THE SURFACE WATER BALANCE OF THE WOMBAT STATE FOREST, VICTORIA: AN ESTIMATION USING EDDY COVARIANCE AND SAP FLOW TECHNIQUES

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What's the purpose of this study?

The problem

- Global/regional climate change
- IPCC predictions for SE Australia (2007)
- Effects on water use/output from forest catchments

A solution

Measure water balance of forests:

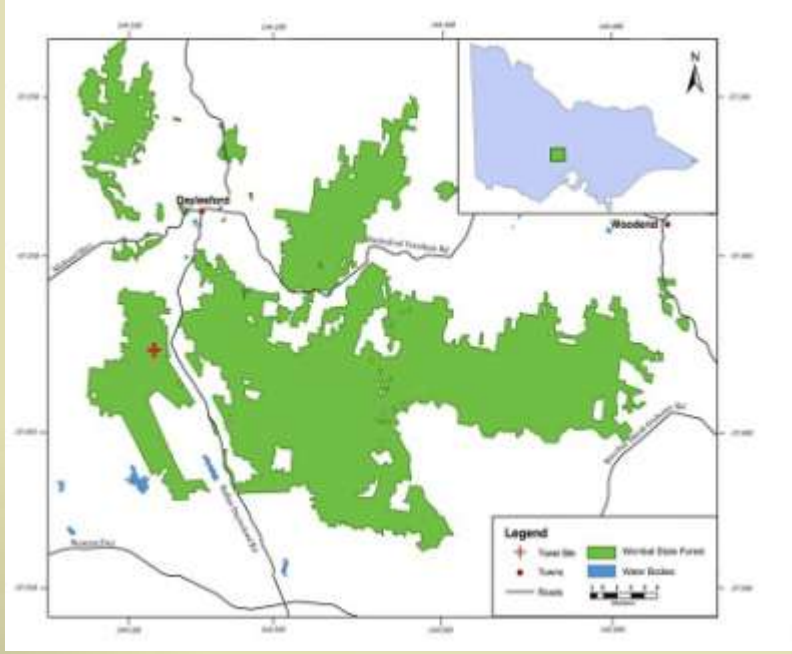
- Eddy covariance
- Sap Flow
- Remote sensing
- Catchment water balance

Who cares

- Forest managers and planners
- Catchment management authorities
- Local residents/land managers

Wombat State Forest

- Near Daylesford, Central Victoria
- Covering 70,000 ha
- Temperate climate zone at an elevation of 713 m asl
- Long term average maximum daily temperature ~ 18 °C + range of 3-44 °C
- Declared a state forest in 1871
- Disturbances: Fire and harvesting



(adapted from wombatwaterwatch.com.au)

(www.nearmap.com)

