C
root
shoot
MMP
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

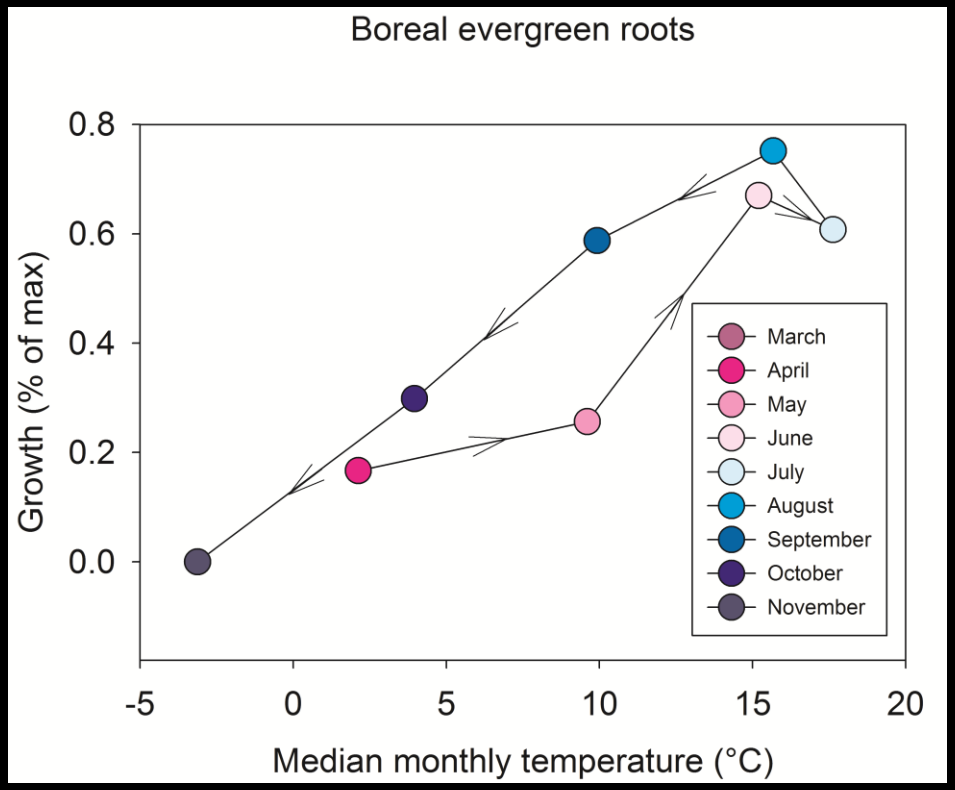

Boreal
Average root growth (% max)
Average shoot growth (% max)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

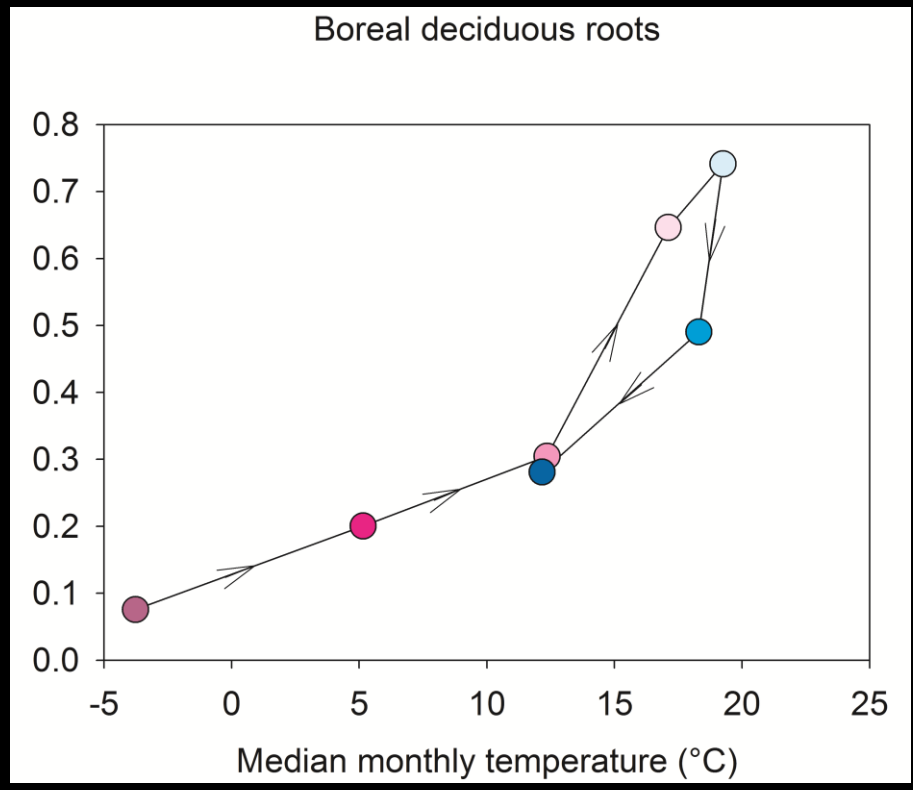
Temperate


Temperate
Growth (% of max)
Mean monthly precipitation (mm)
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

