Tackling climate change: the contribution of forest scientific knowledge , Tours (France), 21/05/2012

Johann Heinrich von Thünen-Institut

Drought-adaptive potential of central and marginal provenances of European beech

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Outline

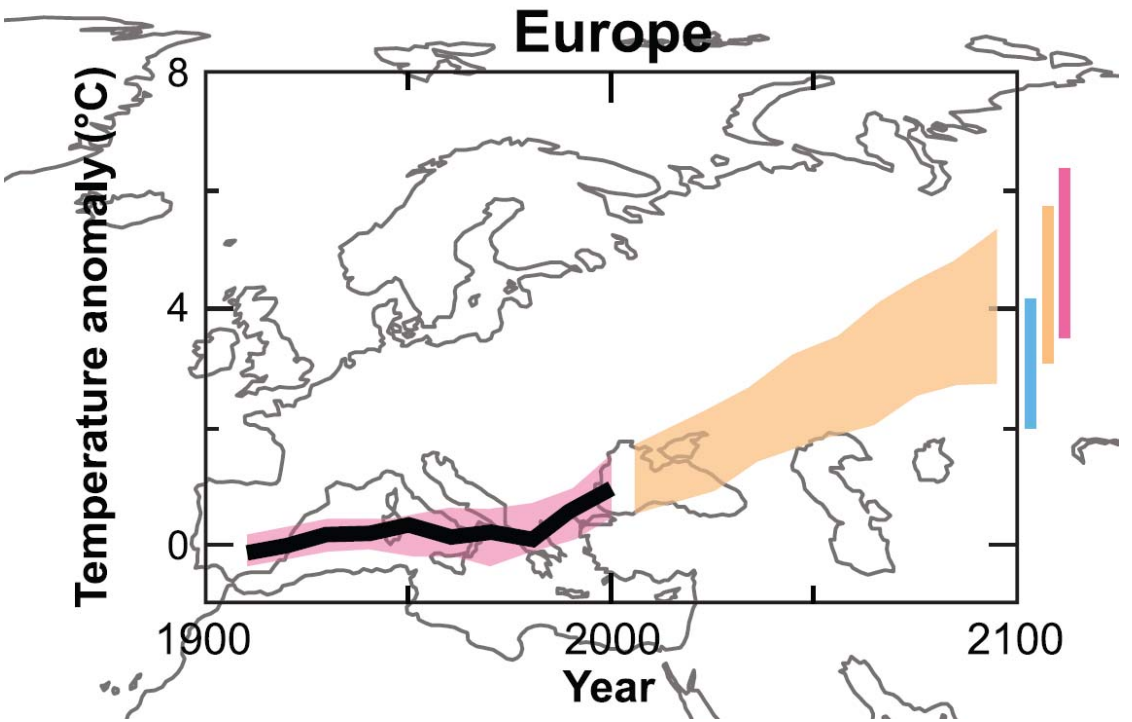
- Climate change - migration and adaptation processes in forest trees
- Critical drought limits and adaptation potentials of European beech
- Conclusions and outlook

Climate change - migration and adaptation processes in forest trees

Climate change

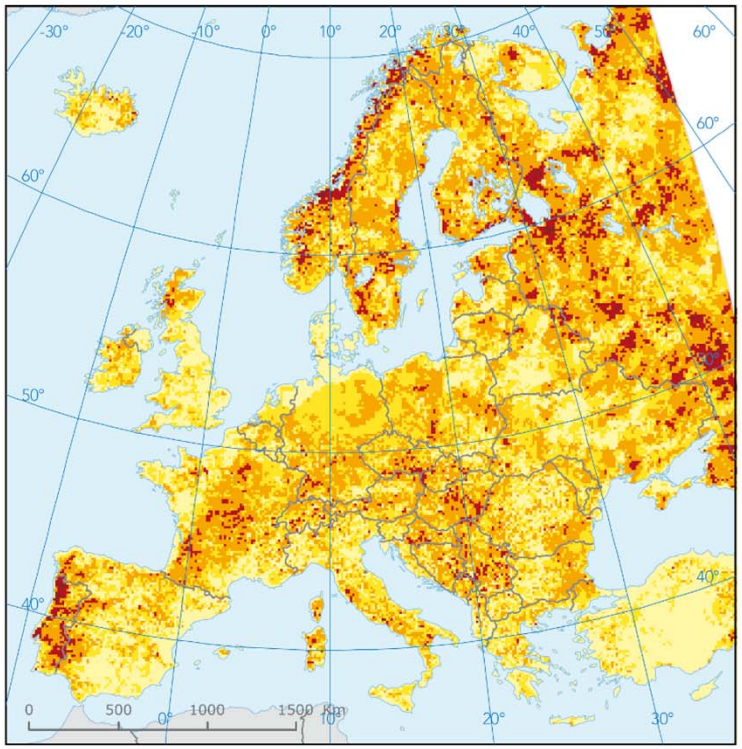
Projections Europe 2100 (*IPCC, 2007)*:

