Long-term crown and structural dynamics of the Wombat Forest

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PhD objectives

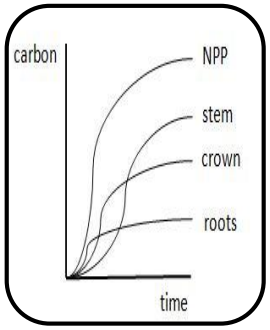
Climate change

Detection of carbon fluxes

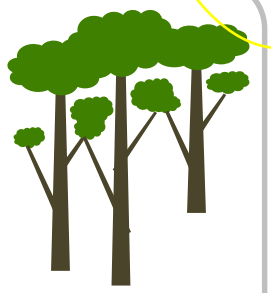
Crown dynamics

Stem increments

Seasonality of growth



Structural dynamics



Carbon and water fluxes

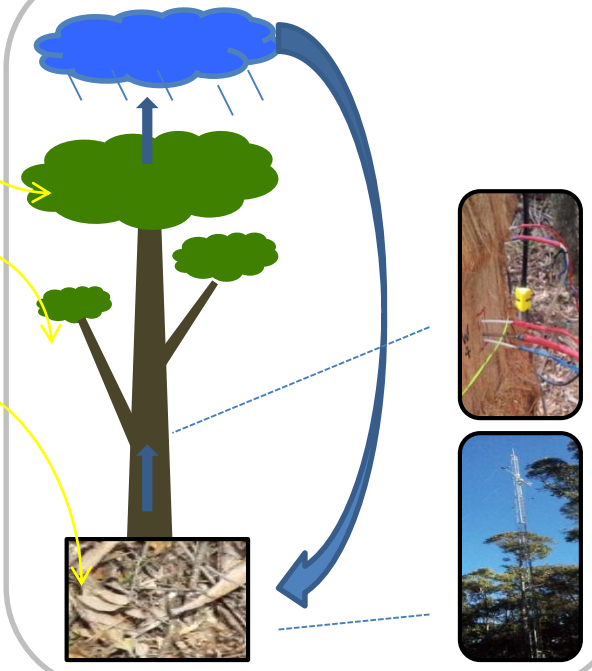


Fig. 1. Overview of general PhD objectives.

