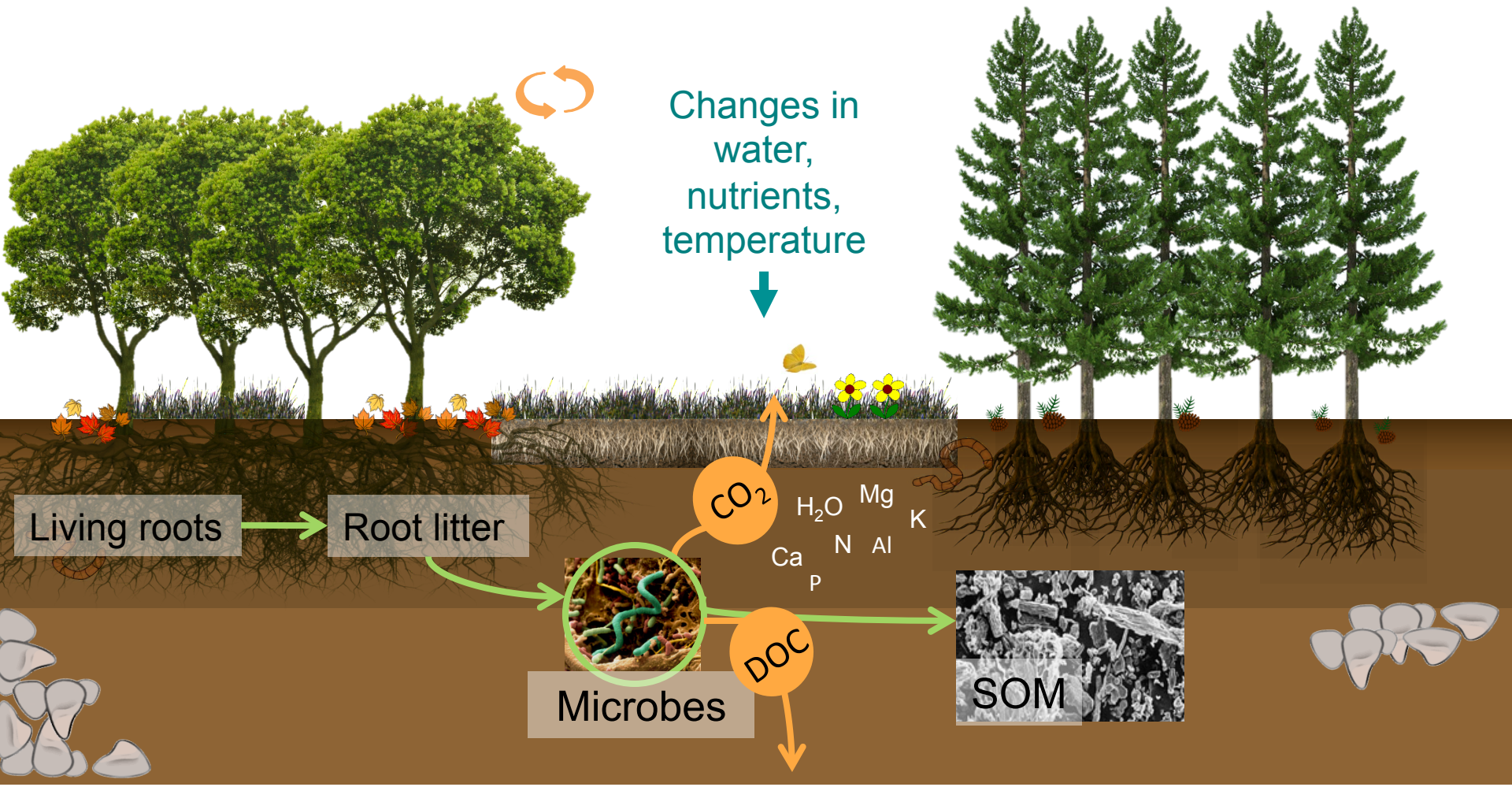
Irrigation alters the "C age" but not the physiological age of fine roots

Emily F. Solly*, Ivano Brunner*, Claude Herzog*,
Ingo Schöning**, Marion Schrumpf**,
Fritz H. Schweigruber*, Susan E. Trumbore**, Frank Hagedorn*