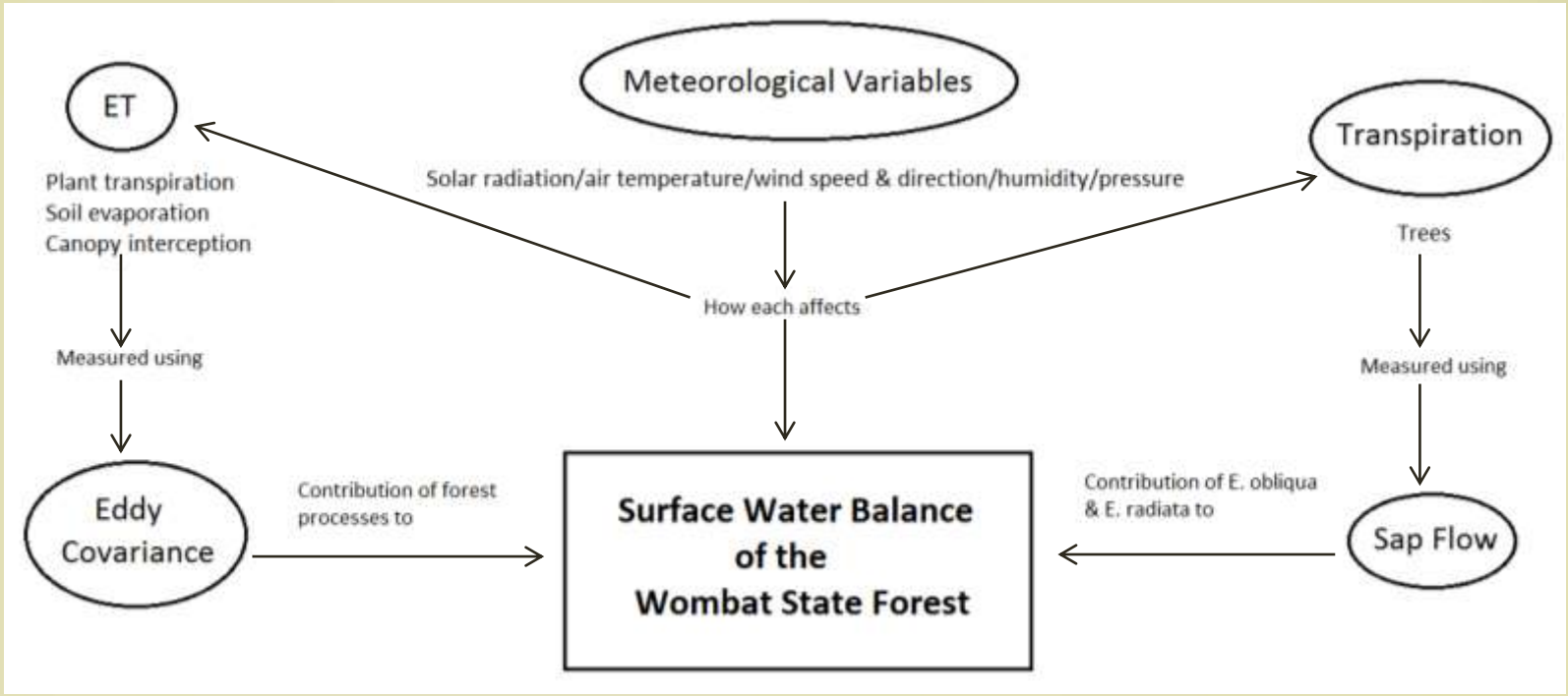
The Trees of Wombat State Forest

a) b) c)

(Brooker 2006)

a) *Eucalyptus obliqua (L'Herit) – Messmate Stringybark*
b) *Eucalyptus radiata (Sieber ex DC) – Narrow-leafed Peppermint*
c) *Eucalyptus rubida (Deane & Maiden) – Candlebark*

