Do seasonal growth patterns explain carbon and water fluxes?

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**Overview**

**dry sclerophyll eucalypt forests:**
- 200 – 1000 m asl
- 550 – 1000 mm precipitation

→ important carbon stores on a national level

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Fig. 1: Mean annual precipitation from 1990 – 2011. (Haverd et al., 2012)

Fig. 2: Forest distribution in Australia.
(Australia’s state of the forest report, 2008)
Study design

Fig. 3: PhD study design at the Wombat Forest Research Site
**Project objectives I – carbon flux detection**

**Wombat Forest Research Site:**
Q1: How well does the combination of new ground-based lidar technology and well established measurements detect forest structure and dynamics?

*along a continental rainfall gradient:*

Q1b: How applicable is this combination to describe forest structure and quantify above ground biomass in various forest types?

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**diameter variations**

- sap flow
- auto dendro
- band dendro

- carbon allocation in stems
- stems contain most biomass in a tree
- closely linked to tree water use
- growth signal difficult to detect

**crown dynamics**

- VEGNET
- hemi pictures
- litter traps

- carbon allocation in branches and foliage
- canopy structure strongly affects NPP
- vertical forest structure

plus additional site survey
**Project objectives II – seasonality of growth**

**Wombat Forest Research Site:**

Q2: Can seasonal carbon fluxes be partitioned into leaf, stem and below ground fluxes and how are they linked to environmental variables?

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**Carbon allocation dynamics & in-situ carbon fluxes**

**Fig. 4: Stylised representation of carbon allocation to pools.**
Project objectives III – structural dynamics

Wombat Forest Research Site:

Q3: Are changes in forest structural dynamics related to changes of NEP, NPP and stand-level water fluxes?

Leaf Area Index

VEGNET  hemi pictures  litter traps

- diameter variations
- water fluxes
- NPP and NEP
- environmental variables

auto dendro band dendro

sap flow

flux tower + sensor network
Wombat Forest Research Site:

Q4: At what temporal scale are carbon and water fluxes linked?

- carbon allocation in stems and foliage from sensor network
- NEP from flux tower
- carbon fluxes from tree to stand-level
- tree water use from sensor network
- precipitation and evapotranspiration from Wombat flux tower
- water fluxes from tree to stand-level

Water and carbon fluxes measured by the same instrument
Project objectives V - modeling

**Wombat Forest Research Site:**
Q5: Which model type represents most accurately the growth of this temperate eucalypt forest?
Q5b: Will this forest likely continue as a carbon sink under climate change?

- Evaluation of existing growth models
- Improvement of existing models for:
  - vertical crown dynamics/changes in LAI
  - coupling of carbon and water fluxes

- Future predictions of forest growth:
  - structural dynamics on a longer time scale
  - impact of changes in climate
Fig. 5: Visualization of research questions and their interaction with each other.

- Detection of carbon fluxes
- Seasonality of growth
- Structural dynamics
- Carbon and water links

Question 1 + 1b
Question 2
Question 3
Question 4
Question 5
Example data: dendrometer

November 2011 – February 2013

data gaps & settling in / readjusting bands

noisier signal in summer

outlier: loose bark

Fig. 6: Automated dendrometers compared to manual bands

automated dendrometer
manual band dendrometer
Example data: dendrometer

- **E. radiata**
  - 1.5 mm
  - 17 mm/day
  - Seasonal trends and interspecies comparisons

- **E. rubida**
  - 2 mm
  - 23% soil moisture
  - Growth followed by shrinkage

- **E. obliqua**
  - 2.5 mm
  - Growth ceases

**Fig. 7: Seasonal trends and interspecies comparisons**

- 3 months of data (autumn 2012)
- Growth triggered by rain events

- 36 mm/week
- 27 mm/day
- 20% soil moisture

- More efficient water use

- Growth slower but steady
Example data: tree water use

long-term tree water use at VN2

Fig. 8: Seasonal trends and interspecies comparisons

Shortwave downwelling radiation
Example data: VEGNET

Fig. 9: Two seasons of plant area index (PAI) measured with VEGNET sensors.

- 3 weeks interval
- general decrease in PAI: 2 → 1.75
- greater variation in summer
Example data: VEGNET

PAVD spring 2012

highest PAVD

overall reduction above 9 m: ca. 20%

larger variety

PAVD summer 2013

largest reduction of PAVD

Fig. 10: Two seasons of plant area volume density (PAVD) measured with VEGNET sensors.
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Questions?!