Study layout

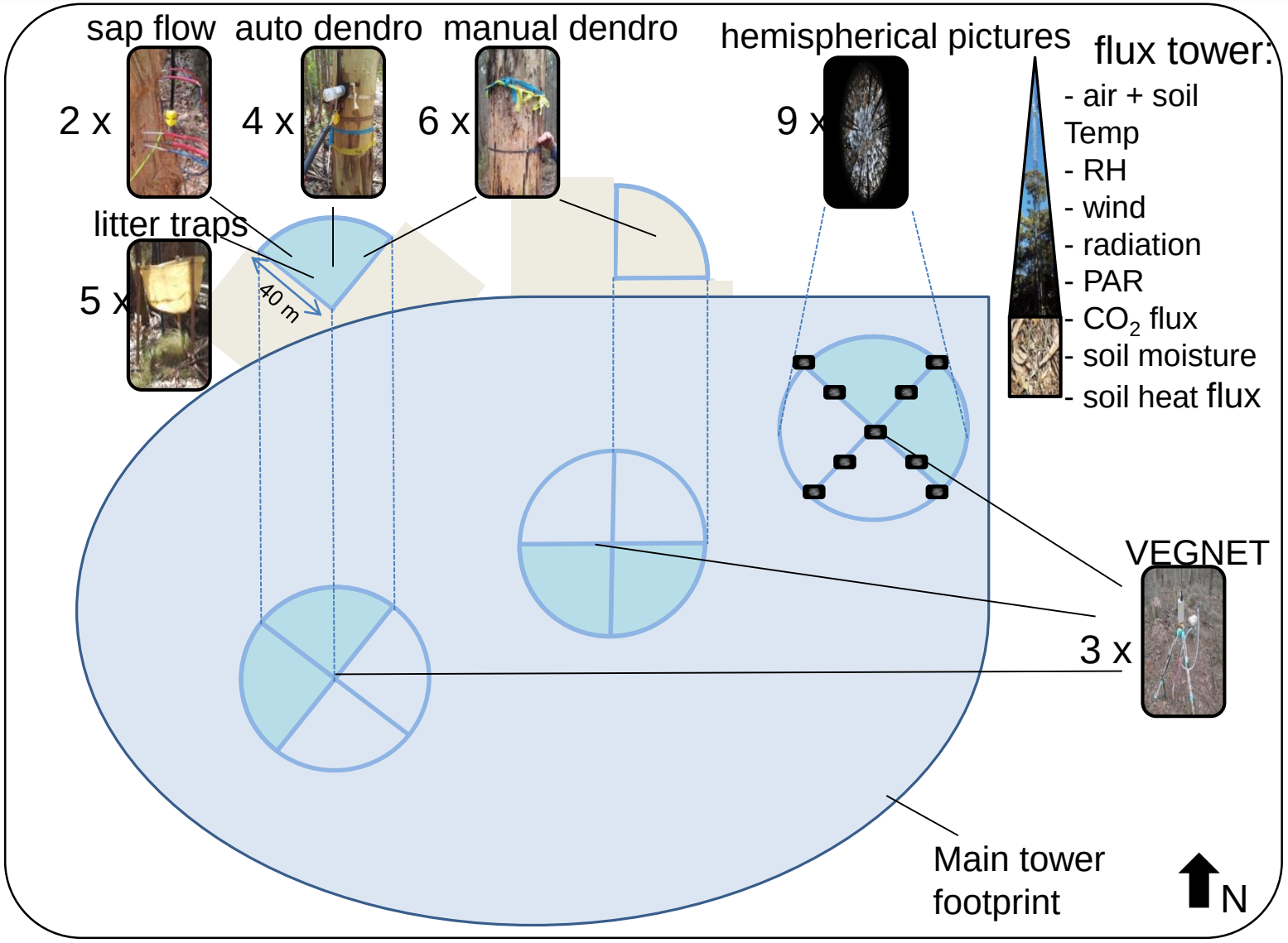


Fig. 2. Instrument set up at the Wombat Forest flux site.

Leaf Area Index (LAI)

Definition:

Leaf Area Index (LAI) is the single-sided leaf area per unit ground area
(Chen & Black, 1992)

Directly measured:

Biomass harvest or litter traps

Indirectly measured

Hemispherical or cover photography, LAI-2000

Problem:

- Direct measures are very *time and labour intensive, large number of traps required to accurately represent canopy dynamics*

- Indirect measures *are prone to multiple bias* during image acquisition (light and weather conditions, exposure settings) and post processing (thresholding).

VEGNET sensor overview

- Tracks LAI/PAI and vertical forest structure dynamics
- Adds an additional dimension to LAI/PAI through vertical structure profiles
- Weather-resistant material for long term field deployment (permanent and portable option)
- Fully automated daily scans
- Low acquisition cost
- Low maintenance requirements

VEGNET sensor overview

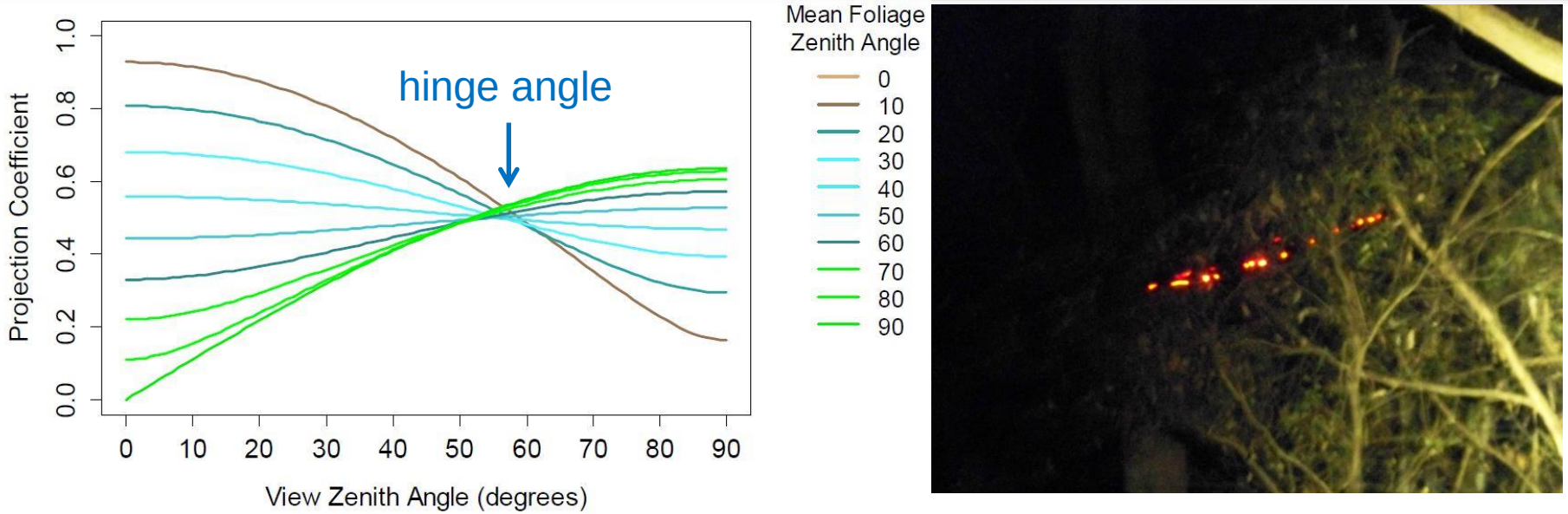


Fig. 3 Hinge angle is located at 57.5º and has low sensitivity of LAI estimation to the leaf angle distribution (Culvenor et al., 2014)

VEGNET sensor overview:

- <1000 range measurements at fixed angle (hinge angle, 57.5º)
- Hinge angle meets assumption of randomly distributed leafs in the horizontal plane
- Laser wavelength 635nm
- Effective range of 60m (maximum canopy height of 30m)

→ Night time operation and automated data processing removes bias from non-ideal light conditions and subjective processing

crown dynamics – VEGNET timeseries

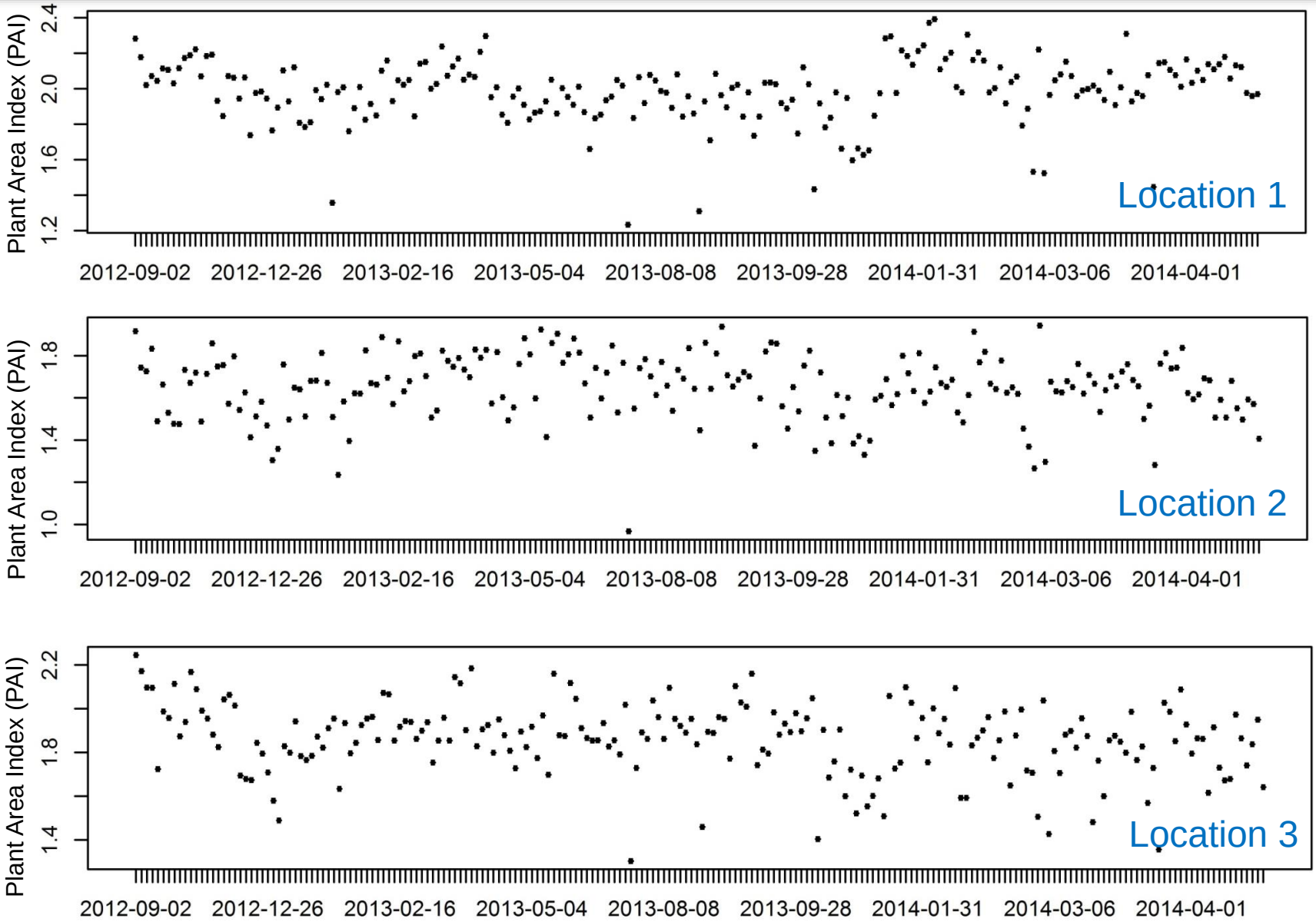


Fig. 4. Timeseries of plant area index (PAI) from three different VEGNET sensors at three locations.