* Swiss Federal Research Institute WSL, Birmensdorf, Switzerland (emily.solly@wsl.ch)
**Max Planck Institute for Biogeochemistry, Jena, Germany

Introduction



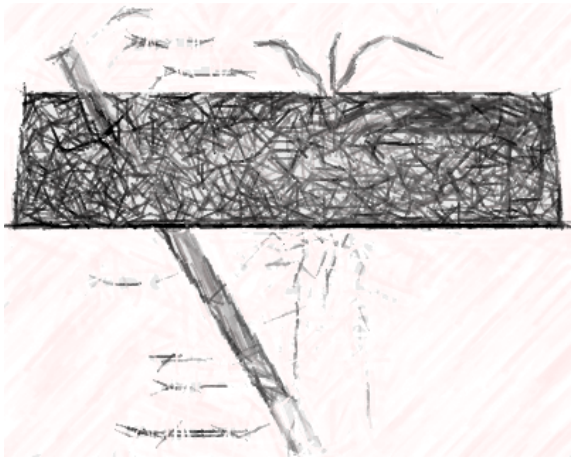
Estimating fine root turnover times is crucial to quantify their contribution to the annual net primary production and inputs to the soil

(Rasse et al. Plant & Soil 2005, Schmidt et al. Nature 2010)

An ongoing debate

Quantifying root turnover times is one of the biggest challenges in soil ecology and one of the least understood aspects of the belowground C cycle