Methods



Flux Tower Instrumentation

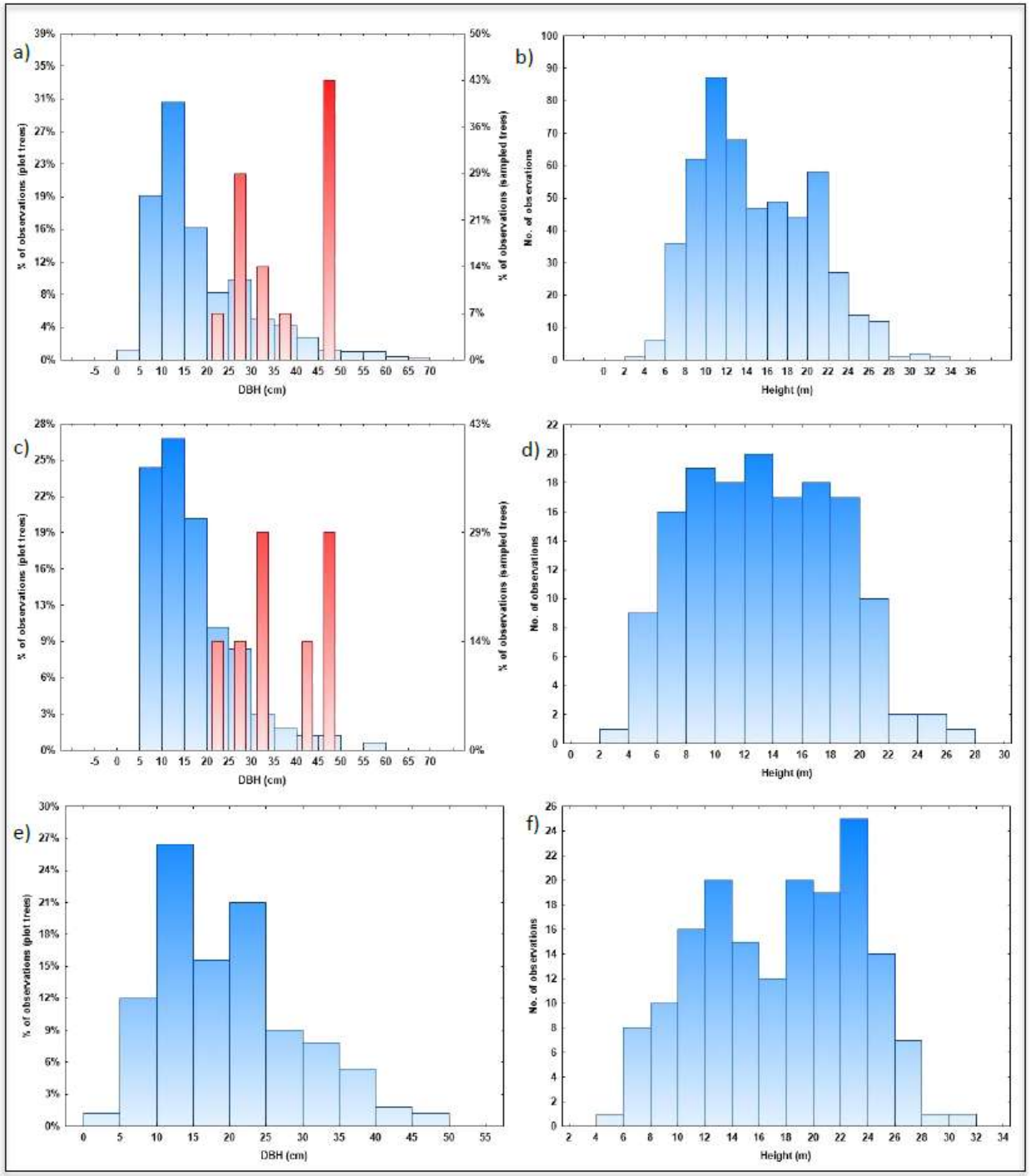
E. radiata

E. obliqua

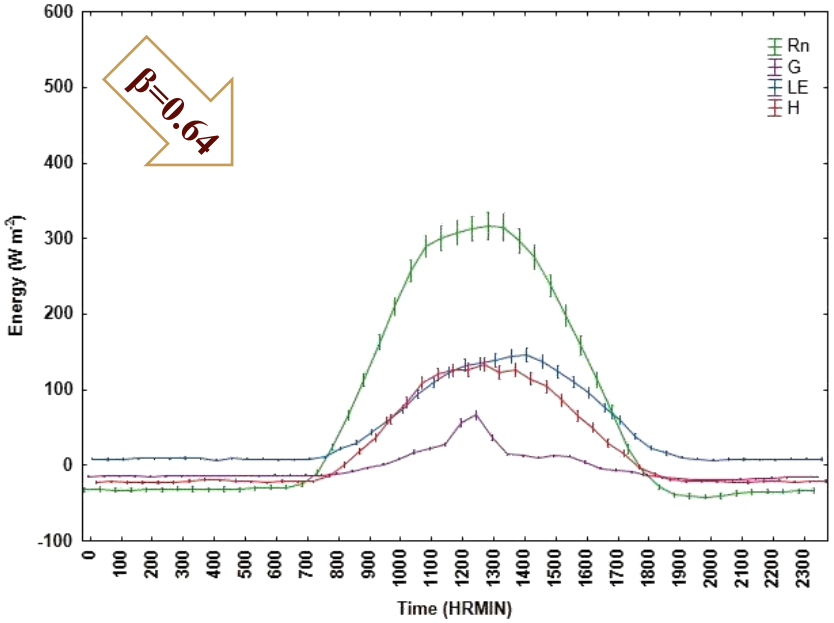
Eucalyptus obliqua

Eucalyptus radiata

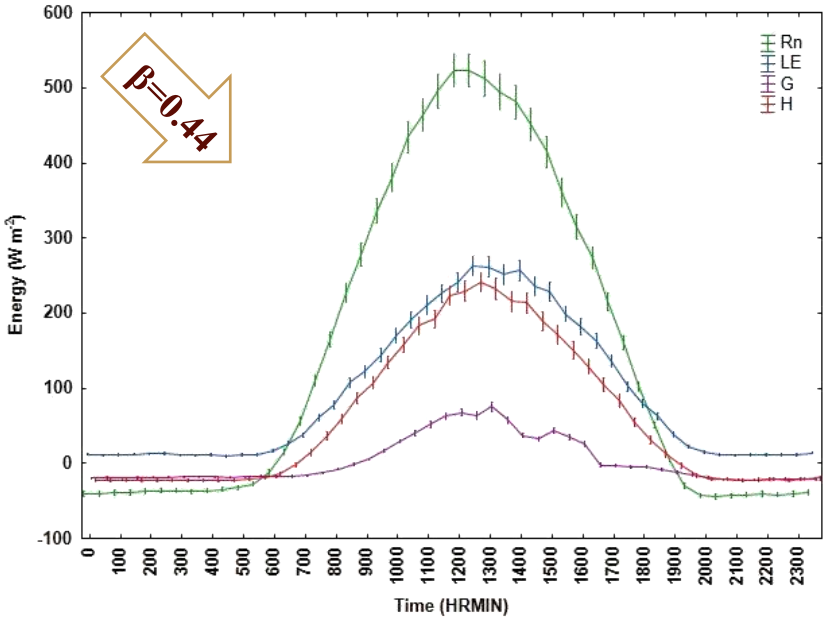