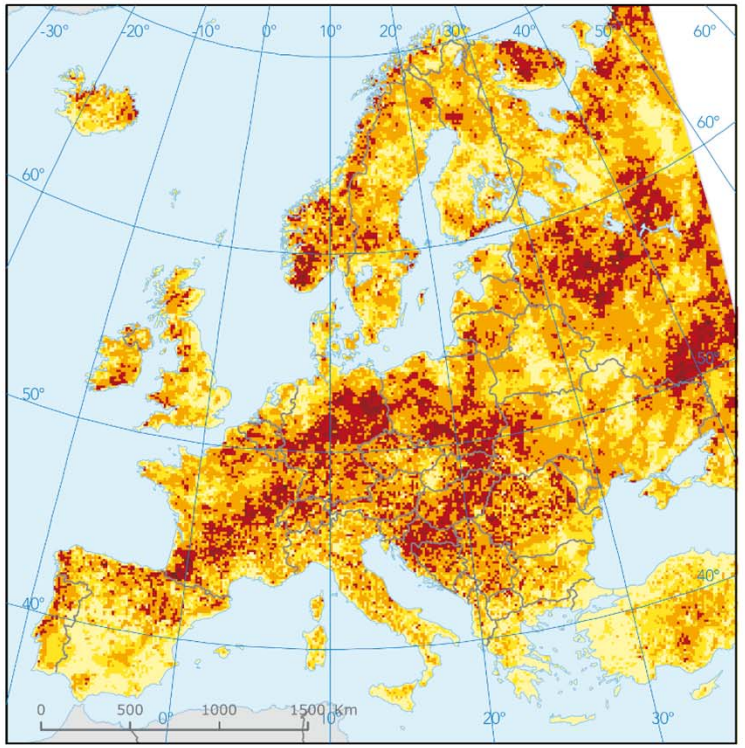
- **Temperature: +2.0°C to +6.2°C (min. SRES B2 to max. A2 scenario)**
- **More extremes: more frequent and intensive <u>heat waves</u> and <u>droughts</u> <u>(Mediterranean area, central Europe)</u>, more storm events (N-Europe)**



Source:
IPCC., *2007*
(4tf Assessment IPCC report)

Projections of heat waves





Heat wave frequency for the periods 1961–1990 (left) and 2071–2100 (right)
Based on the IPCC-SRES A2 emission scenario and the DMI climate model

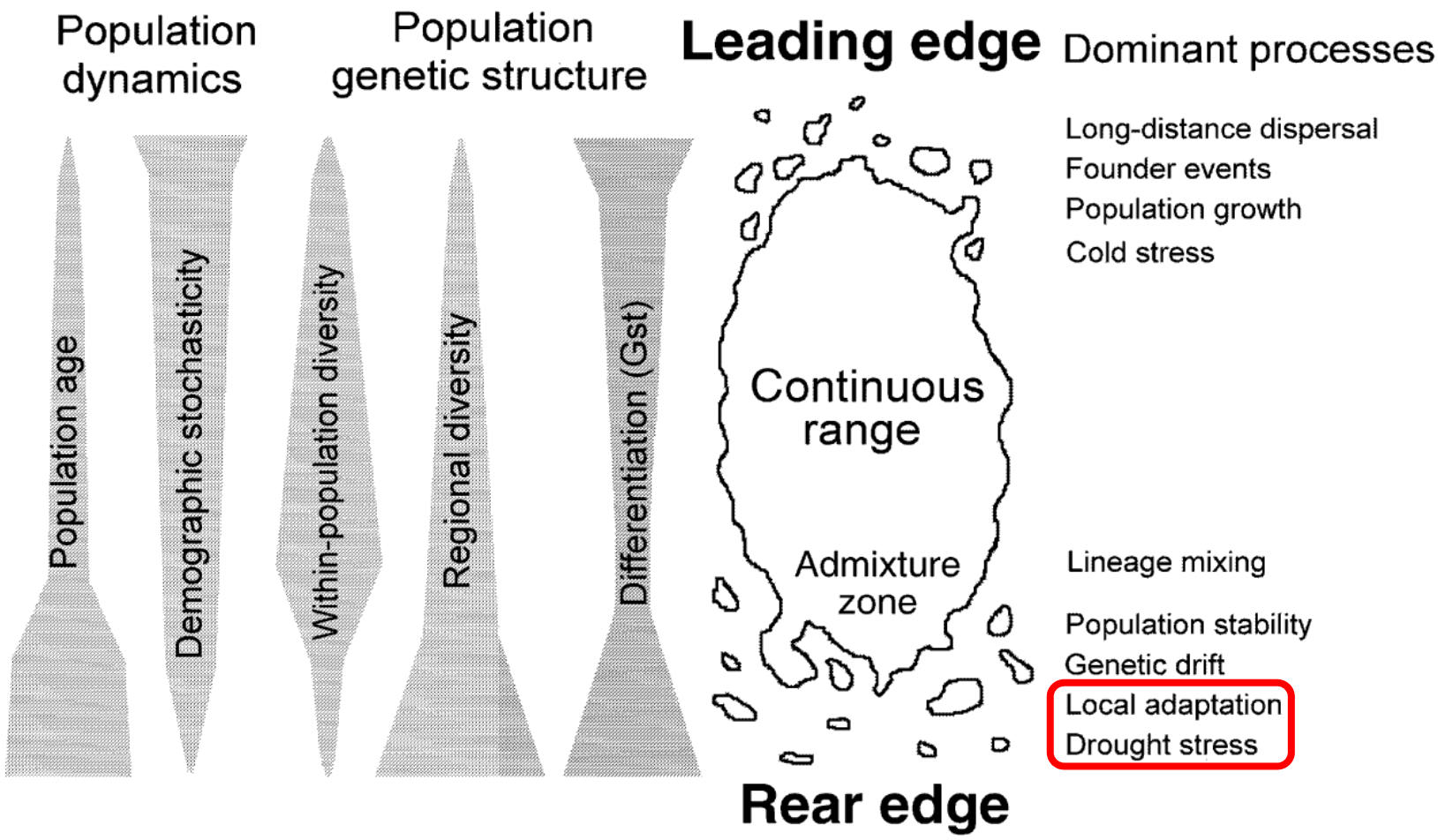
< 1 | 1 | 2–3 | 4–5 | 6–7 | 8–9 | ≥ 10 | Outside report coverage