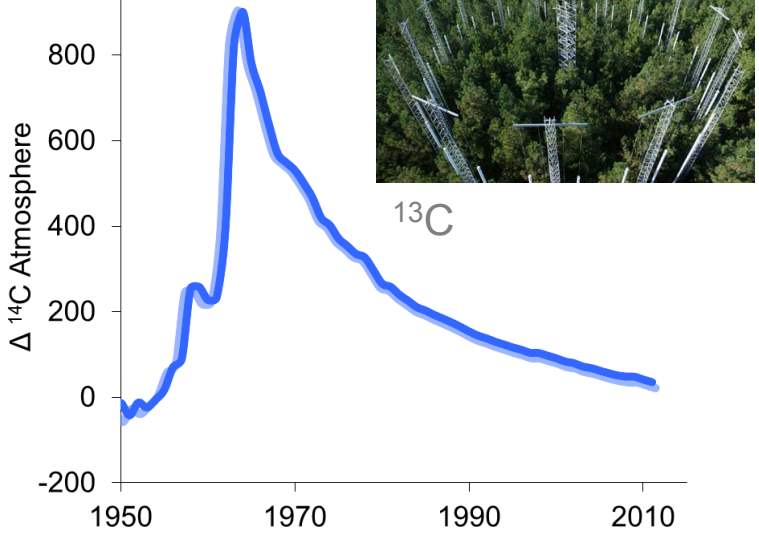
Months to few years



Minirhizotrons

Ingrowth cores

Several years



^{13}C

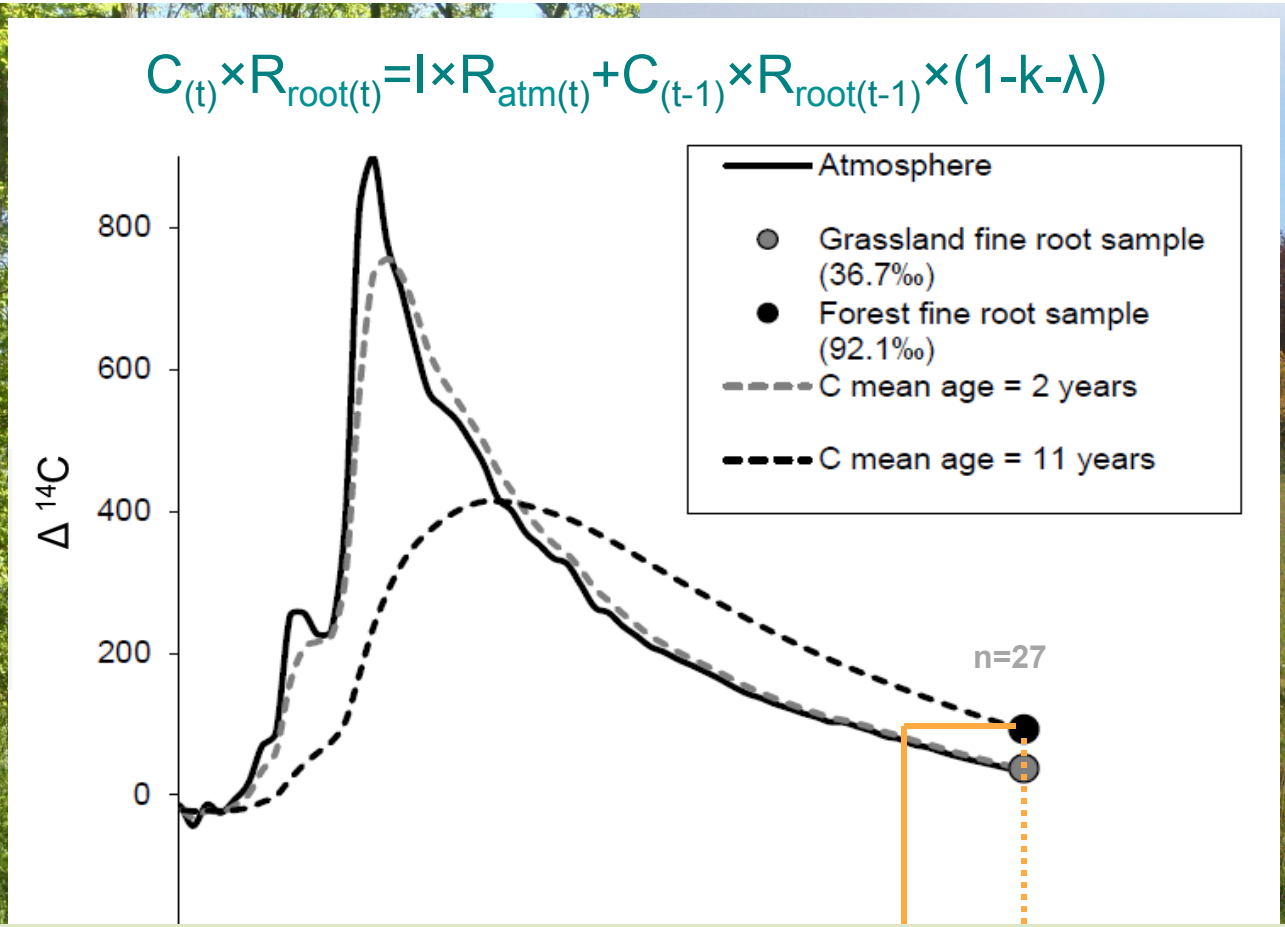
Radiocarbon (^{14}C)

Different methods yield very diverse pictures of fine root dynamics in forest ecosystems

(Matamala et al. Science 2003, Trumbore & Gaudinski Science 2003, Strand et al. Science 2008, Ahrens et al. NP 2014)

Root carbon ages

$$C_{(t)} \times R_{root(t)} = I \times R_{atm(t)} + C_{(t-1)} \times R_{root(t-1)} \times (1-k-\lambda)$$



-Higher contents of old structural root tissues in forests?

-Use of old storage compounds for tree root metabolism and growth?

Implications

Proc. Natl. Acad. Sci. USA
Vol. 94, pp. 7362–7366, July 1997
Ecology

A global budget for fine root biomass, surface area, and nutrient contents

R. B. JACKSON*, H. A. MOONEY†, AND E.-D. SCHULZE‡

*Department of Botany, University of Texas at Austin, Austin, TX 78713; †Department of Biological Sciences, Stanford University, Stanford, CA 94305; and ‡Lehrstuhl Pflanzenökologie, Universität Bayreuth, Postfach 101251, D-95440, Bayreuth, Germany