Eucalyptus rubida

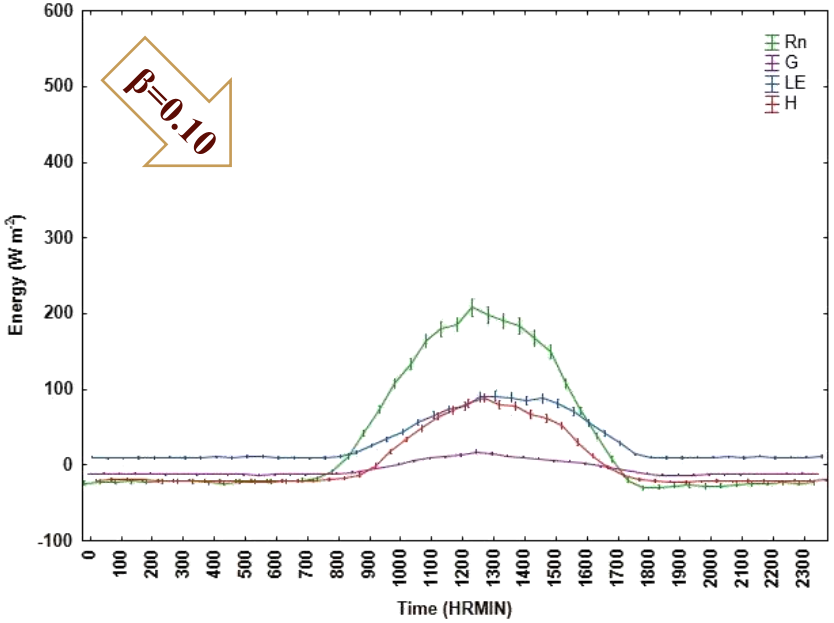


Autumn

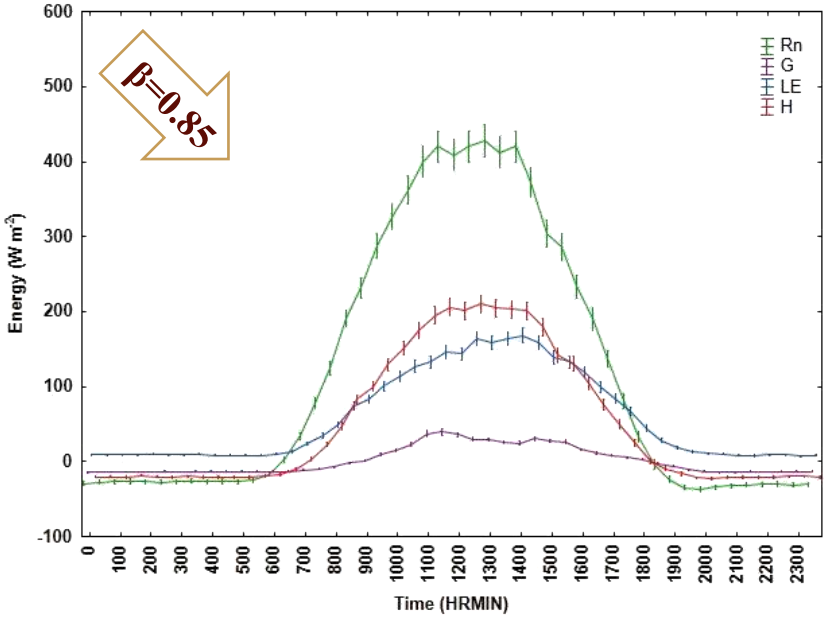


Summer





Winter

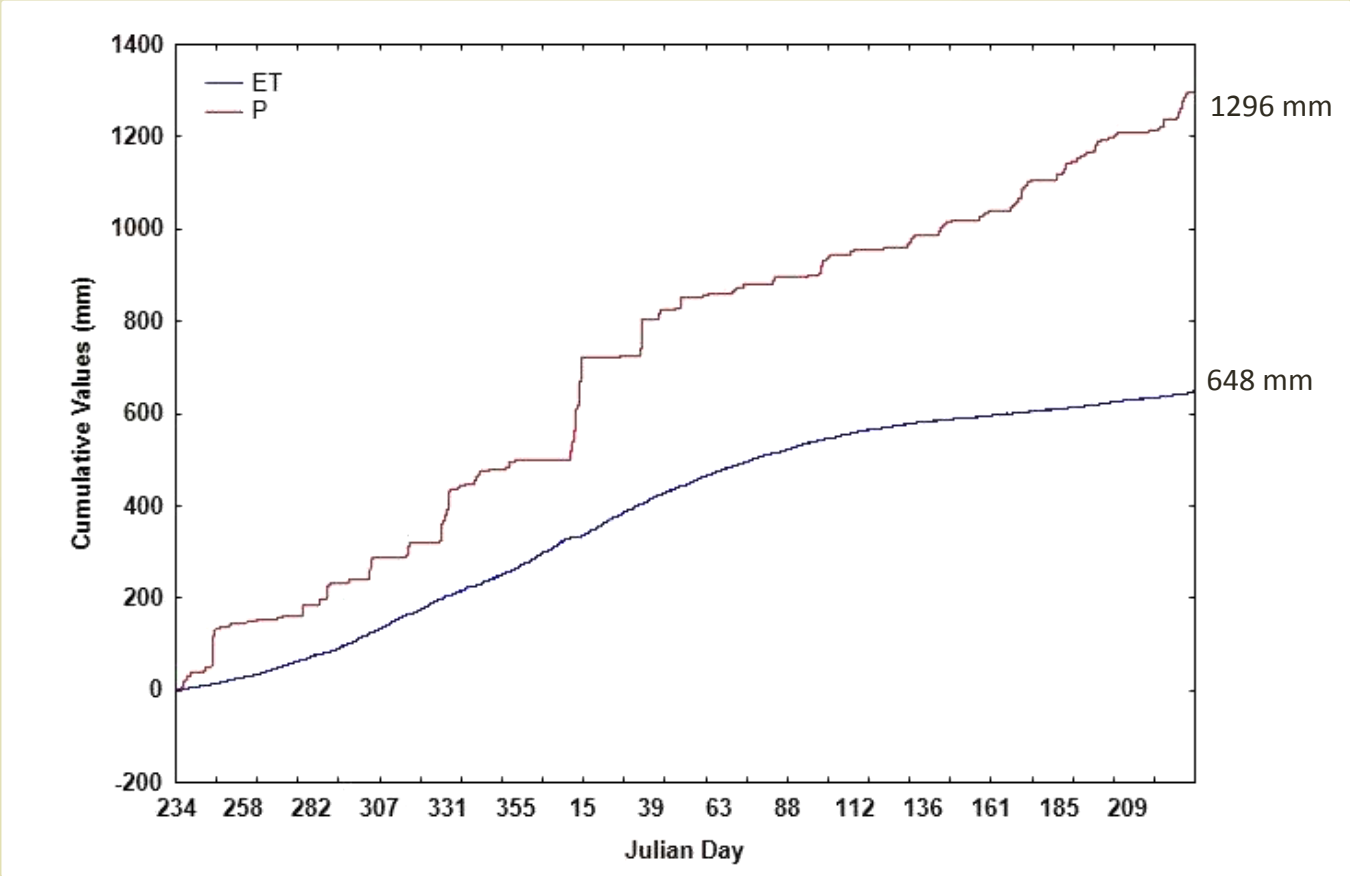


Spring

Wombat's Water Balance