Note: The A2 baseline scenario in combination with the Danish regional climate model.

Source: Indicator elaboration: R. Hiederer, European Commission DG Joint Research Centre, Institute for Environment and Sustainability, 2007.
Data: PRUDENCE Project 12km HIRHAM4, Danish Climate Centre, 2006.

Source: *EEA, 2008*

Migration processes



Source: *Hampe and Petit, 2005*

Adaptation processes in forest trees

(1) Long-term evolutionary adaptation

- over one or more generations
- due to selection processes

(2) Phenotypic plasticity

- ensuring short-term persistence of several years or a decade
- due to individual alternation of plant morphology and/or physiology

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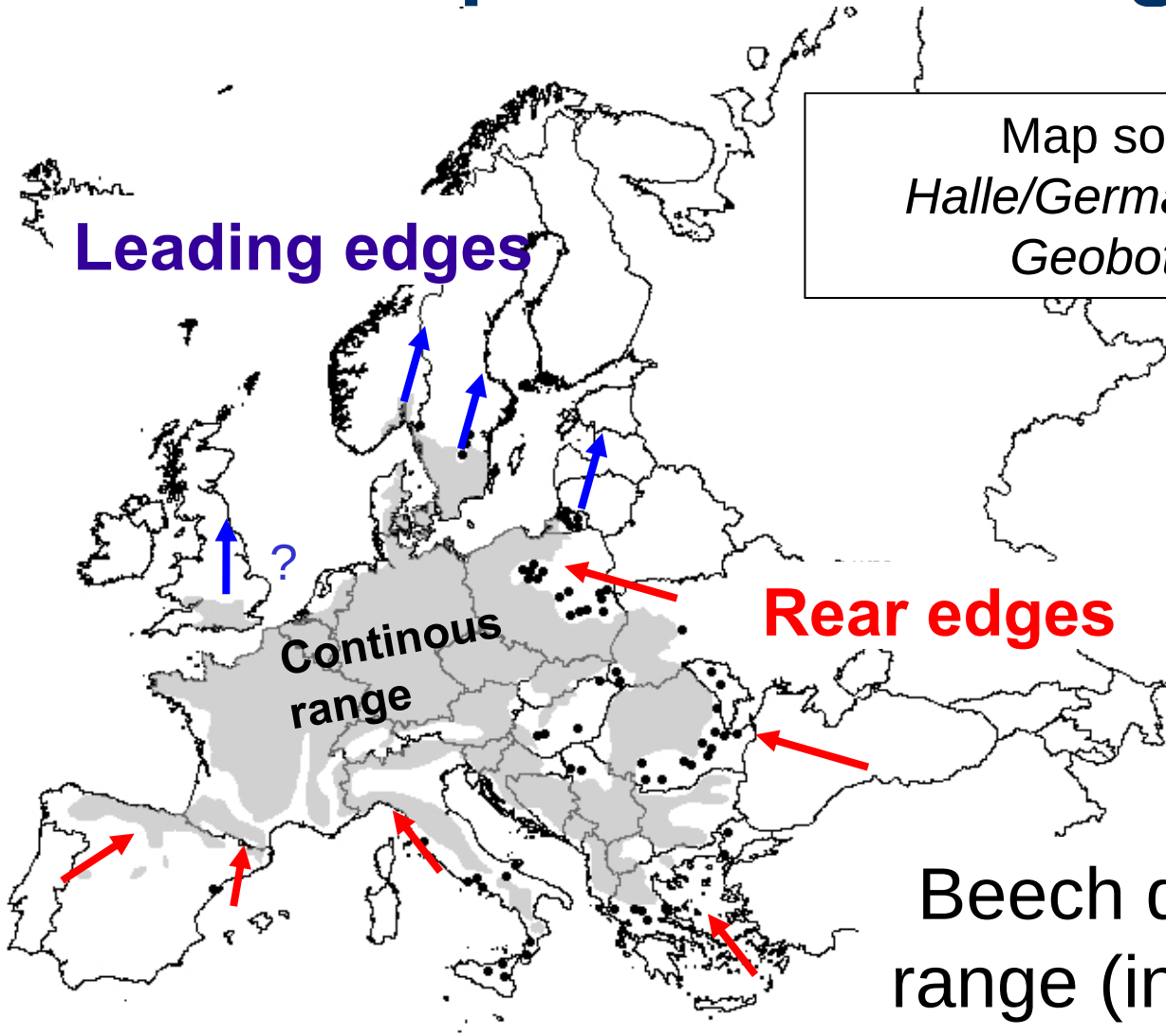
European beech range



