



## **WATER USE BY EUCALYPT FORESTS**

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# WATER USE BY EUCALYPT FORESTS

Craig Macfarlane (CSIRO Sustainable Ecosystems), [craig.macfarlane@csiro.au](mailto:craig.macfarlane@csiro.au), 08 9333 6670

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## Summary

It is well established that forest and woodland density decline with increasing aridity and Australia is no exception. In this presentation I investigate and quantify the relationships between key water-use characteristics of south-western Australian forests and woodlands, and compare these forests with those from other parts of southern Australia. Key results are that:

1. the “Ellis-Hatton line” relating leaf area index to aridity applies equally well to SW forests.
2. sapwood depth is nearly constant in eucalypts,.
3. wood density increases with increasing aridity but is not well correlated with sap velocity.
4. mean annual sap velocity appears more constant than ‘per-unit-leaf-area’ rates of transpiration, across forests in SW Australia.

I briefly explore the implications of these findings for modelling water use of eucalypt forest based on forest structure.

## Introduction

While the general decline of forest cover with increasing aridity is well documented, there is little knowledge of how attributes such as sapwood area and density, the ratio of leaf area to sapwood area, and sap velocities vary with aridity in eucalypt forests. It is expected that in drier climates xylem vessels will shrink to prevent catastrophic embolism in the water conducting pathway, leading to denser wood. Less conductive sapwood should also result in slower sap velocities.

Less conductive sapwood is also expected to cause the ratio of leaf area to sapwood area to decrease because a greater area of sapwood would be needed to supply the same area of canopy, all else being equal. As an alternative to decreasing the leaf:sapwood area ratio eucalypt forests might reduce their leaves’ conductance to evaporation, i.e. have fewer or more closed stomata.

I present data to test the above hypotheses and also quantify some of the relationships between aridity (defined as the ratio of rainfall to potential evaporation) and forest water-use characteristics. A simple approach to estimating overstorey water use from forest structure is then developed.

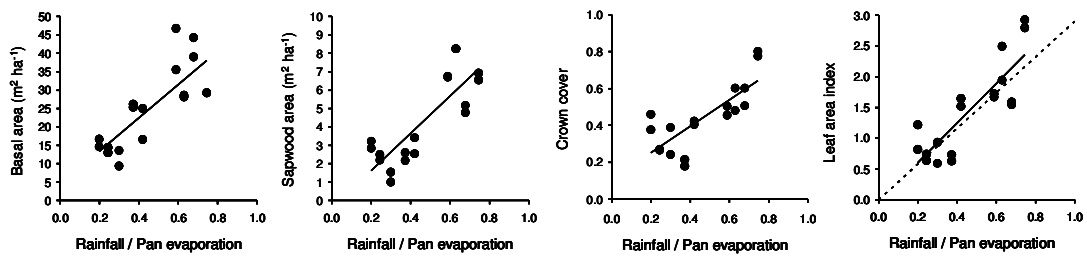
## Methods

Plots (40\*40m) were established in eucalypt forest from Pemberton to Quairading in WA. Leaf area index and cover were measured using digital cover photography. From tree diameter measurements and estimates of sapwood area from tree cores I estimated sapwood area. In a separate study stem wood of 16 species of eucalypt were sampled from forests across Victoria and WA. Sapwood depth, density and water content were measured on samples. Sapwood depths from visual estimation were validated using microscopic examination of wood for blocked xylem vessels. Sap velocities were measured using a combination of thermal dissipation probes and heat ratio method probes.