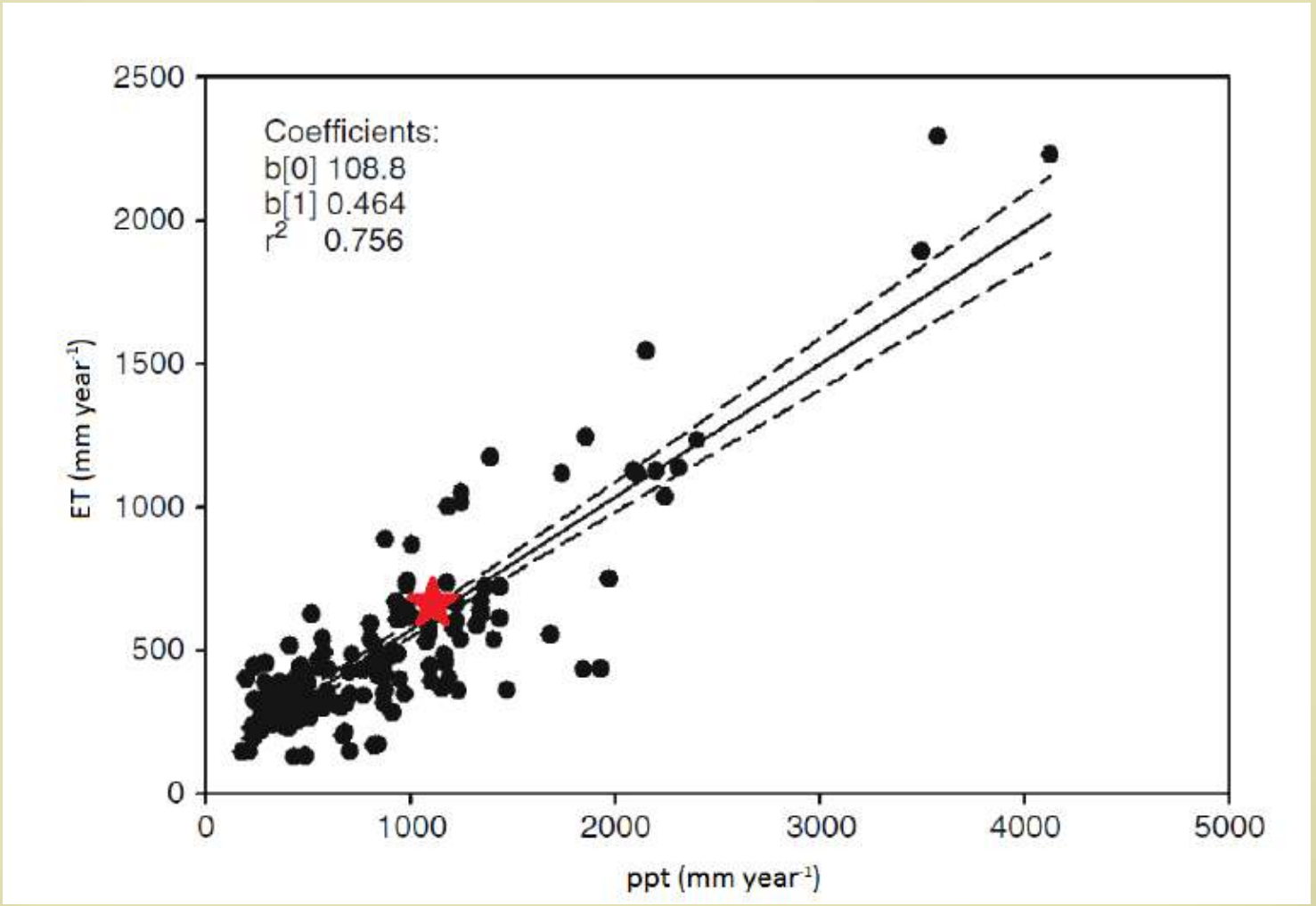
- Total rainfall from August 2010 to August 2011 at Wombat was 1296 mm – A wetter than average year (av. 844 mm)
- Total evapotranspiration (LE flux) was 648 mm ~ 50 % of total rainfall