Crown dynamics – VEGNET vs. DHP

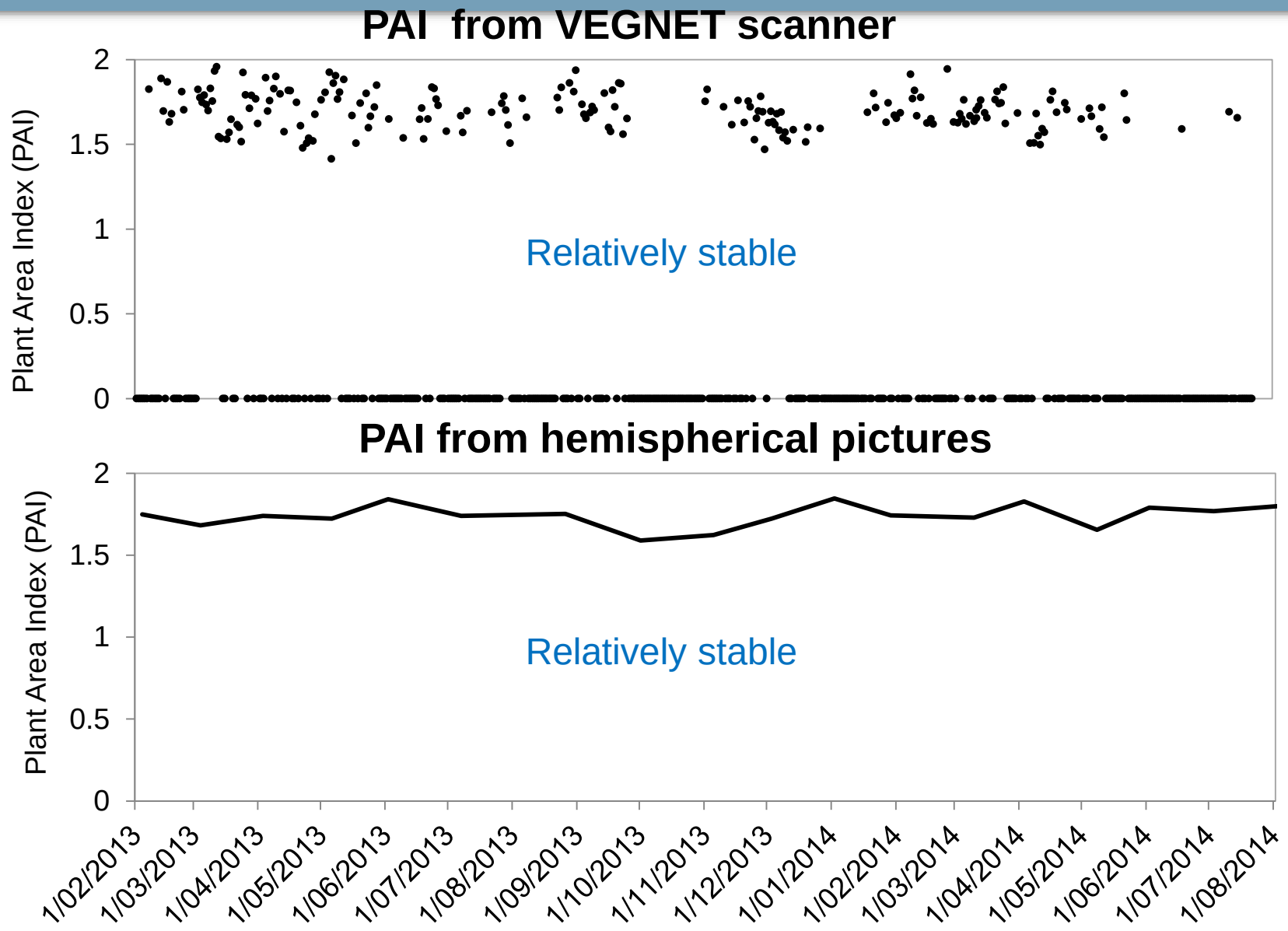


Fig. 5. Timeseries of plant area index (PAI) from VEGNET sensor and from DHP at the same location.