Map source: *Univ. Halle/Germany, Institute of Geobotany, 2006*

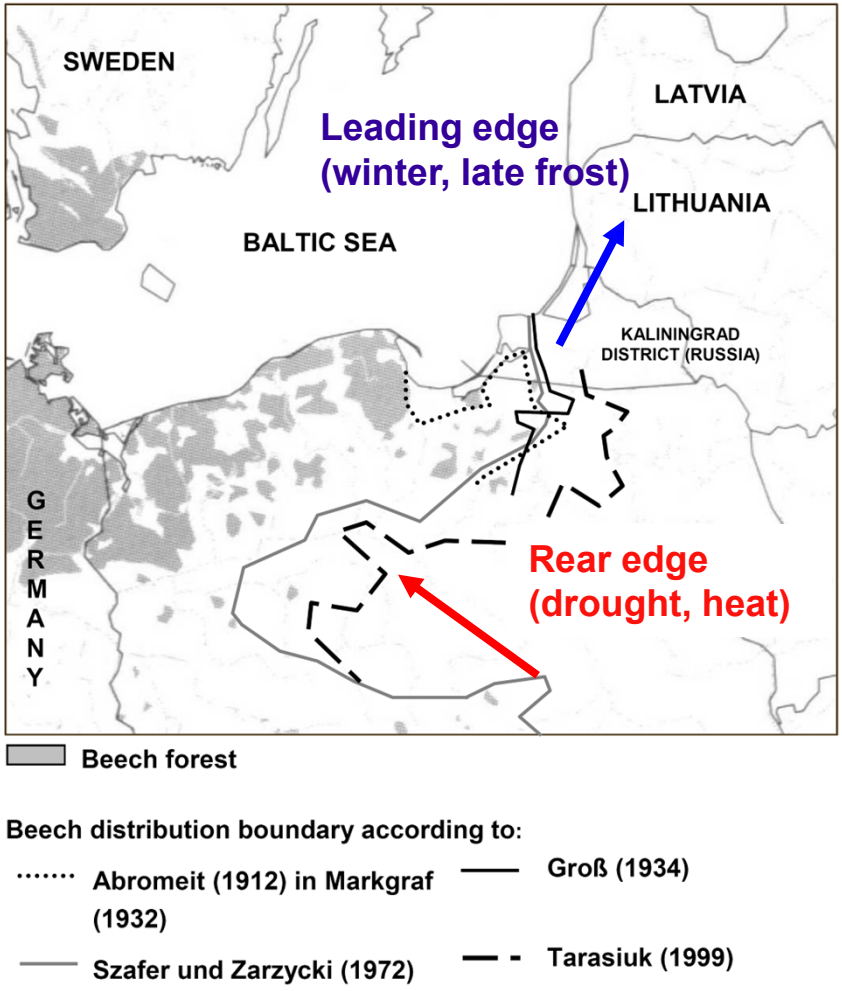
Beech distribution range (incl. isolated occurrence)

Source: *Bolte et al.,, 2007 (completed)*

Critical drought limits and adaptation potentials of European beech

North-eastern distribution range

- Contradictory opinions about the NE beech range margins (‘rear edge’)
- Different (micro)-site conditions?
- Different adaptation status of beech?
- Contraction of beech range due to climate change?



Source: *Bolte et al. 2007* (completed)