Contributed by H. A. Mooney, May 9, 1997

Root production/Ro

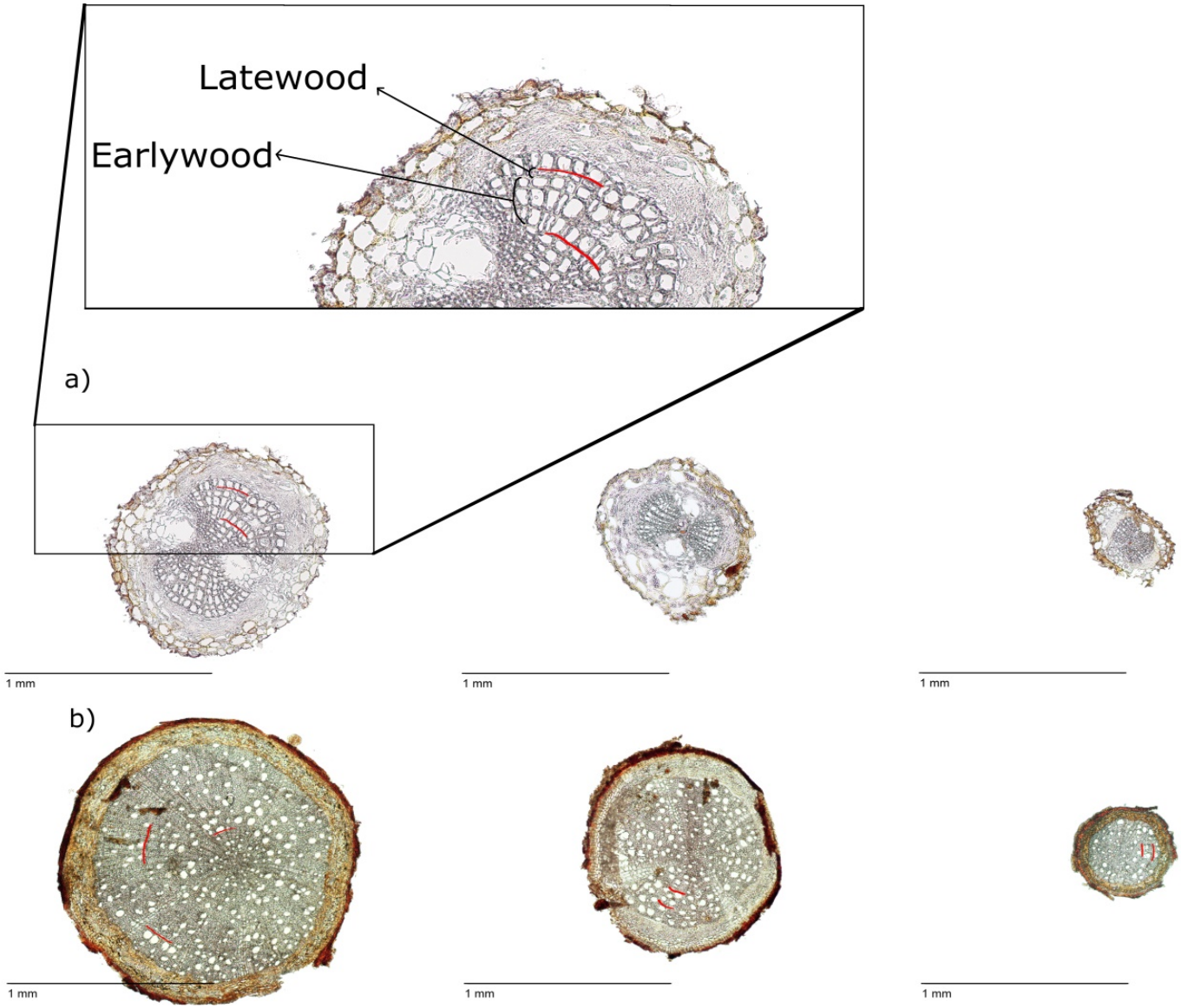
Globally, fine roots have been estimated to comprise 33% of NPP assuming fine roots live and die in 1 year.

Whether fine roots live and persist in the soil environment for a decade or less than 1 year, drastically alters NPP estimates

What about the effects of changes in water, temperature and nutrient conditions?