Crown dynamics – litter trap trends

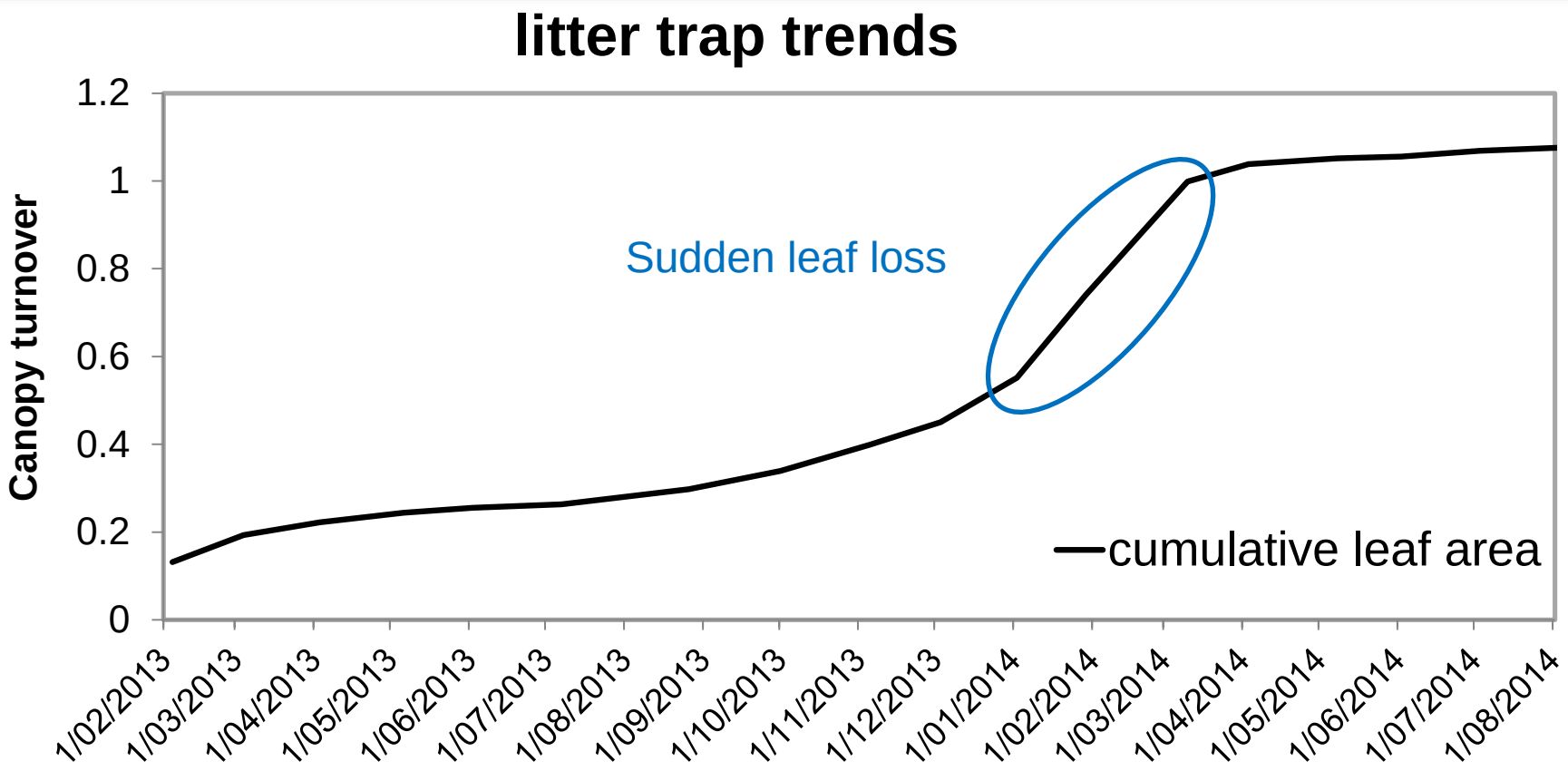


Fig. 6. Timeseries of litter traps during the same period as VEGNET and DHP (hemispherical pictures)

- Major loss of leaf area during summer 2014 with 50% of canopy turnover
- Litter fall very stable throughout other seasons
- Explains low LAI variations from observations of VEGNET and DHP during rest of the study period, *but not during summer 2014*