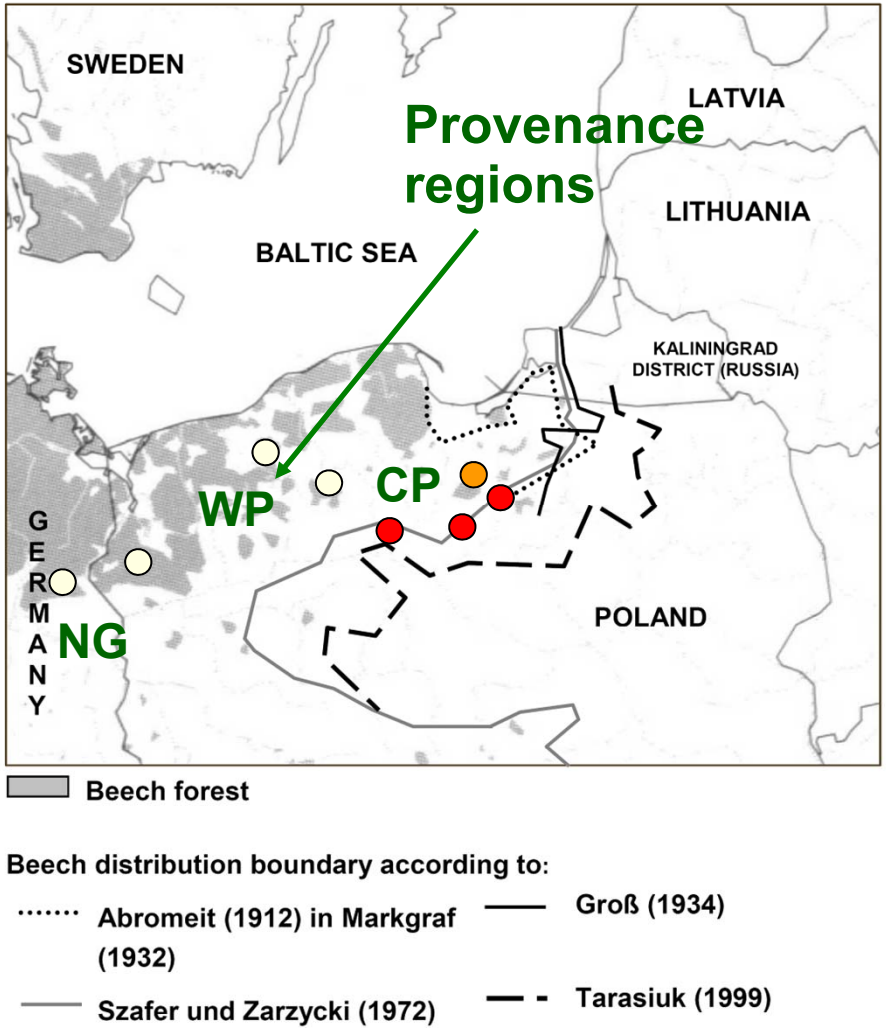
Studies on adaptive potentials

Field studies (beech 2-7 yrs)

- Plant water status = pre dawn potential in summer 2003
- Rel. plant growth 2003, 2004
- Overstorey competition = below canopy irradiance (hemispherical photos)

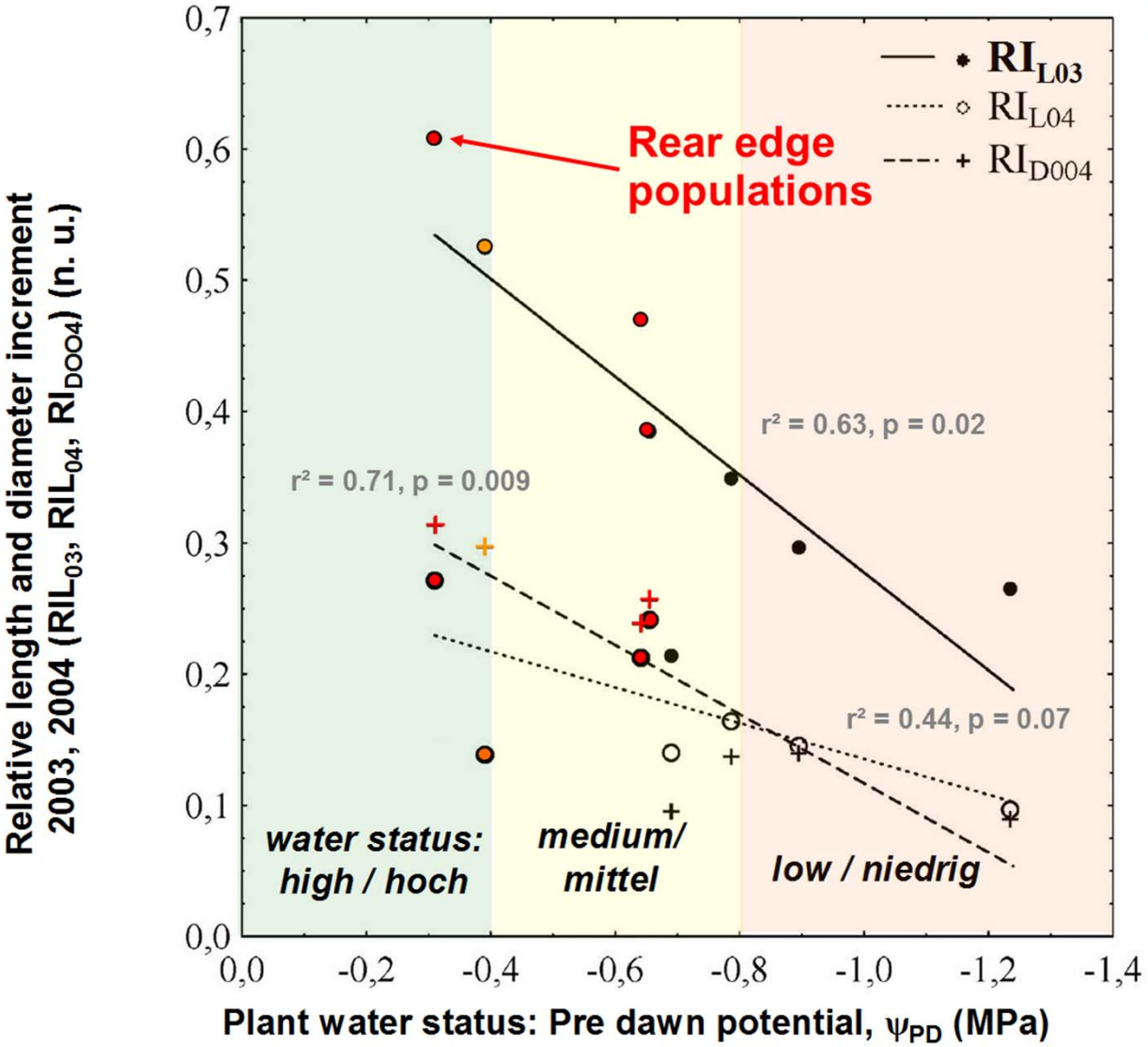
Lab studies (beech 2-3 yrs)