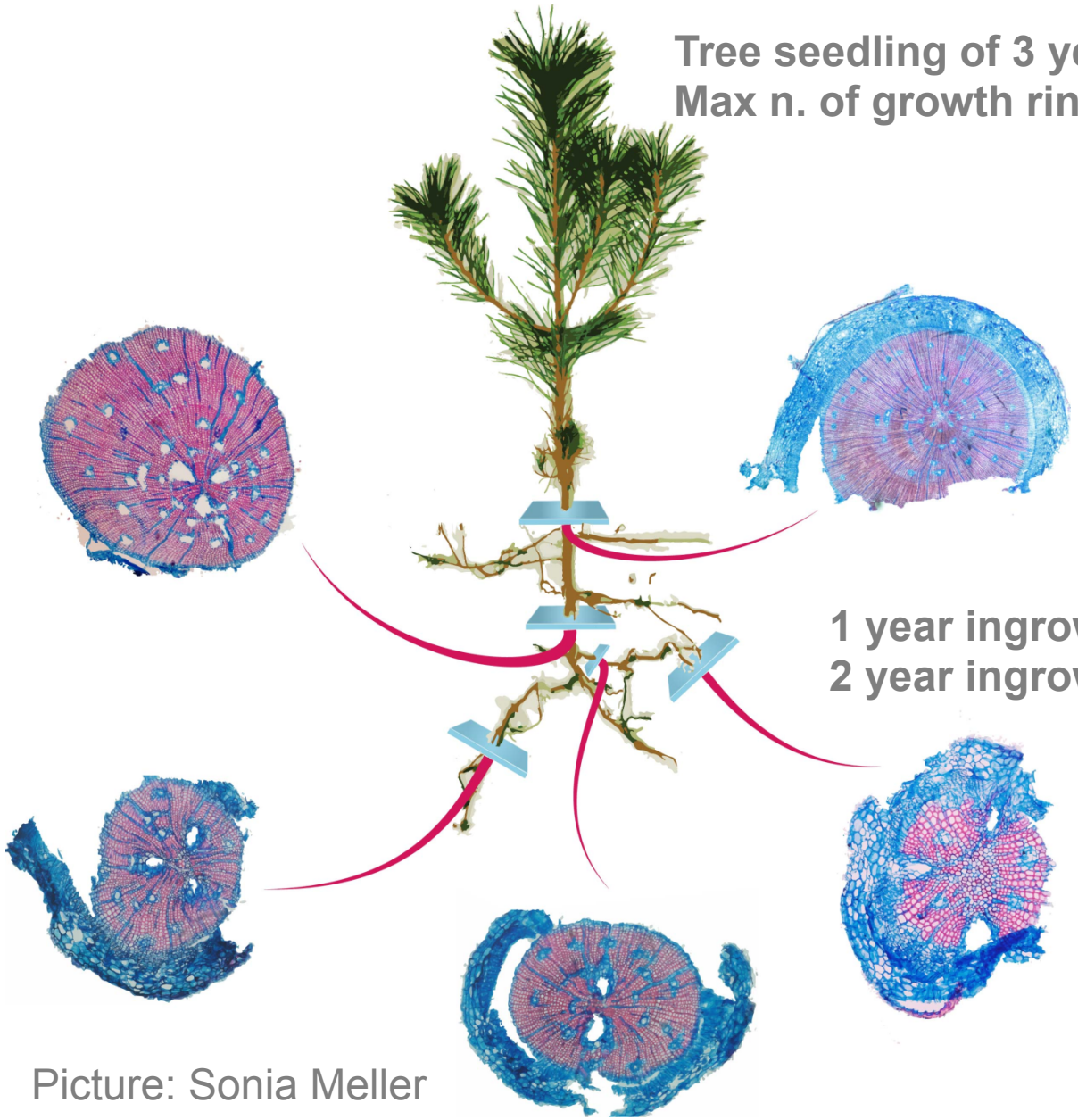
There is a large uncertainty in our current understanding of belowground C allocation!