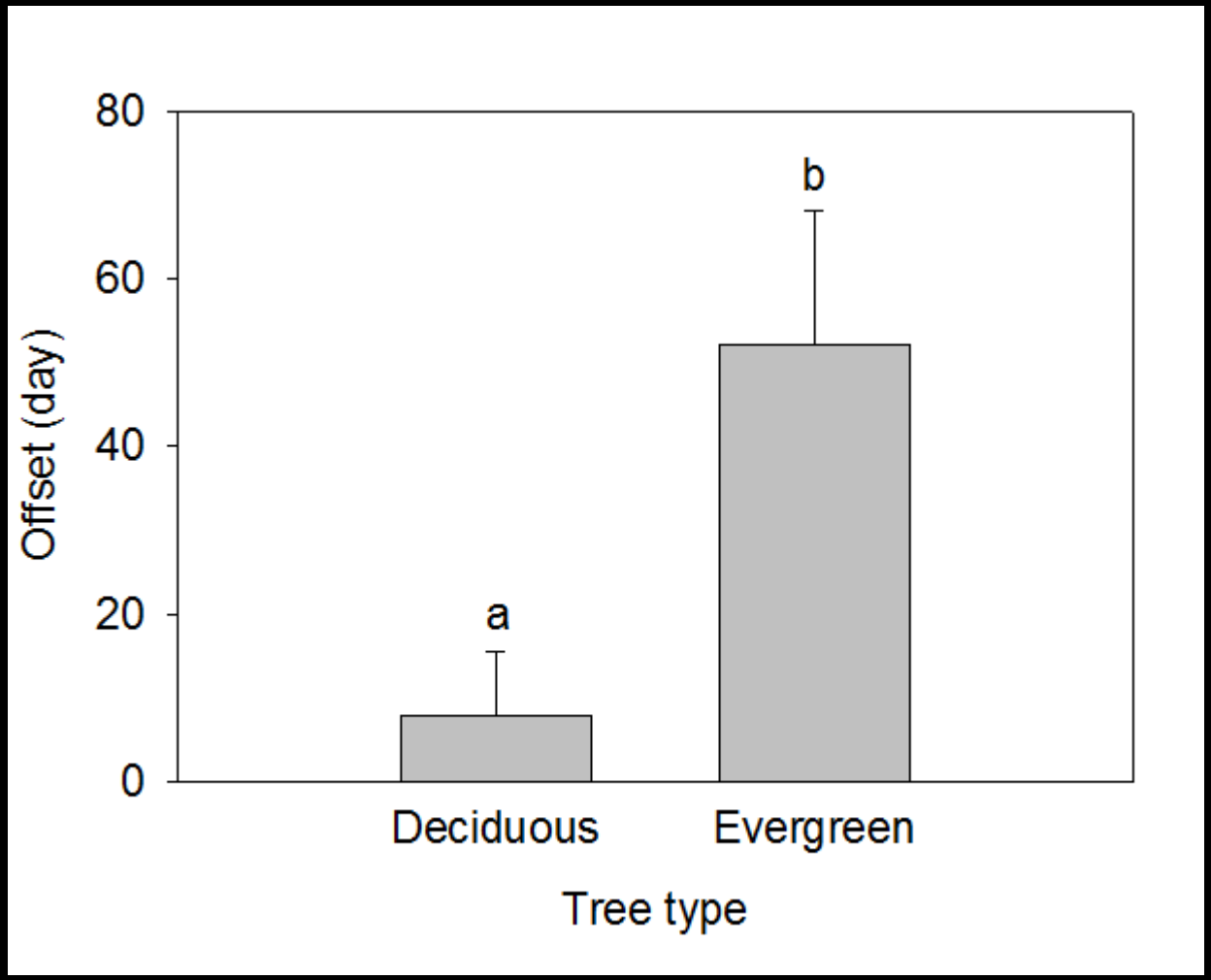

Temperate
Average root growth (% max)
Average shoot growth (% max)