- Different regional provenances
- Drought simulation 2004, 2005
- Drought effect = soil water content
- Plant response (evapotranspiration, plant water status = pre dawn water potential, δ13C isotope signature of buds, plant growth)



Source: *Bolte et al. 2007* (completed)

Field studies – results on growth performance

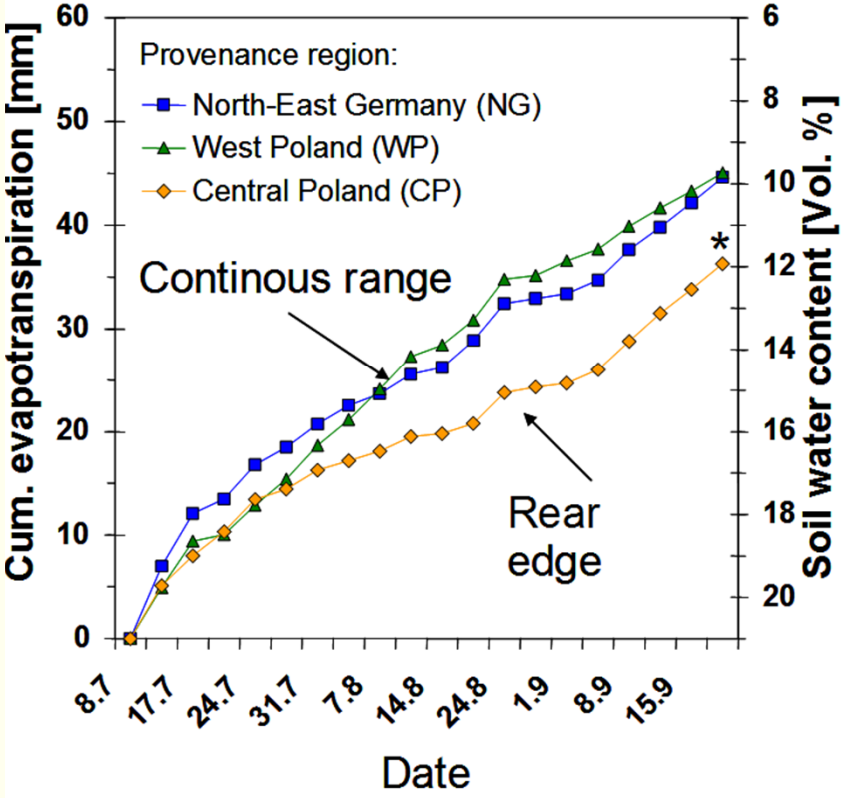


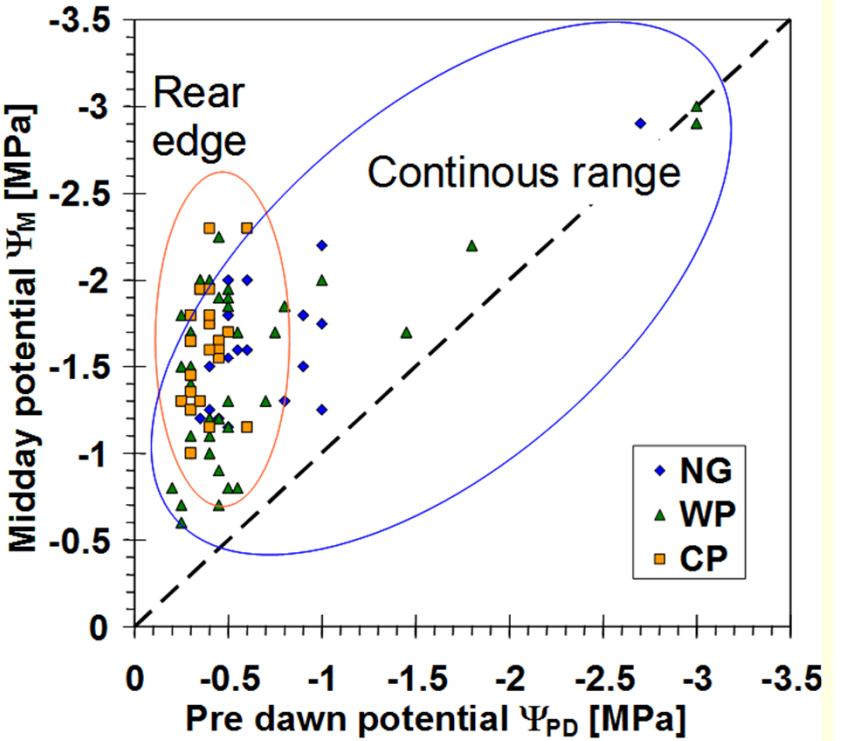
Source: *Czajkowski et al.* 2005

Evolutionary drought adaptation of beech (simulation 2004)