Cumulative precipitation (P) and Evapotranspiration (ET) from Wombat State Forest



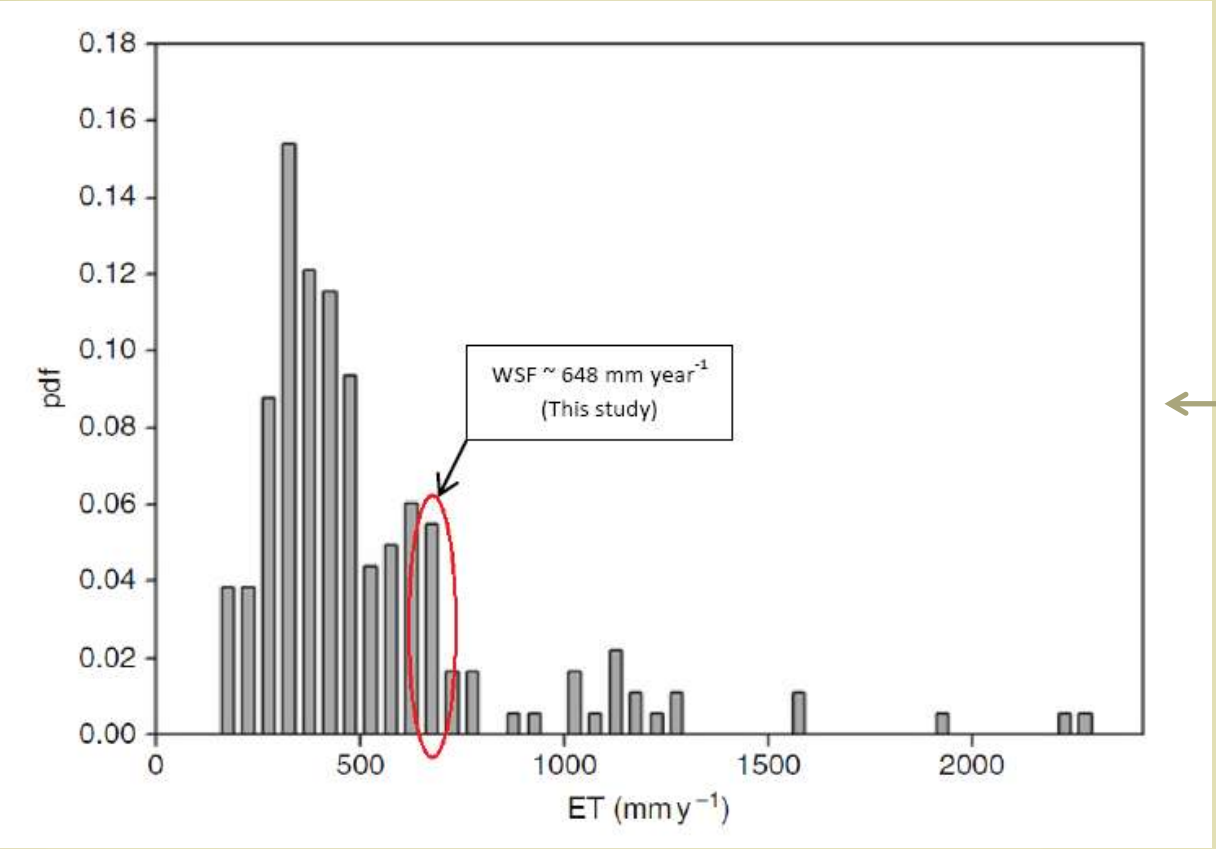
Wombat in the bigger picture

Annual precipitation vs. Evapotranspiration for forests globally



n=165 (modified from Baldocchi & Ryu 2010).