Boreal: Evergreen vs Deciduous

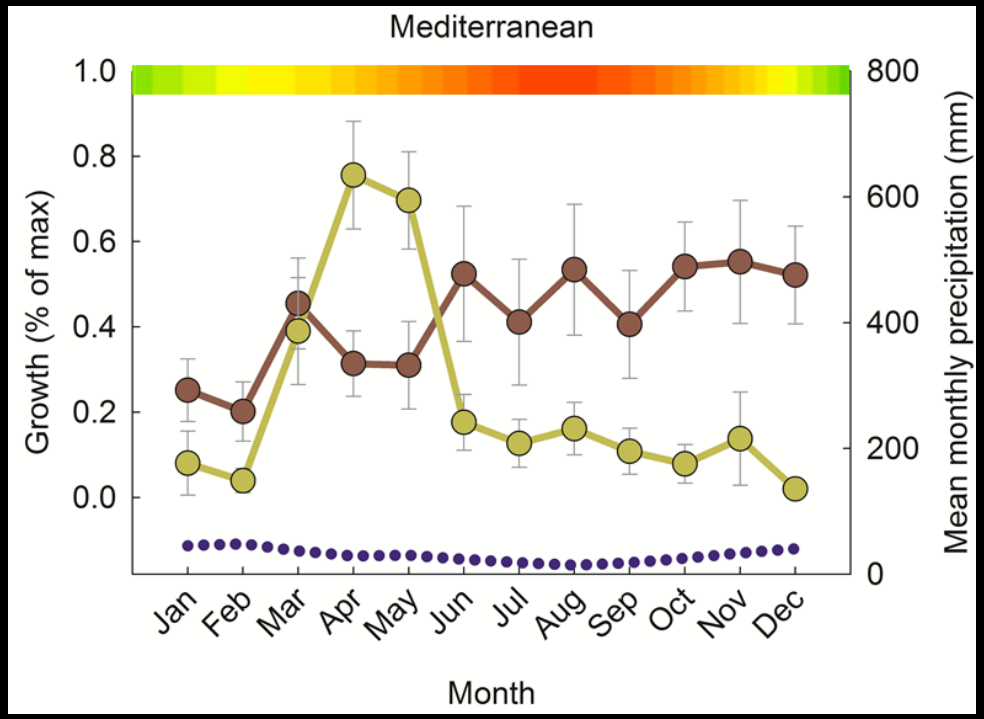


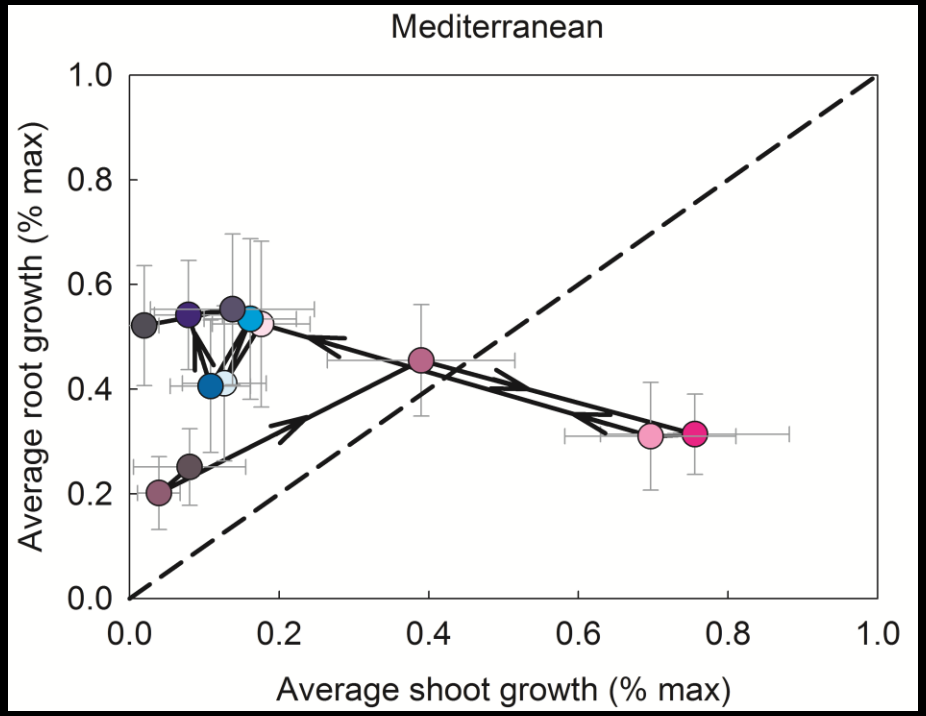


All biomes: Evergreen vs Deciduous

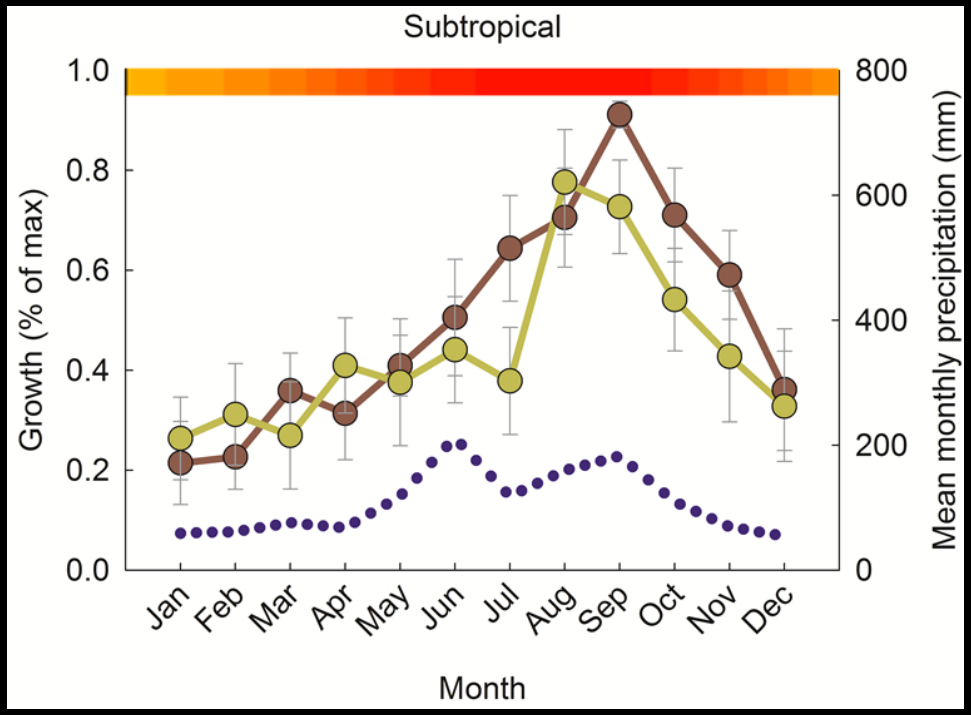


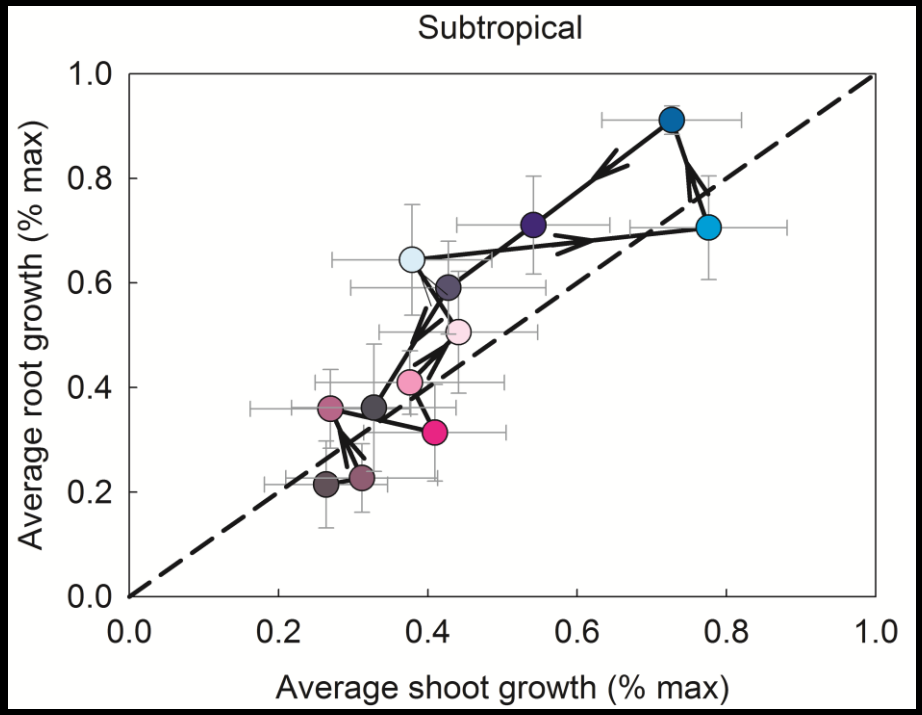
Mediterranean





Subtropical





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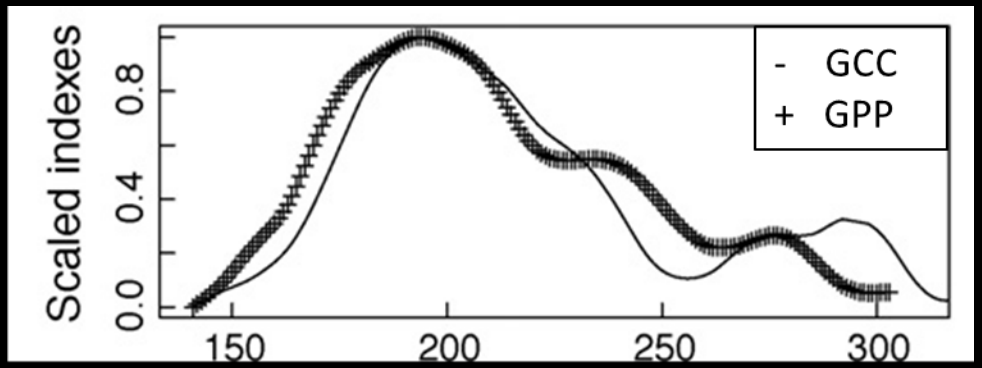
Harvard Forest
ME
VT
NH
MA
NY
RI
CT
MI
PA
NJ
OH
MD
DE
DC
IN
WV
VA
KY
NC
NEON Inc.