Crown dynamics – VEGNET vs. DHP

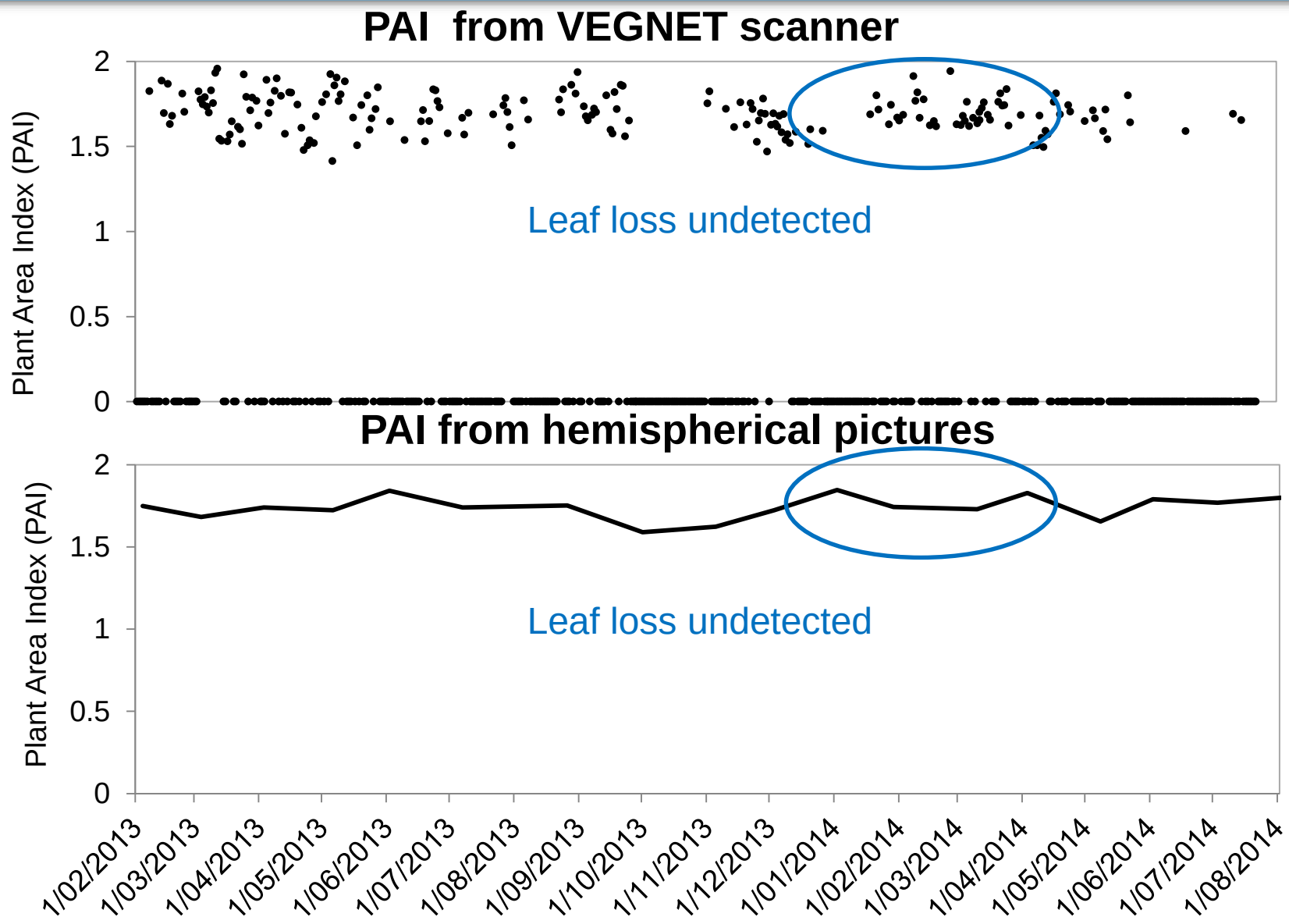


Fig. 5. Timeseries of plant area index (PAI) from VEGNET sensor and from DHP at the same location.

Vertical structure dynamics – VEGNET

PAVD

Plant area volume density is the density of vegetation components at any height level

- three scans a month apart
- Every line represents one scan
- Comparison of different scans from different times

Result:

Most biomass is located at ca. 20m height

Canopy volume changed between dates and with differing rates between heights

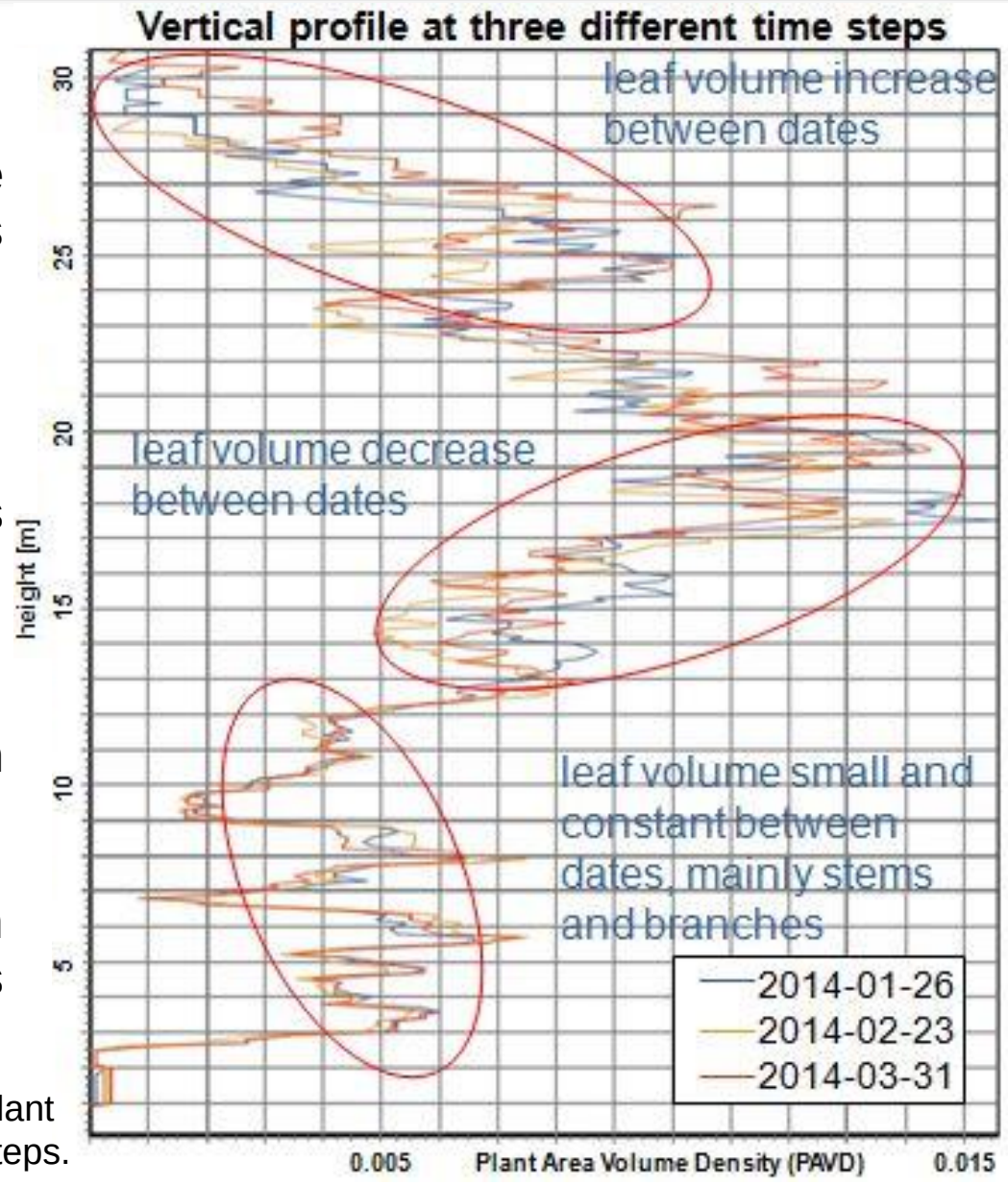


Fig. 7. Vegetation density indicated by PAVD (Plant Area Volume Density) at three different height steps.

Vertical structure dynamics - VEGNET

Long-term PAVD trends at three heights within stand

25-30m

Two leaf flushes during observation period, both during summer

15-25m

Leaf volume slowly but constantly decreasing

5-10m

Leaf volume relatively stable, mainly stems and branches

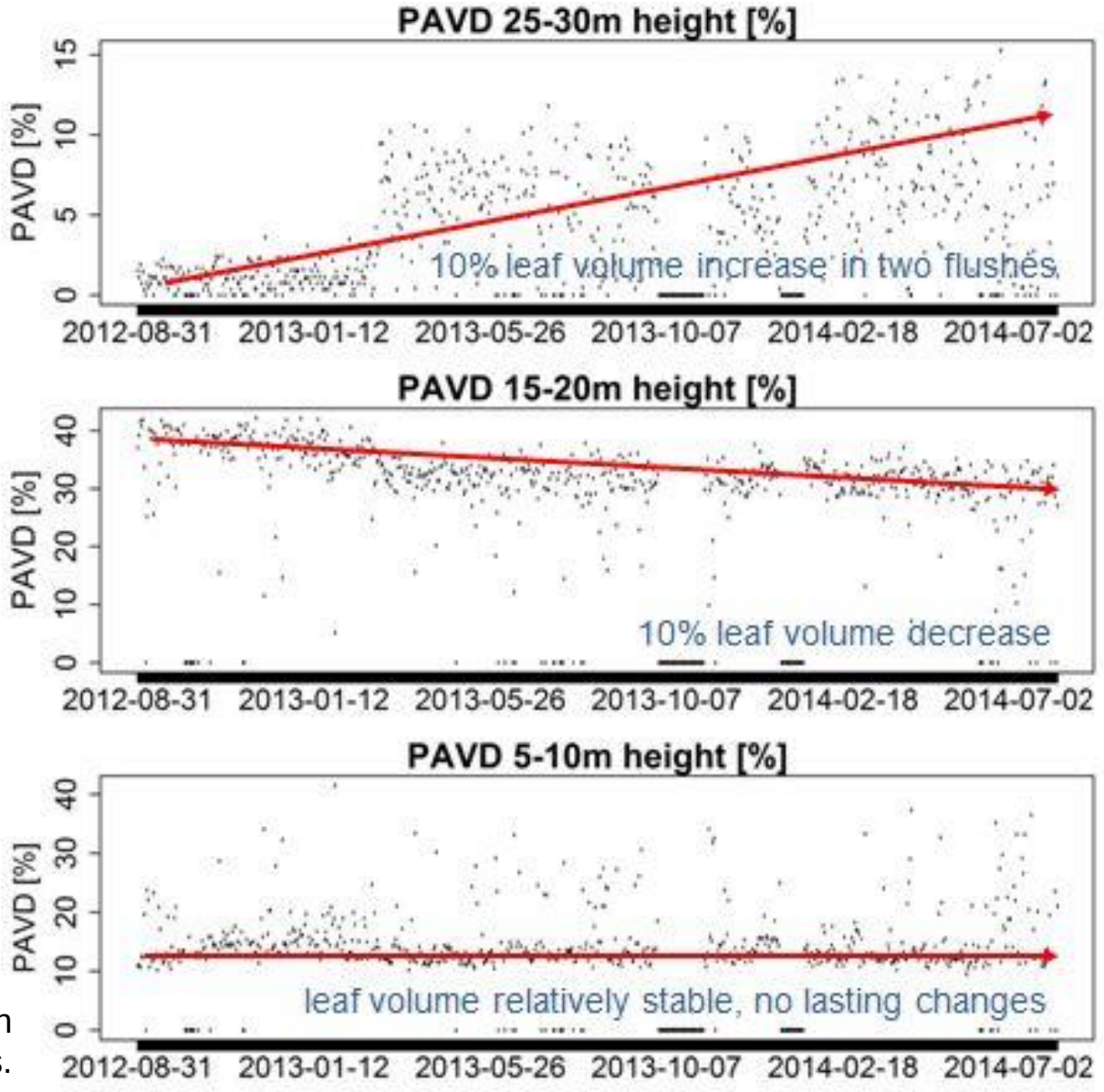


Fig. 8. Long-term dynamics of vegetation density at three different height steps.