Global probability distribution of annual ET for forests



Mean global water use for forests is 503 ±338 mm yr^{-1}
(Baldocchi & Ryu 2011)

Daily water use values for different forest types

Forest Type	Climate	Water Use (mm day^{-1})	Reference
Broadleaved Deciduous	Temperate	1.47-1.67	(Wilson and Baldocchi, 2000)
Broadleaved Evergreen	Temperate	2.49-4.03	(Leuning et al., 2005)
Broadleaved Evergreen	Tropical	3.0-3.75	(Fisher et al., 2009)
Savanna Woodland	Tropical	1.4	(Hutley et al., 2000)
Savanna Woodland	Semi-arid	1.04	(Baldocchi et al., 2004)
Coniferous Evergreen	Temperate	1.07-1.47	(Grunwald and Bernhofer, 2007)
Coniferous Evergreen	Boreal	0.1-3.5	(Arain et al., 2003)
Broadleaved Evergreen	Temperate	0.74-2.81	This study

Preistley-Taylor Coefficient

- Calculation of the Preistley-Taylor coefficient (α) provides a useful index for comparing the evaporative control of different forest types (Komatsu 2005).
- α = ETeq:ET
- High leaf area, ample soil water supplies and a large photosynthetic capacity can increase this ratio (Baldocchi & Ryu 2010).

Priestley-Taylor coefficients for forest types around the world

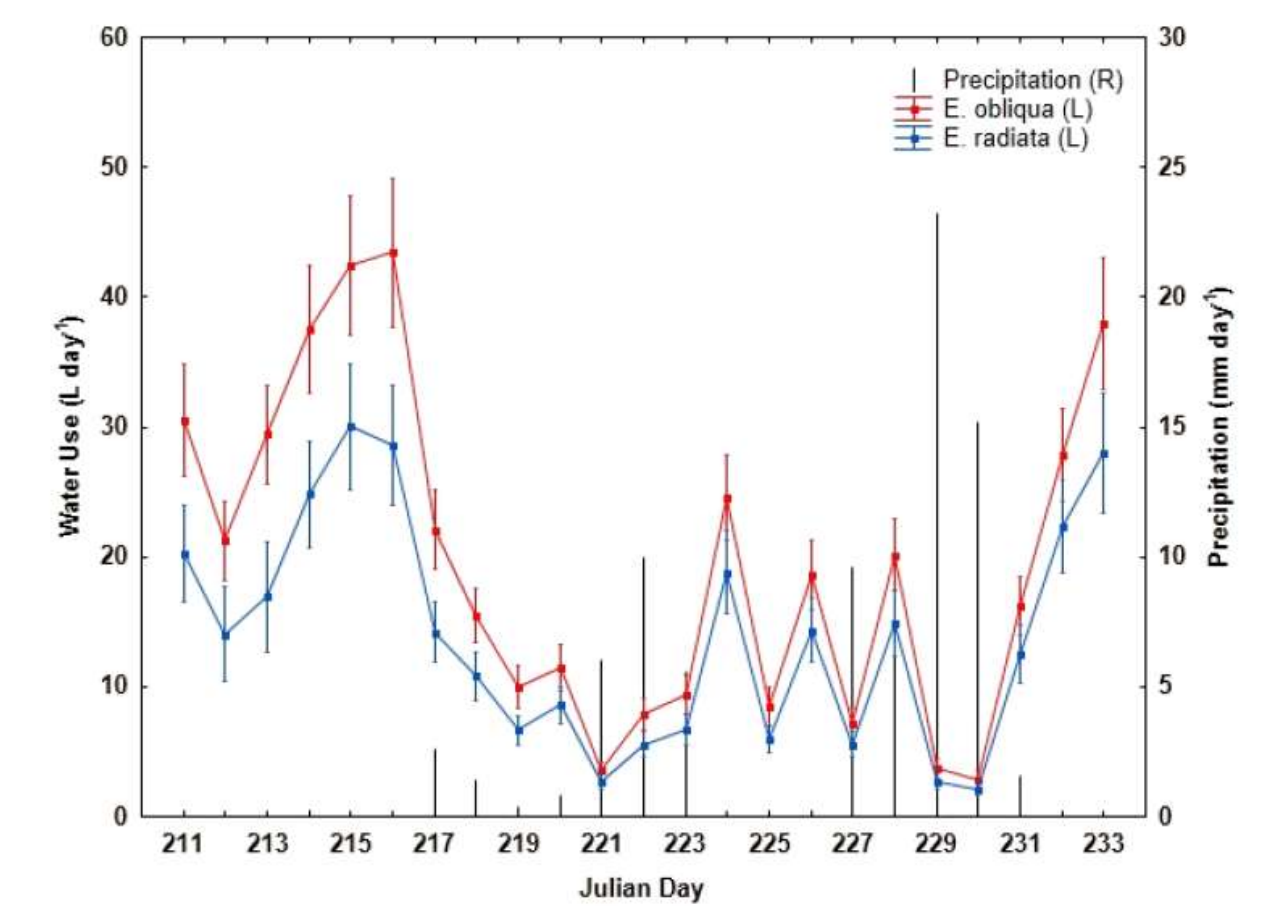
Forest Type	Mean	Standard Deviation
Boreal Broadleaved Deciduous	1.09	-
Temperate Broadleaved Deciduous	0.851	0.147
Tropical Broadleaved Evergreen	0.824	0.115
Temperate Broadleaved Evergreen	0.764	0.181
Temperate Coniferous	0.652	0.249
Boreal Coniferous Evergreen	0.550	0.102
Boreal Coniferous Deciduous	0.530	0.084
Wombat State Forest (this study)	0.990	-

(Baldocchi & Ryu 2010).

Sap Flow

- Average daily water use (L day^{-1}) was 19.7 and 13.8 for *E. obliqua* and *E. radiata*, respectively.

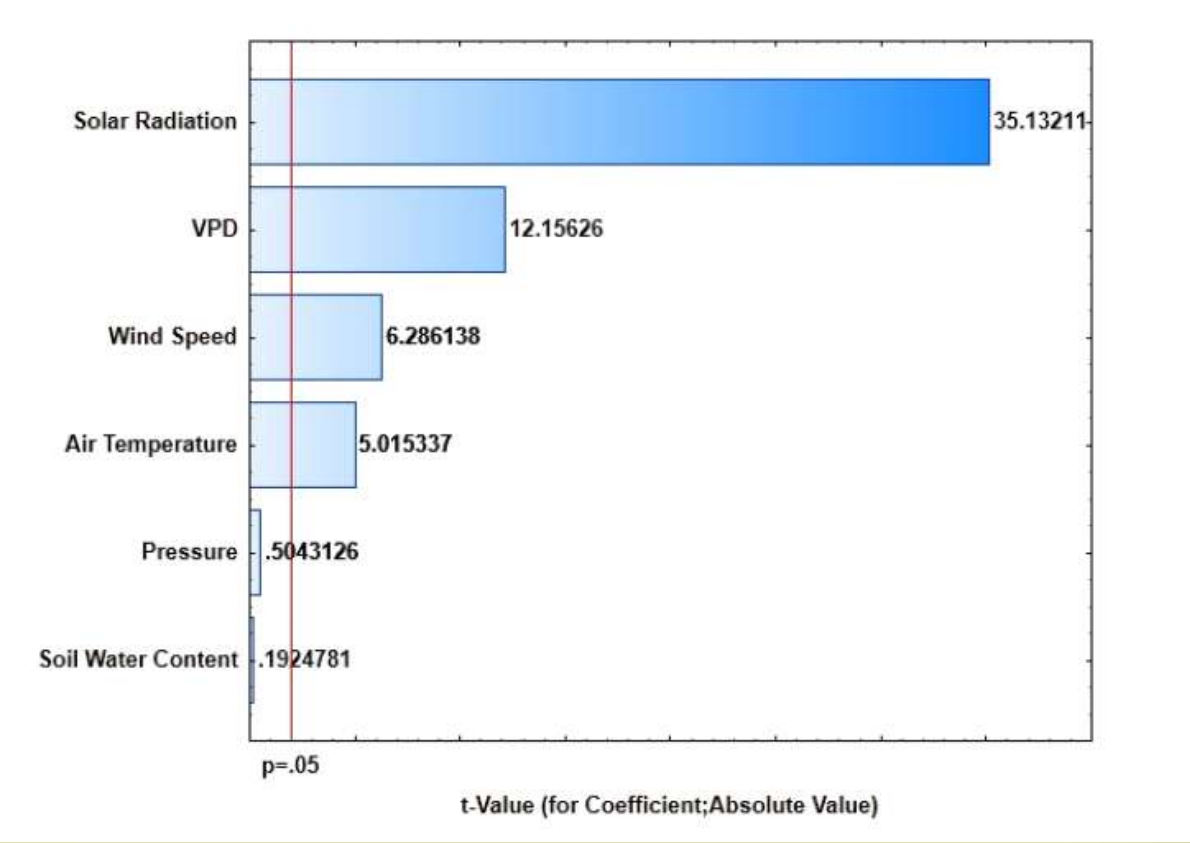
Mean (±SE) daily tree water use (L day^{-1}) at WSF for 23 days



Variables influencing sap flow

- Daily tree water use followed the trend in daily total precipitation, with a MLR revealing solar radiation, VPD, wind speed and air temperature each had a significant effect on tree water use.

Pareto chart of t-values for the meteorological variables affecting tree water use at WSF (30/07/11 – 21/08/11)



Outcomes

- In a climatically wet year, the Wombat State Forest output approximately half of the annual rainfall sum.
- Eddy covariance measurements conform with the expected range for temperate forests around the world.
- Sap flow measurements reveal the contribution of individual trees and species to the total water use of the forest
- The WSF was more likely to be energy limited, rather than water limited, during the period of measurement.

Future Directions

- Continue measurements in order to capture a wider range of climatic variability; i.e. wet, dry and average years.
- Findings can be used to provide a dry sclerophyll component to climate/vegetation models or validate remote sensing measurements.

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