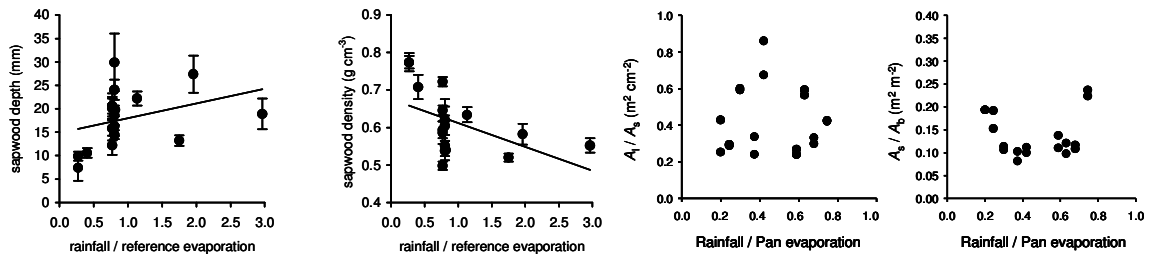
## Results and Discussion

Basal area, sapwood area, cover and LAI were highly correlated with the ratio of rainfall to potential evaporation (P/E) (Fig 1). Sapwood density was also well correlated with P/E (Fig 2) but was not related to mean annual sap velocity (Table 2). Sapwood depth was not related to aridity, nor were the ratio of leaf area to sapwood area or the ratio of sapwood area to basal area (Fig 2). There was some indication that water use per unit leaf area might be less at the most arid sites (salmon gum and wandoo, Table 1) and this was supported by the observation of less negative  $\delta^{13}\text{C}$  at these sites (data not presented).  $\delta^{13}\text{C}$  is an indicator of water use efficiency and, often, water ‘stress’.

I conclude that eucalypt forests in more arid areas of SW WA have fewer and smaller trees resulting in less basal area, sapwood area, crown cover and LAI. Sapwood depth and sap velocity do not appear to vary in response to aridity in these forests. Leaf conductance to evaporation may be reduced, and water use efficiency increased in forests at more arid locations. The variation in sapwood density may not be related to the conductance of the stem wood to water movement owing to the wood anatomy of eucalypts which, like other hardwoods and unlike softwoods, transport water in vessels which occupy less than half the cross-sectional area of the wood. Density variations in the area of wood occupied by fibres (not involved in water transport) may mask any density variations that result from variations in vessel anatomy.



**Figure 1.** Forests in more arid areas have less basal area, sapwood area, crown cover and leaf area. The dashed line is derived from Ellis and Hatton (2009).

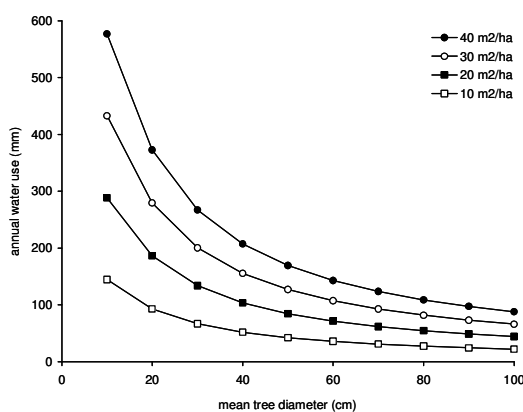


**Figure 2.** Forests in more arid areas have denser wood but sapwood depth and the ratio of leaf area to sapwood area are not well correlated with aridity. The ratio of sapwood area to basal area is determined by structure and sapwood depth.

**Table 1.** Mean annual sap velocity ( $V_s$ ) and water use per unit leaf area index of seven eucalypt forest stands from SW Australia.

species	site	period	mean $V_s$ ( $\text{cm hr}^{-1}$ )	$\text{m}^3 \text{ha}^{-1} \text{d}^{-1} \text{LAI}^{-1}$
salmon gum	Quairading	annual	6.3	3.3
powderbark wandoo	Wandoo NP	annual	6.8	2.4
jarrah	Gordon (Dwellingup)	annual	5.9	4.8
jarrah	Huntly old-growth	annual	6.4	3.1
jarrah	Huntly regrowth	annual	7.5	4.7
jarrah	Lewis ex-mined	Oct-July	5.2	6.7
jarrah	Bates regrowth	Oct-July	5.0	5.8

From relationships developed between sapwood area and tree diameter, and taking the mean annual sap velocity as 6.5 cm/hr (Table 1), I modelled annual transpiration by overstorey as a function of stand basal area and mean tree size (Fig 3). Water use decreases sharply as the mean tree diameter increases from 10 cm to 40 cm, and decreases with decreasing basal area. Removal of small trees has the potential to reduce overstorey transpiration more than thinning that does not target small trees for the same basal area reduction.



**Fig 3.** Water use decreases as mean tree size increases and basal area decreases.