Net Ecosystem CO_2 Exchange (NEE)

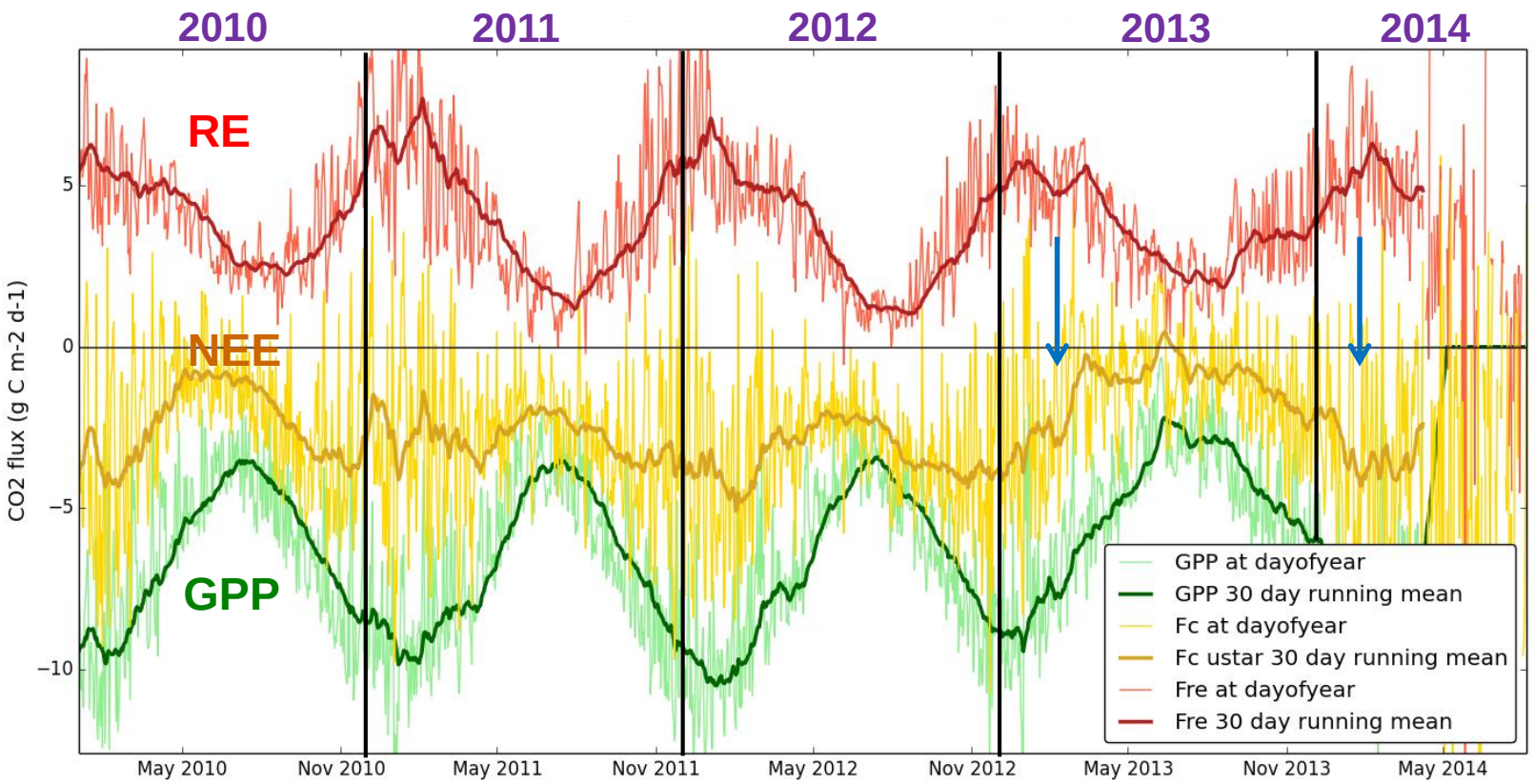


Fig. 9. Net ecosystem exchange shows spikes at the exact timing of leaf flushes.

Conclusion

Summary

- PAI measurements from VEGNET and digital hemispherical pictures (DHP) agree well
- Both methods did not detect a major loss of leaf area (50% in summer 2014) that was detected by litter traps
- VEGNET vertical structure profile (as Plant Area Volume Density, PAVD) showed that timing of major leaf fall coincided with a leaf flush in the upper canopy layers

Conclusion

- Vertical structure profile from VEGNET can identify opposing canopy dynamics at very fine resolution
- VEGNET has the potential to detect sudden changes in canopy dynamics that would get missed with a lower measurement frequency