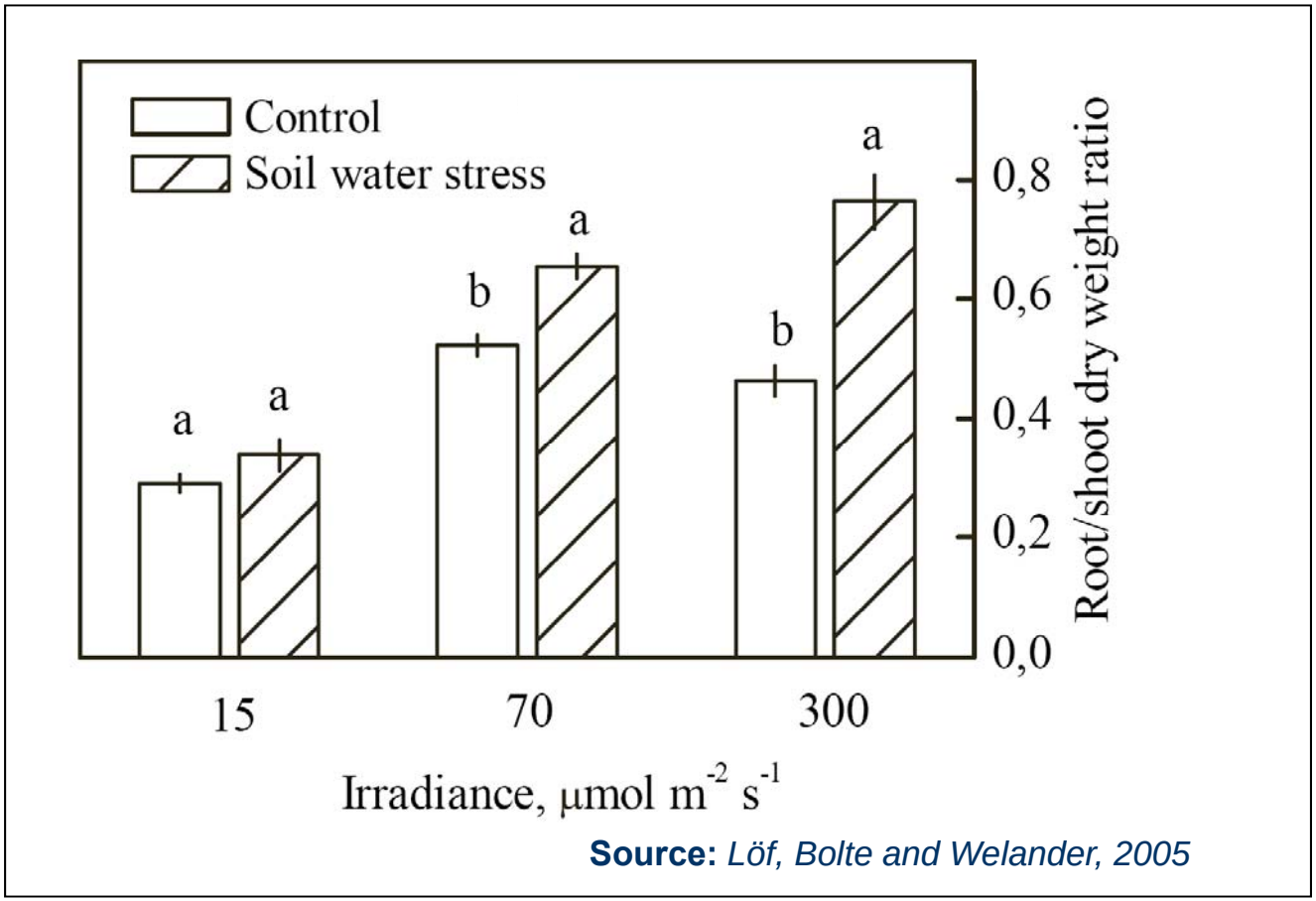
Pre-info: No significant differences in diameter/length increment!