(Migliavacca et al. 2011)

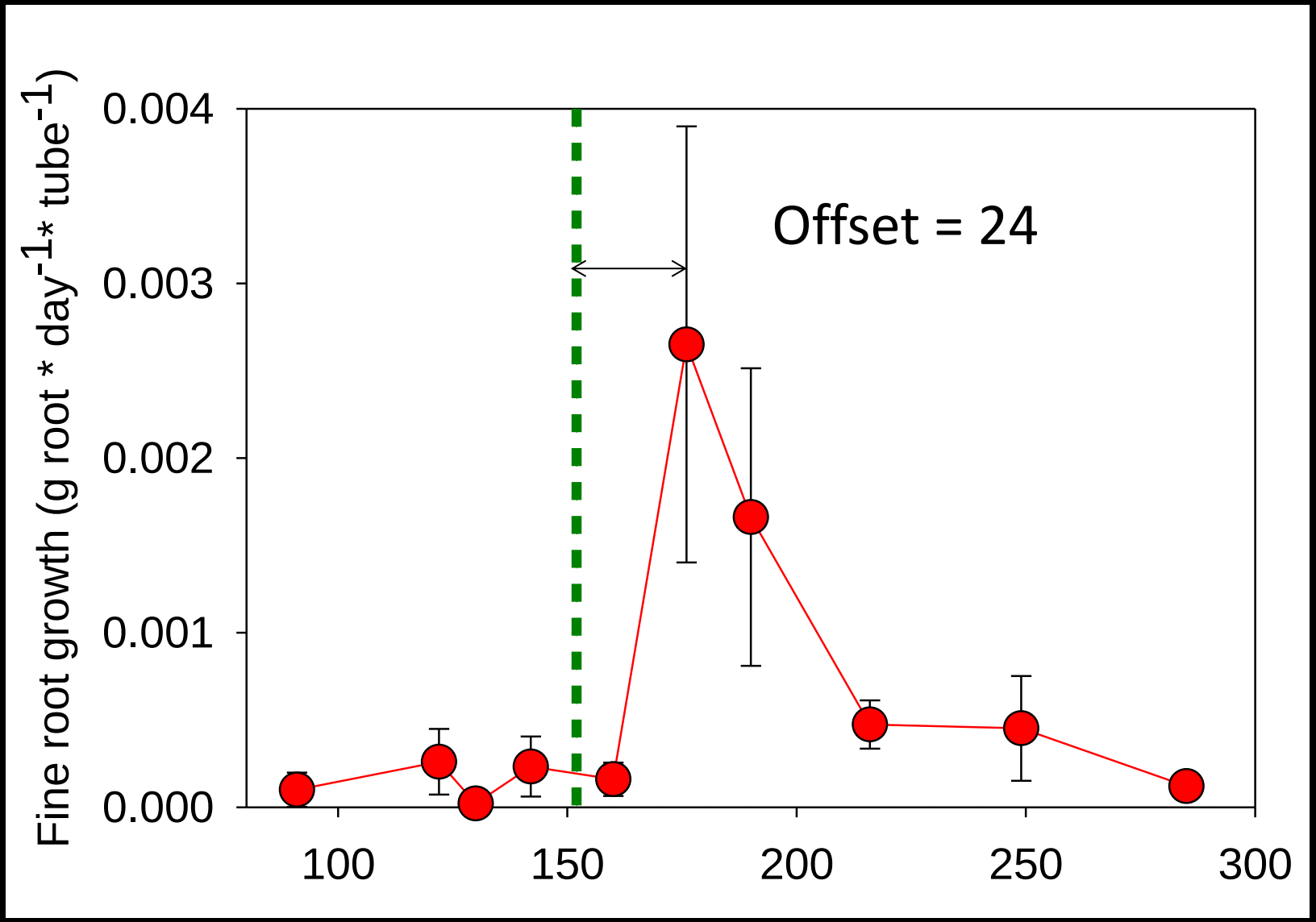
Shoot methods
- Phenocam network
- (GCC= G/[R + G + B])

Root methods
- Minirhizotron camera

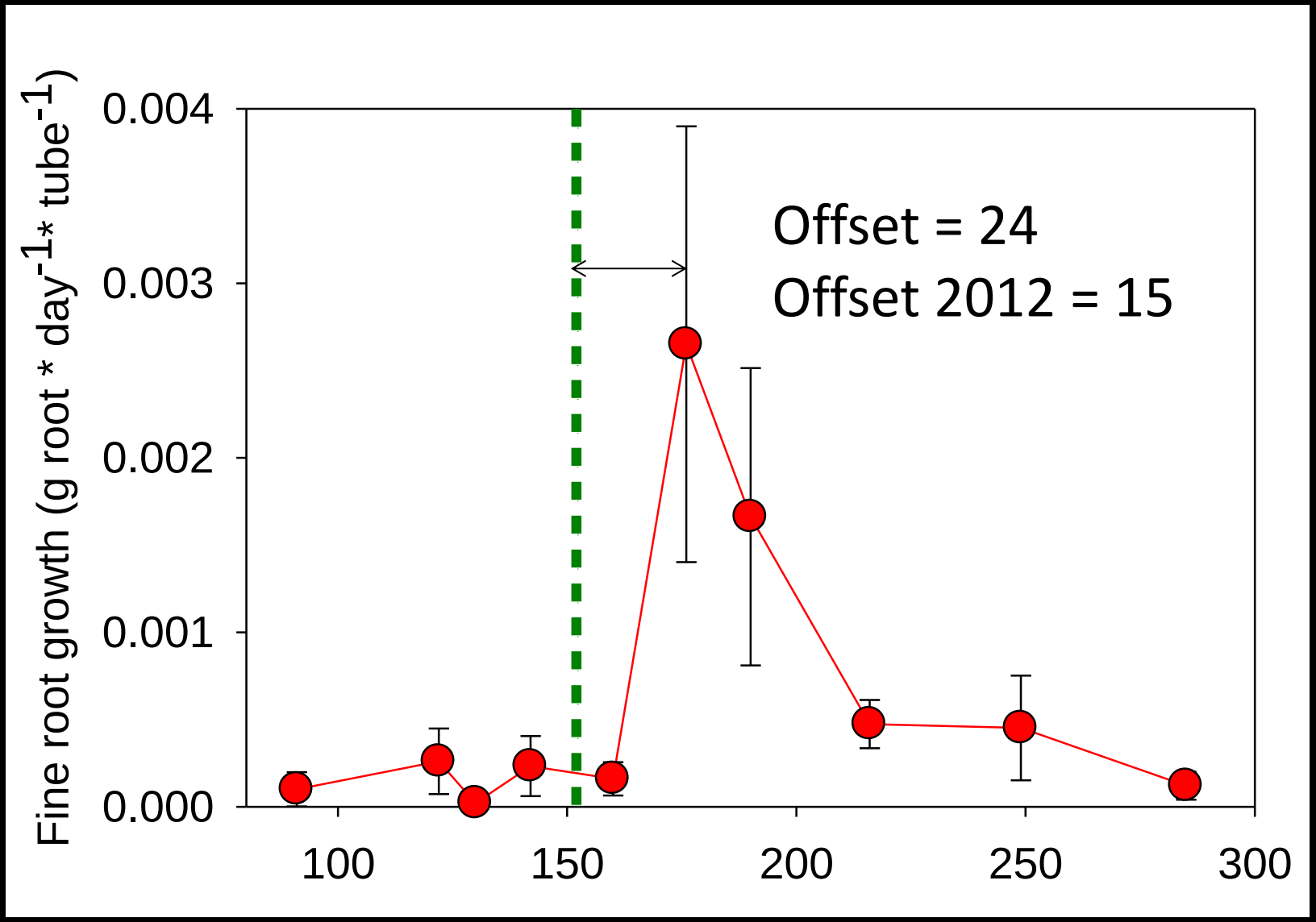
Species	AM/EM	Deciduous/Evergreen
White ash (*Fraxinus americana)*	AM	Deciduous
Red oak *(Quercus rubra)*	EM	Deciduous
Eastern hemlock *(Tsuga canadensis)*	EM	Evergreen