New method to study the age of tree fine roots



Yearly growth rings in the secondary xylem of fine roots

Fine root growth rings

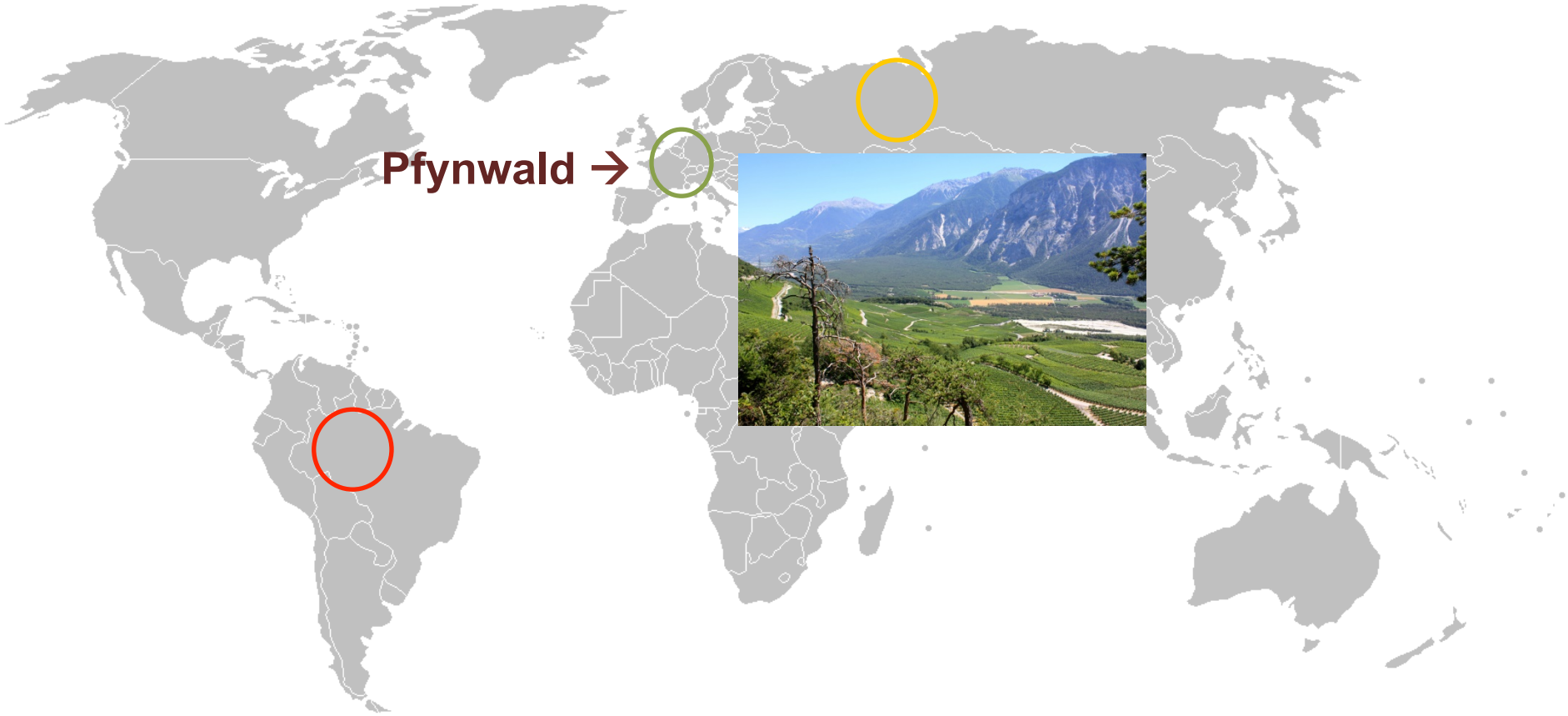


Tree seedling of 3 years
Max n. of growth rings = 3

1 year ingrowth core = max 1 growth ring
2 year ingrowth core = max 2 growth rings