Source: *Czajkowski and Bolte, 2006*

Root:shoot ratio and drought



Source: *Löf, Bolte and Welander, 2005*

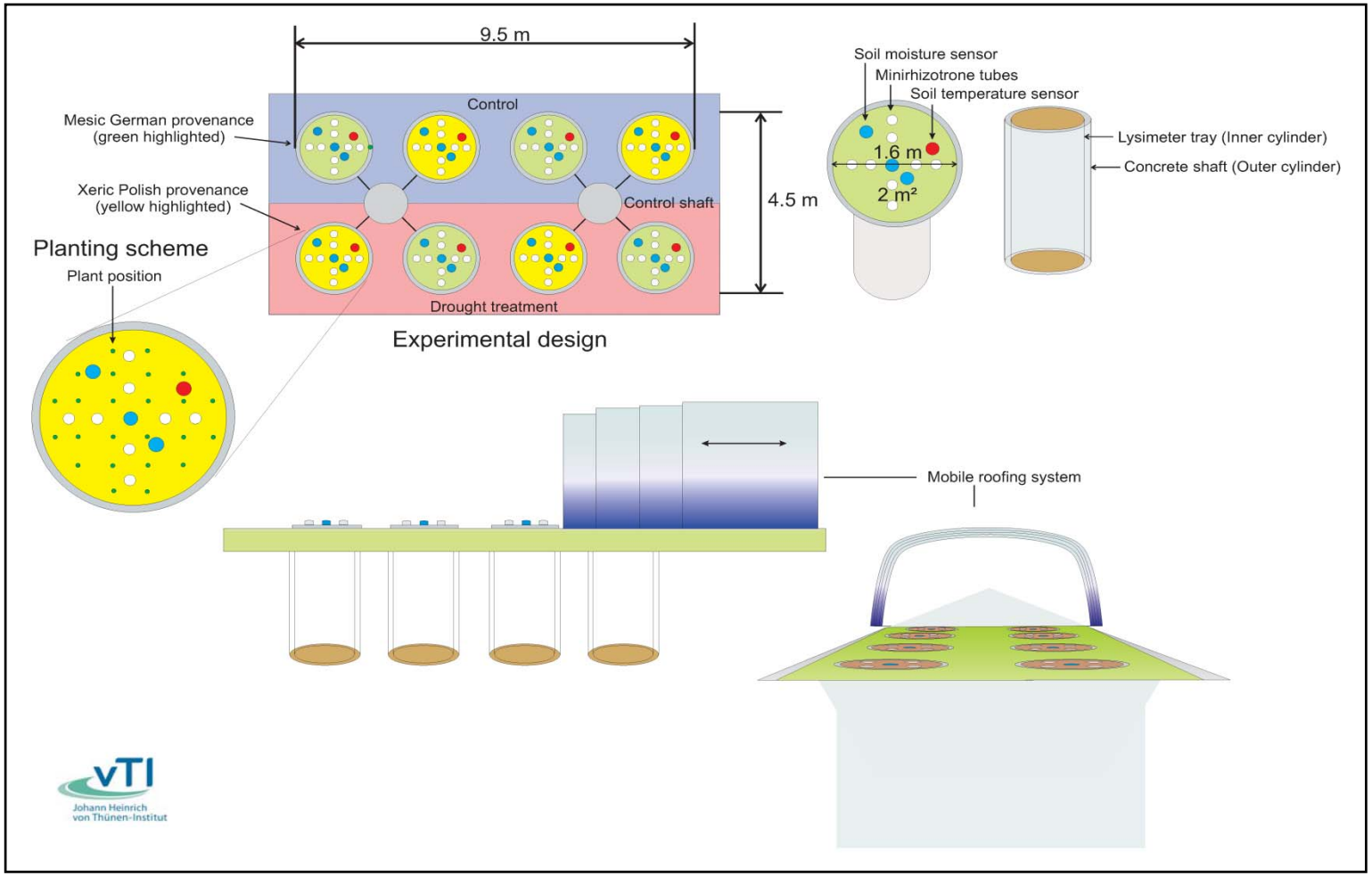
… however, no significant differences in R:S ratio between provenances from the rear edge and the continuous range

Conclusions and outlook

Conclusions and outlook

- The adaptation of beech to climate change varies between different provenances ("beech is merely not like beech!").
- Rear edge populations/provenances exhibit a higher adaptation to drought events than those within the range; however, adaptive potential can be found also within the continuous range.
- Adaptation seems to be more related to a sensitive stomatal control than to the development of higher root biomass (?)
- More research is urgently needed about the:
  - role of root systems in adaptation processes
  - genetic regulation of adaptation (link to ecophysiology)
  - potentials of evolutionary adaptation (more provenances)

New research facility ‚drylab‘



Source: Müller and Bolte, 2009 (modified)

Experiments provenances *Sellhorn* and *Jamy*

- **Simulation of drought 2012 and 2014:**
  Control: P mesic site *Sellhorn* + 20% = 433 mm from May to September
  Drought treatment: P xeric site Jamy -20% = 224 mm from May to September
- **No drought treatment in 2013** in order to detect carry-over drought effects
- **Assessments of drought impacts** (soil water content, matrix potential, xylem water potential) and **plant response** (plant performance, stomatal water conductance, fine root growth by MR technique, biomass partitioning)
- In addition: research cooperation planned with BayCEER (Bayreuth University, Carl Beierkuhnlein on all 11 provenances) and vTI-FG, Matthias Fladung on genetic control of drought adaptation)

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