Root Growth/Mortality

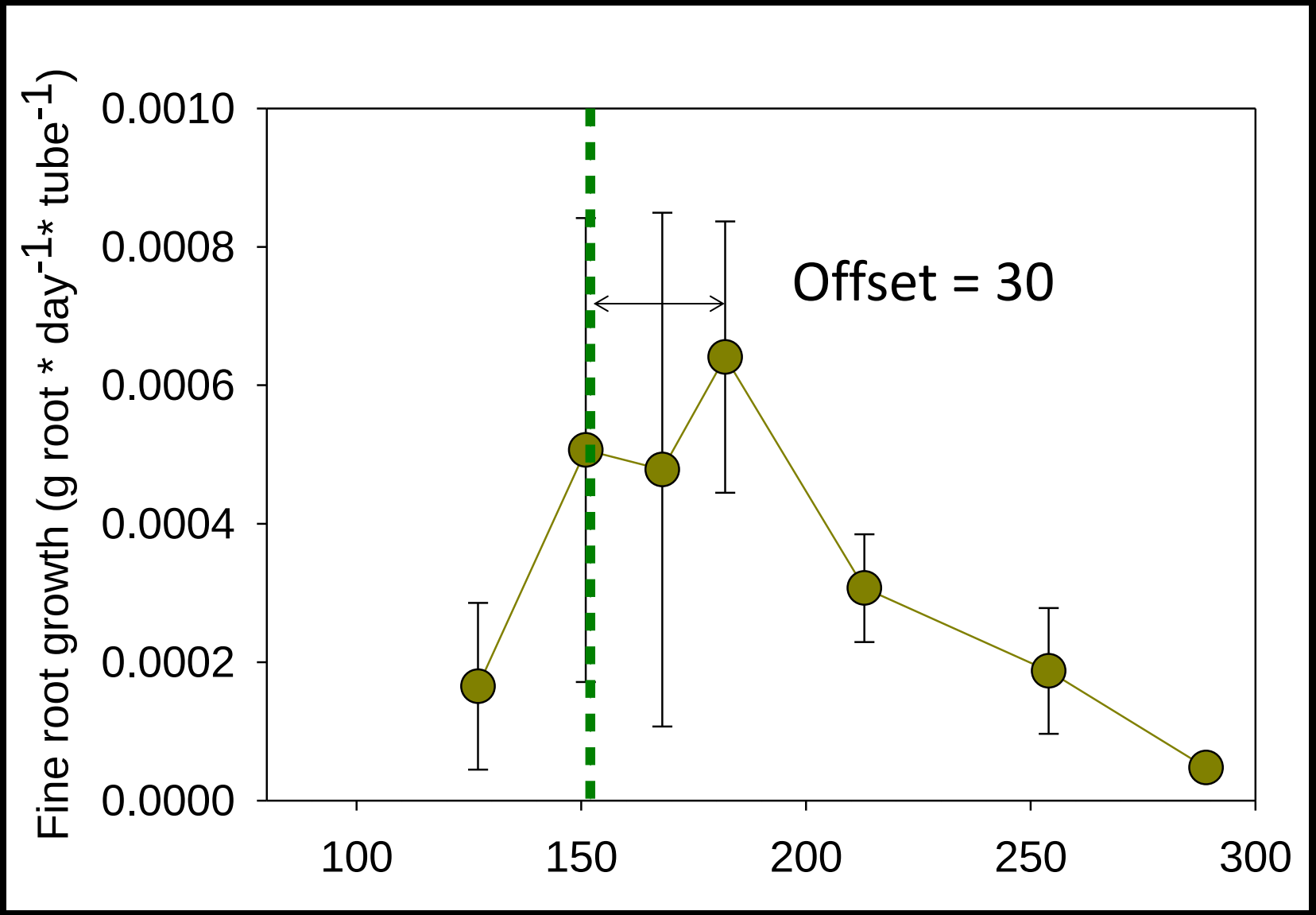
Red oak root growth



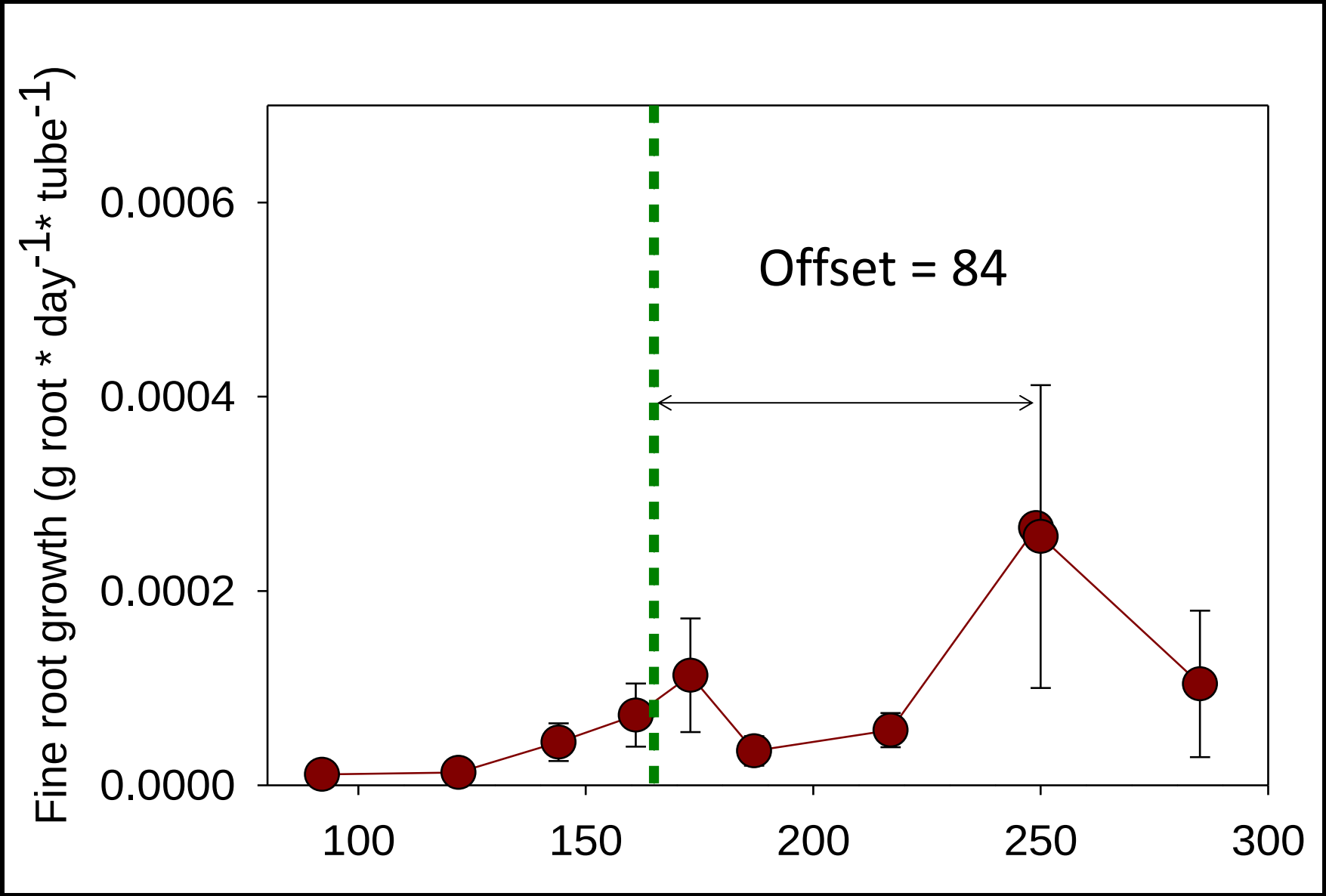
Red oak root growth



White ash root growth



Eastern hemlock root growth



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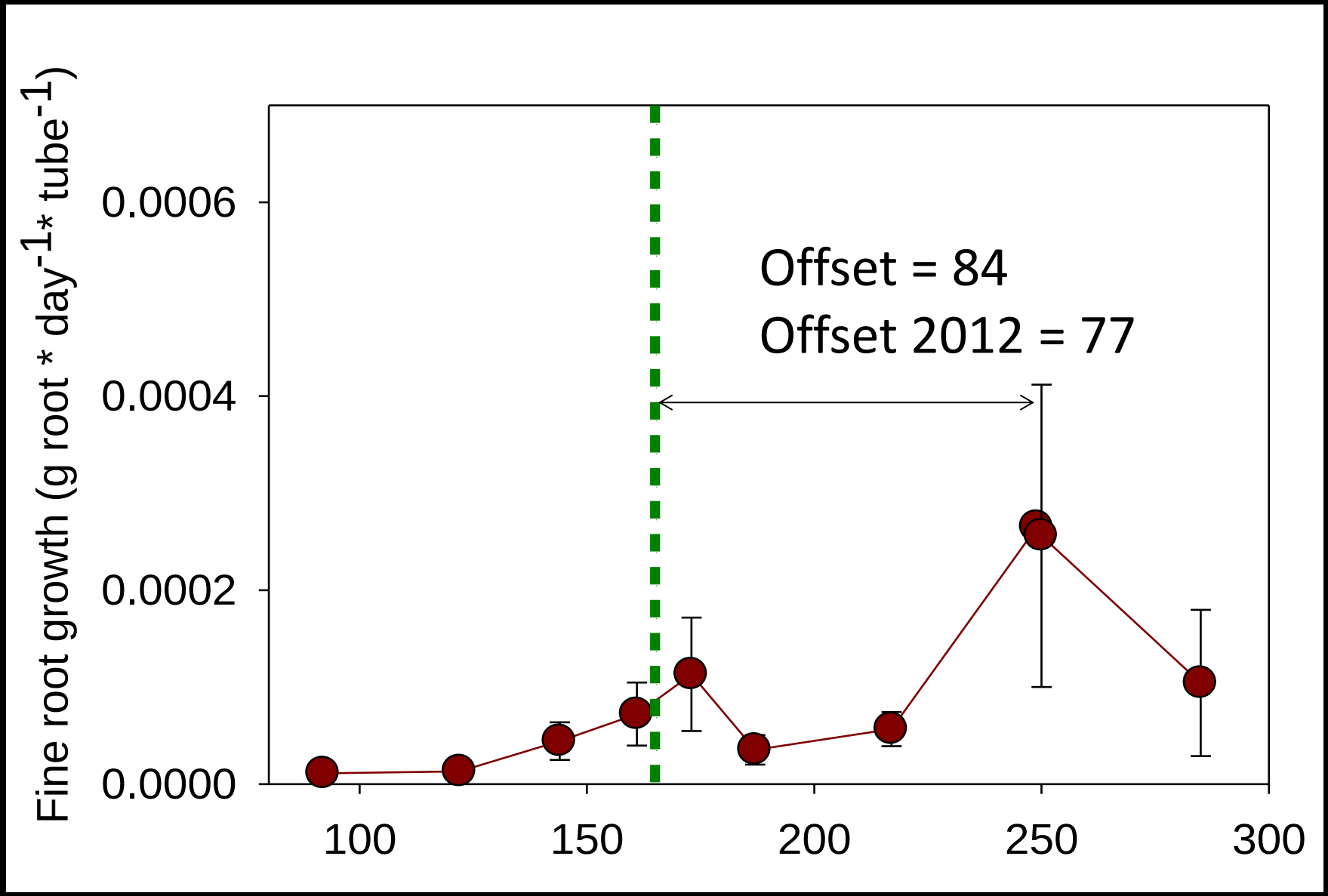
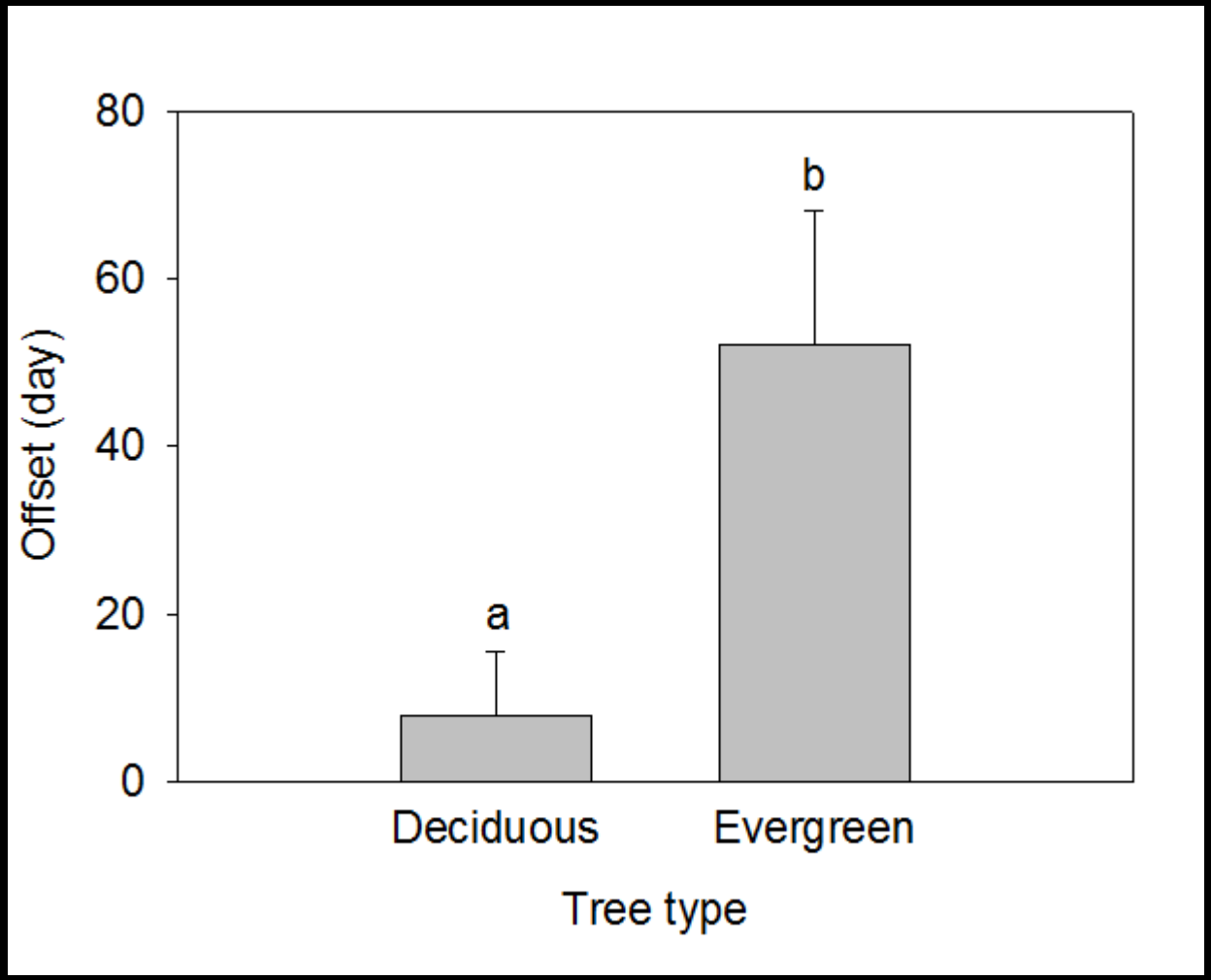
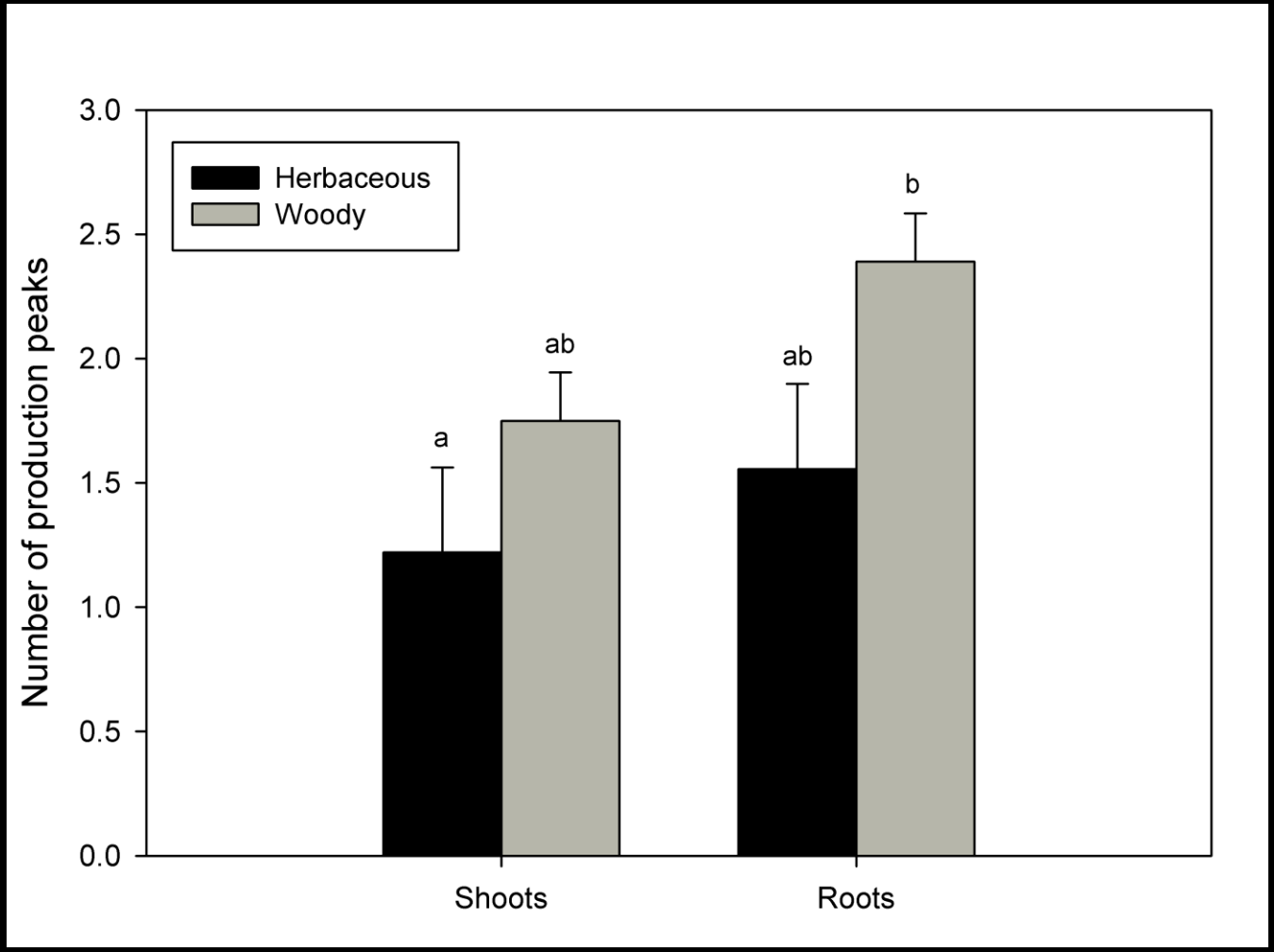