Picture: Sonia Meller

Study sites

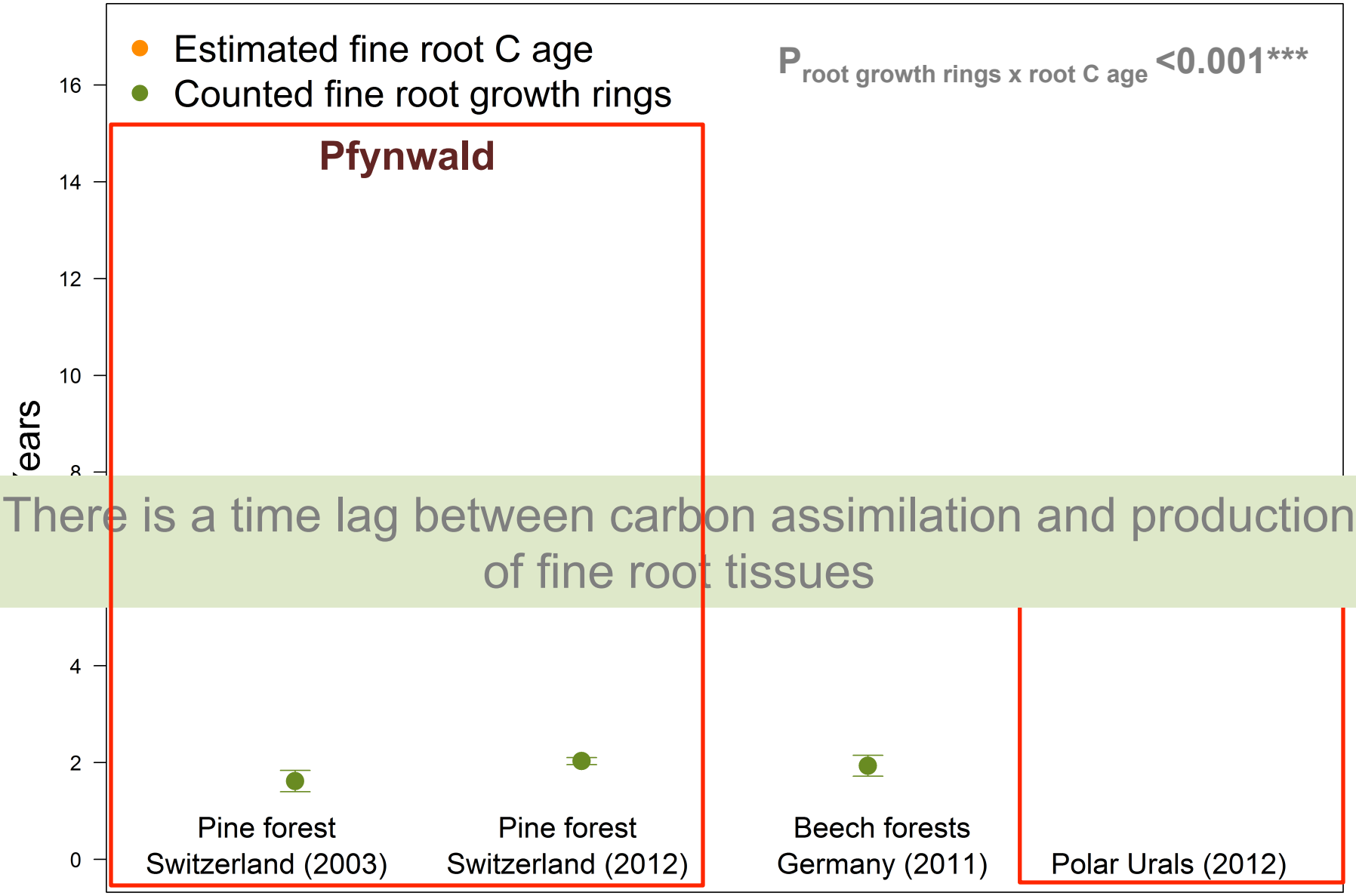


Selection of forests with different water and nutrient limitations

7 forest in Germany
3 forests in Switzerland
2 sites in the Ural mountains
1 forest in Brazil

