Using Minirhizotron Technique for Modelling Fine Root Growth in Deep Drought Exposed Oak and Pine Forest Ecosystems

Martin Gutsch[1], Jan Haase[2], Felicitas Suckow[1], Petra Lasch[1], Franz-W.-Badeck, Bernd U. Schneider[2], Reinhardt Hüttl[2]

Background

Little experience is available in forest management concerning forest conversion from pure Scots pine stands to mixed Sessile oak-(*Quercus petraea* (Matt.) Liebl.) Scots pine (*Pinus sylvestris* L.) stands. One of the key factors for the resilience of such a mixed forest ecosystem under the given climatic conditions refers to the potential interspecific competition between root systems of pine and oak. Current research efforts are therefore aiming at analyzing of root distribution, rooting depth and root water uptake to estimate growth potentials under the combined impact of climate change and increasing atmospheric CO_2.

Methodology

The forest dynamics model 4C

The forest dynamics model 4C (Lasch et al. 2005) was used to analyse the carbon balance of forest stands under current climate and climate change scenarios. 4C simulates the water, carbon and nutrient budget in the forest ecosystem including soil as well as stand dynamics described i.e. by litter fall, height, mortality, regeneration and diameter growth depending on environmental conditions.

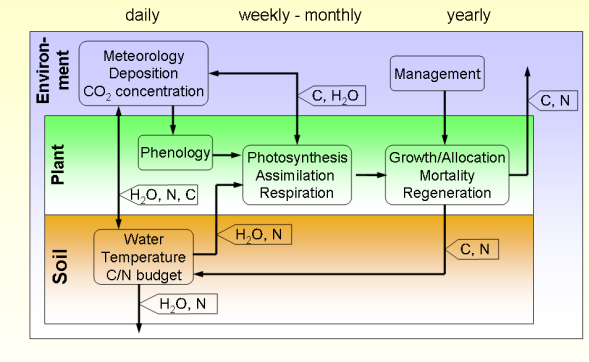

Fig. 1: *Scheme of the forest dynamics model 4C*

Model approaches in 4C for root distribution and growth

4C

static

- root distribution follows JACKSON et al. (1996)
- exponential root density profile

$$Y = 1 - \beta^d$$

Y...cumulative fraction of fine root biomass
β...ecosystem specific parameter
d...soil depth

- rooting depth fixed at 1.35 m

dynamic

- root distribution follows RASSE et al. (2002)
- root density profile depends on stress factors (temperature, soil strength, porosity, acidity)
- variable rooting depth depends on tree age and vertical growth velocity

Soil coring

Soil cores were extracted up to 3m soil depth from three different oak-pine mixed forest sites with different age classes of oak. Minirhizotron data will be gained for 2007 and 2008 from tubes which are built-in to a depth of 3m with an ankle of about 45°. They are installed under pure pine and pure oak tree groups as well as under mixed tree groups with both species.

Simulation experiment

- stand area: ca. 1 ha
- 3-year old monocultural oak stand
- 7500 trees/ha with an mean height of 48.4 cm
- soil: dry sandy Cambisol with medium nutrient supply
- simulation period = 50 years
- two simulation runs:
  1) with static root distribution and rooting depth fixed at 1.35 m
  2) with dynamic root distribution and rooting depth

Results

Due to the dynamic root growth approach the model simulates a rooting depth depending on tree age **(Fig. 2)**.

For a simulation period of 50 years the dynamic approach shows an increased actual evapotranspiration (AET) compared with the static approach **(Fig. 3)**.

The higher water availability leads to an increase of 8 percent in timber yield of standing stock after the 50-year-simulation period (**Fig. 4**).

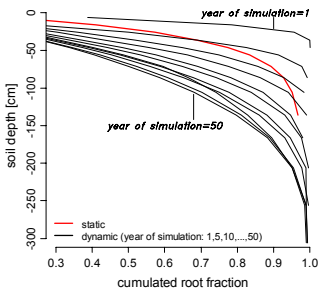

Fig. 2: *Vertical root distribution of the static modelling approach (red line) and of the dynamic modelling approach for different ages (black lines)*

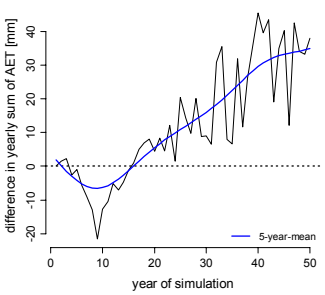

Fig. 3: *Difference between the simulated AET sum for the dynamic approach and for the static approach*

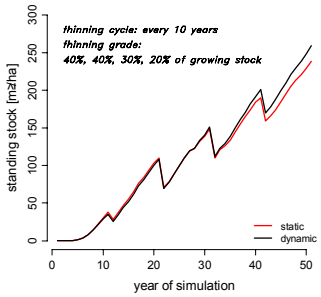

Fig. 4: *Comparison of simulated standing stock with static and dynamic root distribution and root growth models*

Conclusions and Further Activities

- Remarkable sensitivity of tree growth to the approach (static vers. dynamic) of root growth
- Importance of plausible calculation of maximum rooting depth in the root growth model
- Validation with the data from soil coring measurements
- Implementation of a root water uptake model based on water potentials in the soil-plant-atmosphere continuum
- Analyses of the dynamic root growth approach concerning water budget of forest stands

References:

Jackson et al. : Oecologia 108 (3) : 389-411

Lasch et al. : Forest Ecology and Management 207 (1-2): 59-74

Rasse et al. : Plant and Soil 229 (2): 281-293

Potsdam Institute for Climate Impact Research PIK
[1]P.O. Box 601203, 14412 Potsdam, Germany
phone: ++49 (0) 331 288 2632 + e-mail: gutsch@pik-potsdam.de

BTU Brandenburgische Technische Universität Cottbus
[2]P.O. Box 101344, 03013 Cottbus, Germany
phone: ++49 (0) 355 69 4628 +
e-mail: jan.haase@tu-cottbus.de

This work is integrated in the ongoing project *„OakChain“* which is funded by the **BMBF**
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Federal Ministry of Education and Research