Evergreen vs Deciduous



Herbaceous vs Woody
Root vs Shoot



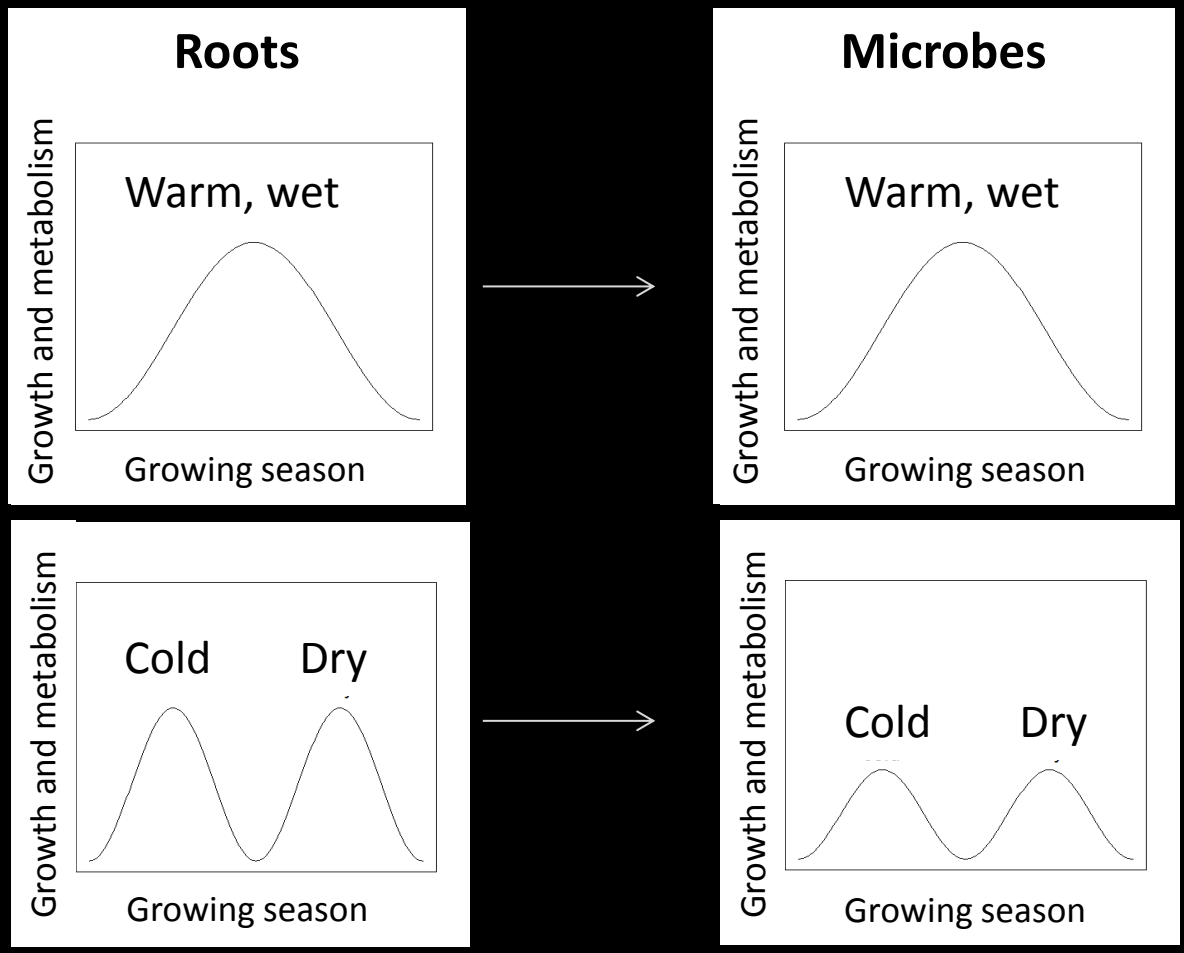
Conclusions

- Root and shoot growth are often asynchronous

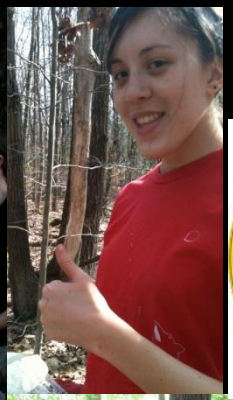
- Environmental drivers:
  - Temperate
  - Precipitation
  - *Nutrient availability*

- Endogenous drivers:
  - Biome
  - Growth form

Phenology feeds back into the C cycle



Acknowledgements



Abramoff, R.A., Finzi, A.C. Are above and belowground phenology in sync? *(in revision at New Phytologist)*

Migliavacca, Mirco, et al. "Using digital repeat photography and eddy covariance data to model grassland phenology and photosynthetic CO2 uptake." Agricultural and forest meteorology 151.10 (2011): 1325-1337.

Richardson, A. D., Braswell, B.H, Friedl, M.A, Hollinger D.Y., Ollinger S.V., Milliman T. 2012. PhenoCam. URL:phenocam.sr.unh.edu/webcam/