… 430 root sections of different diameters

Root ring ages vs root C ages

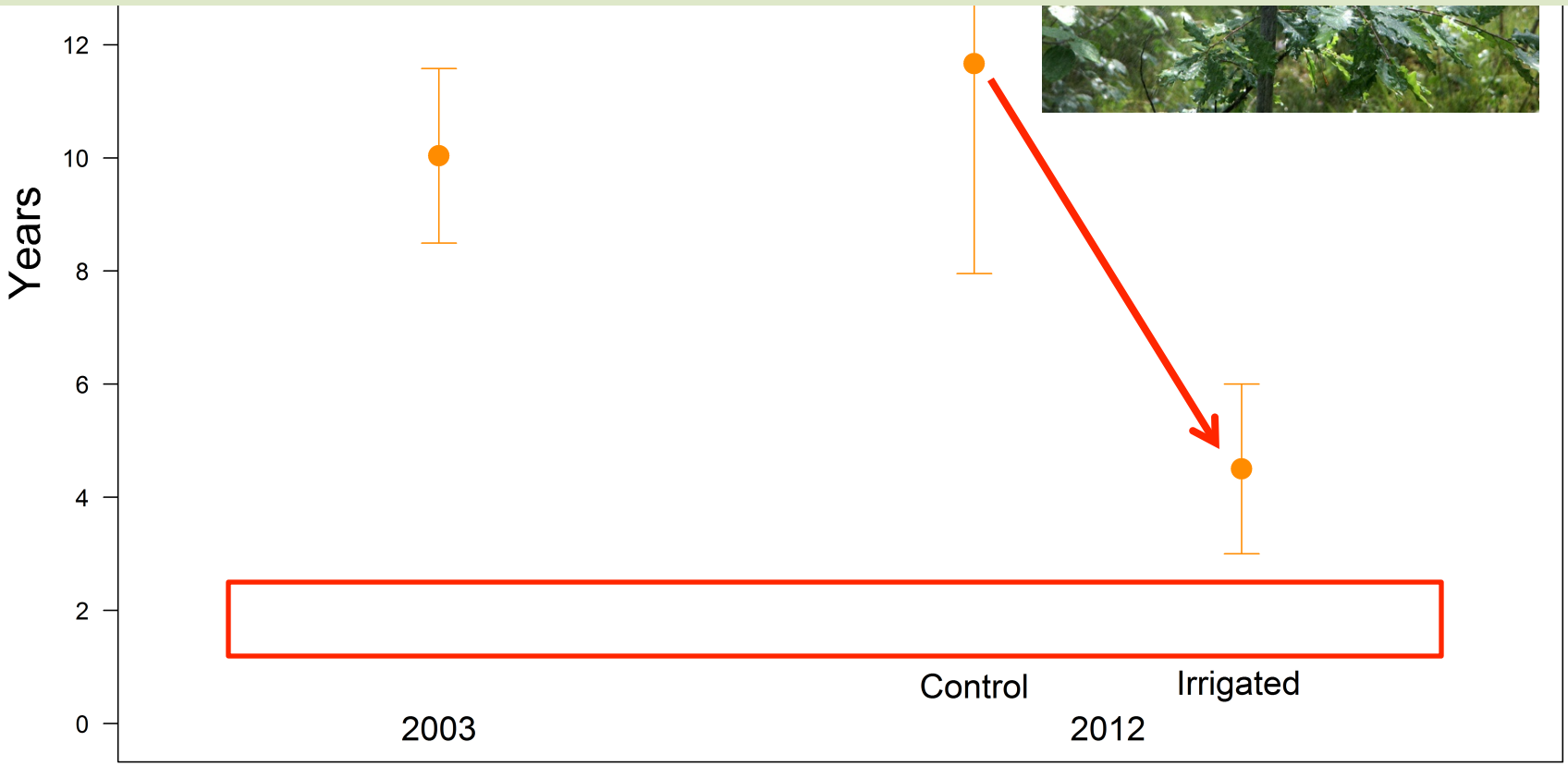


There is a time lag between carbon assimilation and production of fine root tissues

Irrigation alters the C age but not the physiological age of fine roots

In the Pfynwald, drought affected trees invest a considerable amount of energy in the process of root turnover

Irrigation partly releases plant growth limitations resulting in the higher consumption of newly formed photosynthates to produce roots



Herzog et al Plos One 2014

Conclusions

- Counting root growth rings in the secondary xylem is a good method to study root turnover

- There can be time lags between carbon assimilation and production of fine root tissues likely due to the storage of carbon components in trees
  → **Drought, temperature and nutrient limitations**

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- Irrigation partly releases plant growth limitations resulting in the higher consumption of newly formed photosynthates to produce roots

Outlook → **Comparison of root ring ages and carbon ages in tropical and polar ecosystems**

Joint modelling of the data (C and physiological ages) (Bernhard Ahrens, MPI BGC)


Thank you!
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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY