FOR/FES-599

3-PG FOREST GROWTH MODEL

Dr. Richard H. Waring

Dr. Carlos A. Gonzalez-Benecke

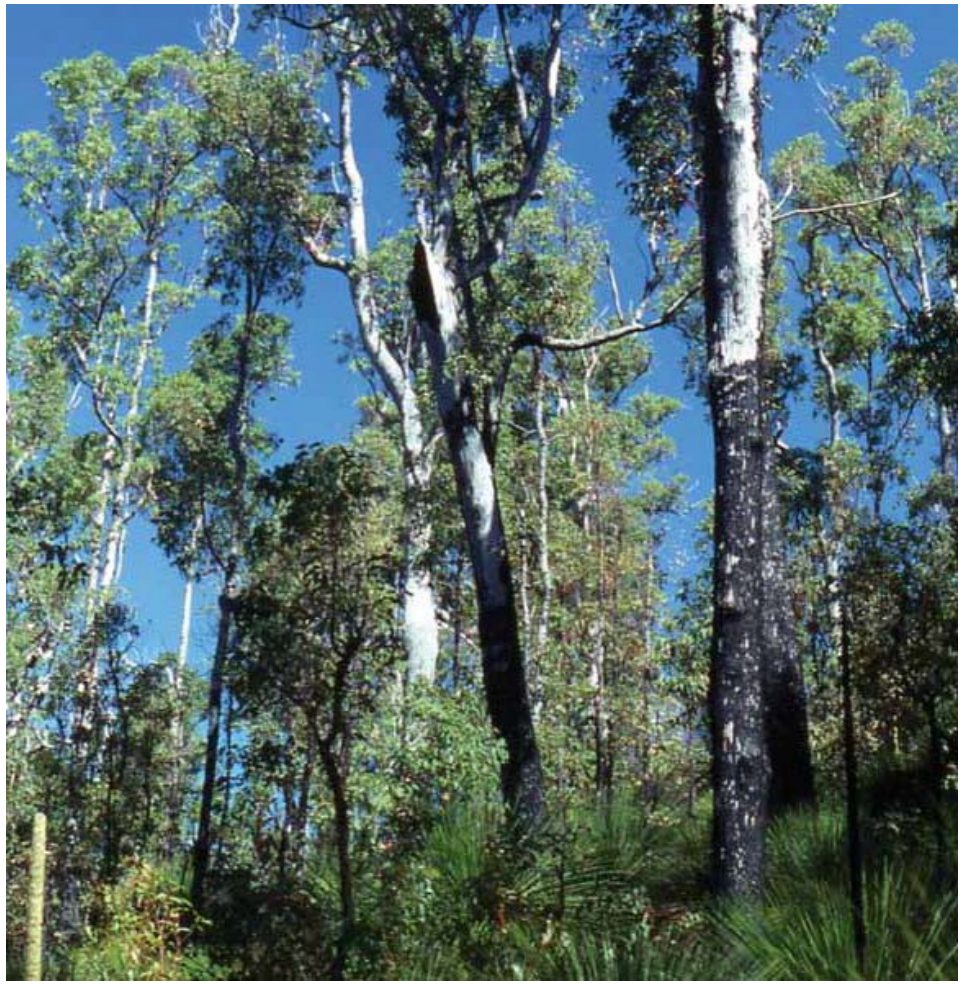
Lecture 10

The Role of Groundwater During Drought : A Modeling Analysis

Moist forest LAI = 5.0

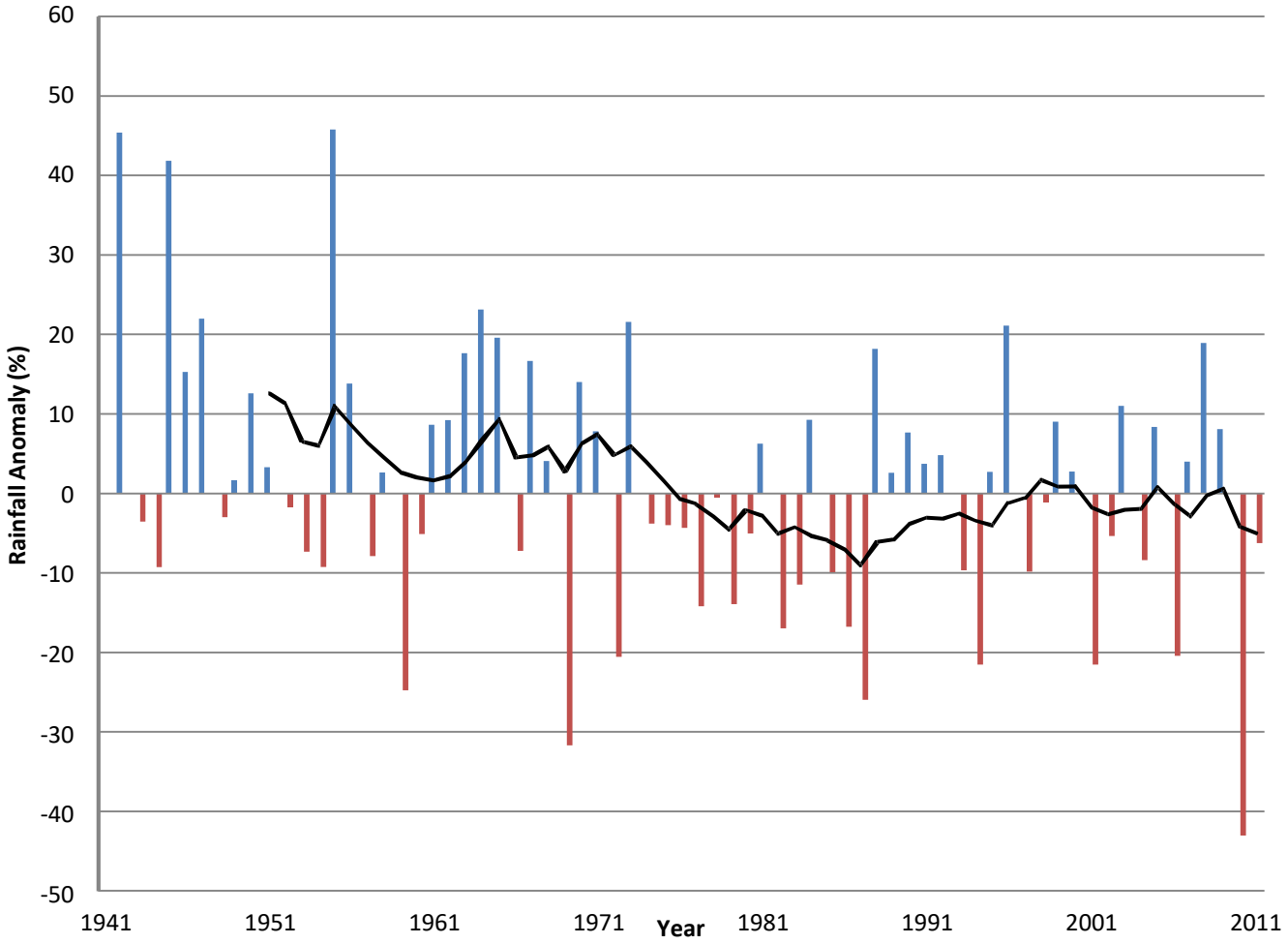
Drier forest, LAI ~ 3.5

Driest forest, LAI ~2.5



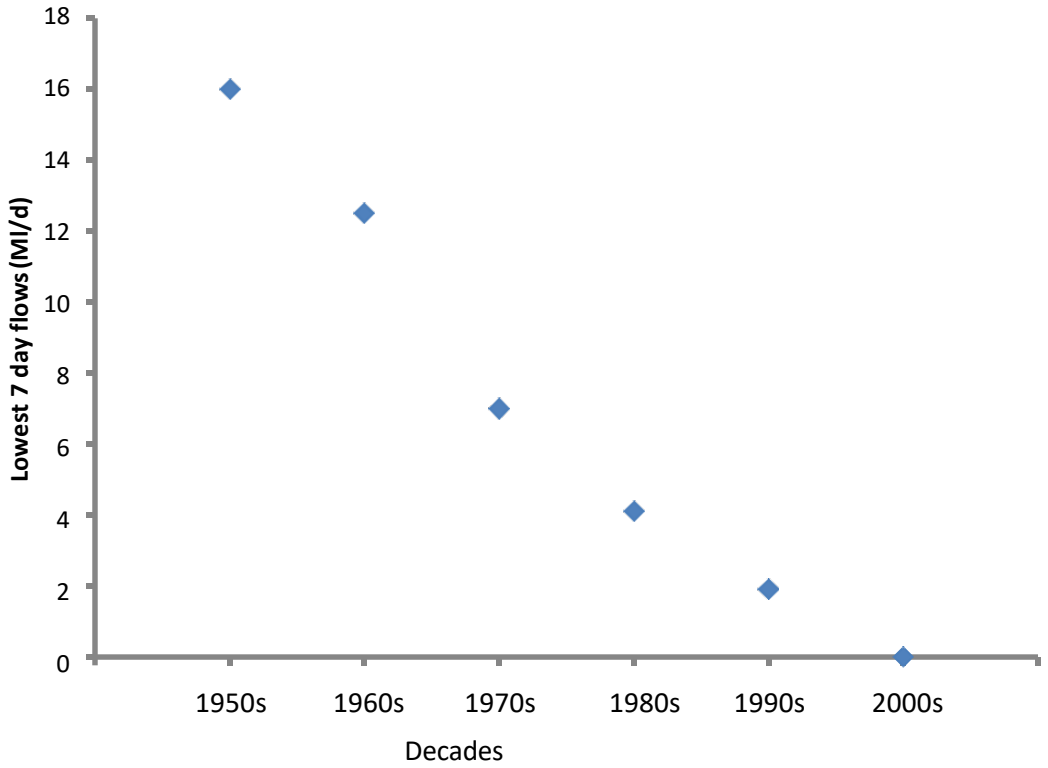
Precipitations

In Western Australia, precipitation has remained below long-term average since 1975



Precipitations

In one watershed, the minimum weekly flow has dropped consistently since the 1950s, with only 2 years of any minimum flow between 2000-2010.



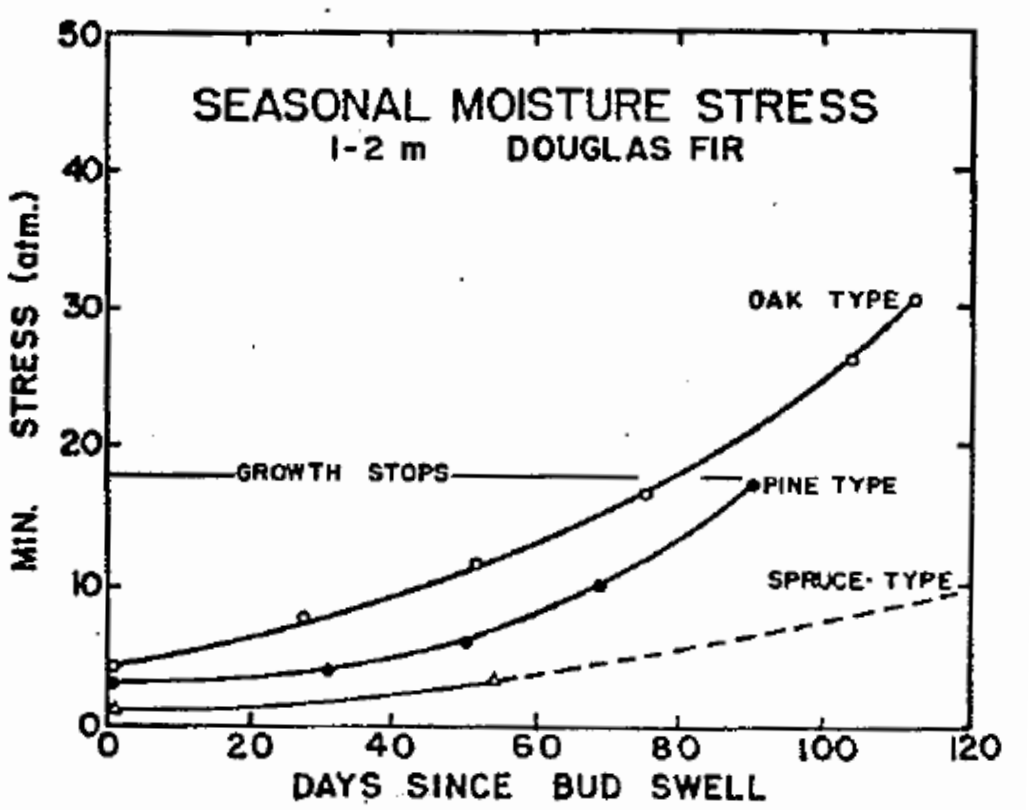
Precipitations and Temperatures

Many forests in Australia are dying back in response to extremes in temperature and record low precipitation (Matusick et al. 2012).

Why is this not the case in the Warren River Catchment?

Matusick et al. 2012. Drought and heat triggers sudden and severe dieback in dominant Mediterranean-type woodland species. Open J. Forestry 2:183-186.

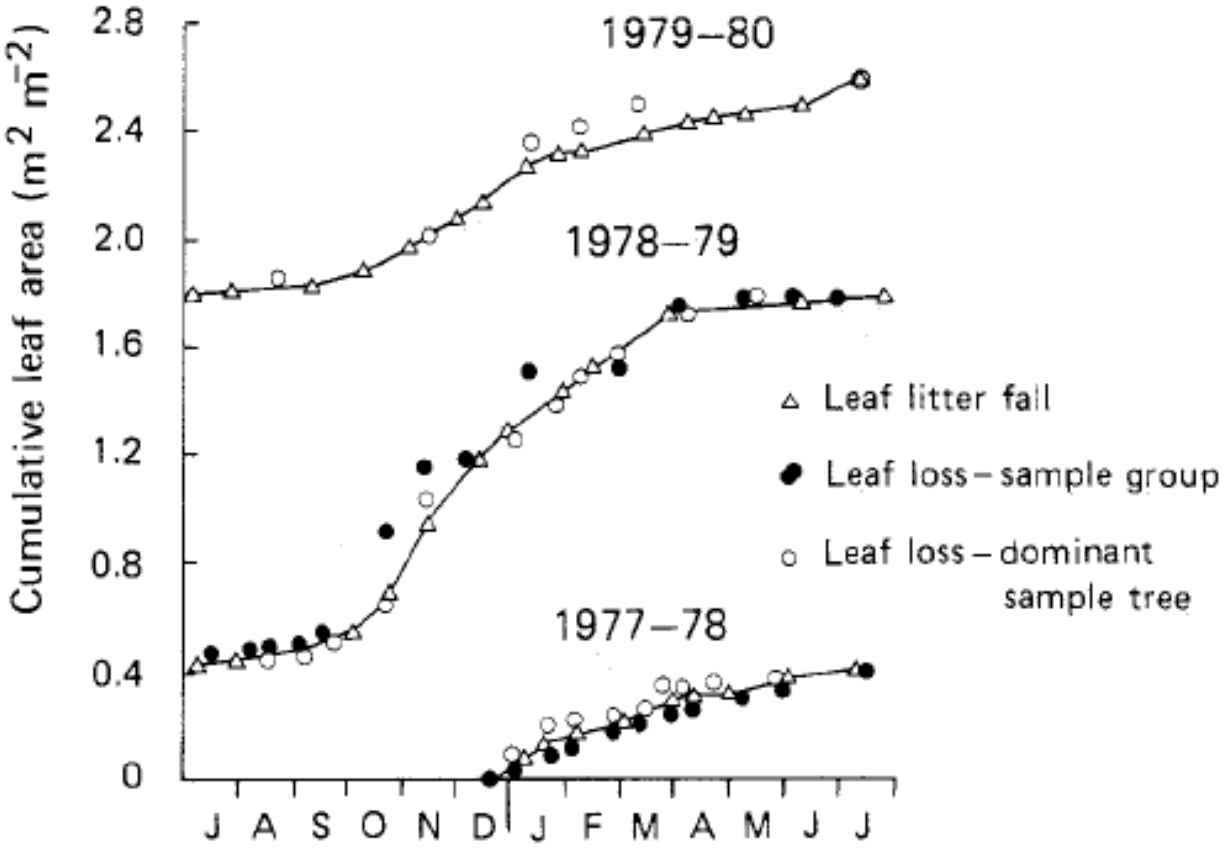
Measure predawn water potential to assess tree access to water



Waring, R.H. 1970. Matching species to site. p. 54-61. IN: R.K. Hermann (ed.), Forest Research Lab., Oregon State Univ., Corvallis, OR

1 atmosphere = - 0.1 Mega Pascals
Trees with continued access to ground water
Pre-dawn potential are not below – 0.5 MPa

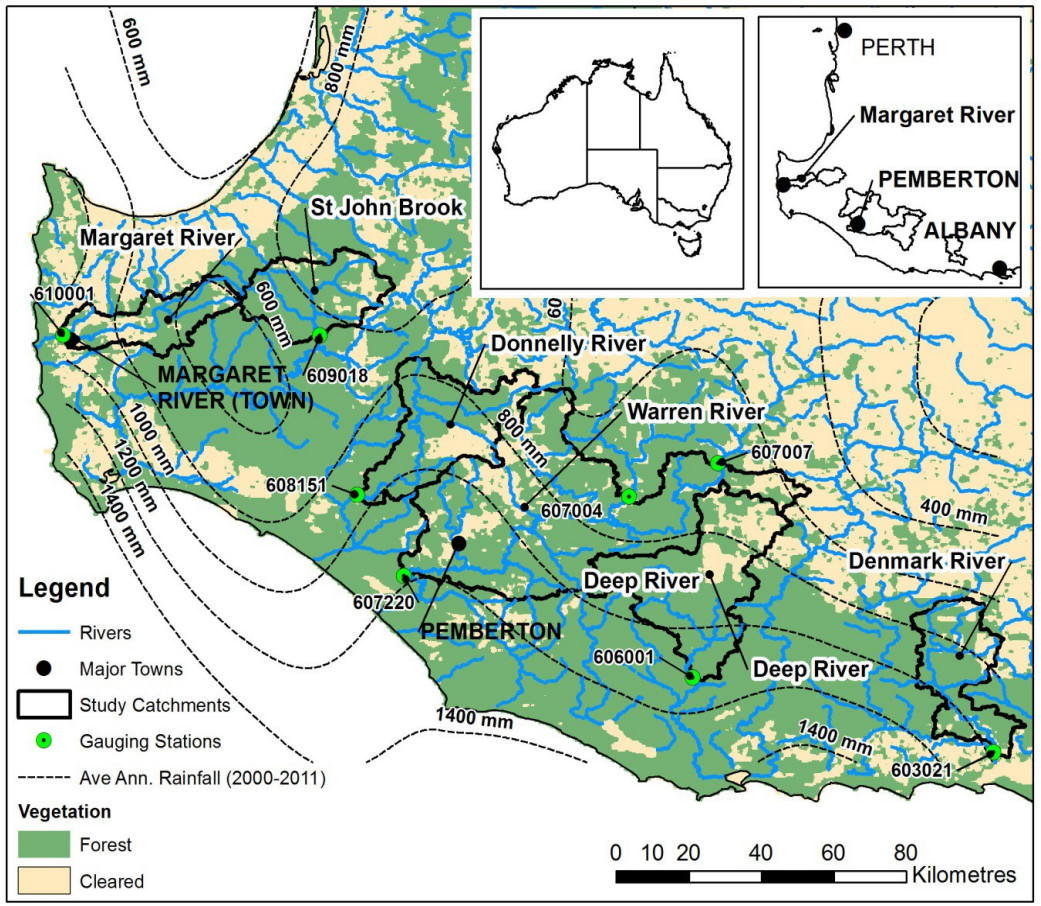
With large variation in annual precipitation we would expect LAI also to vary



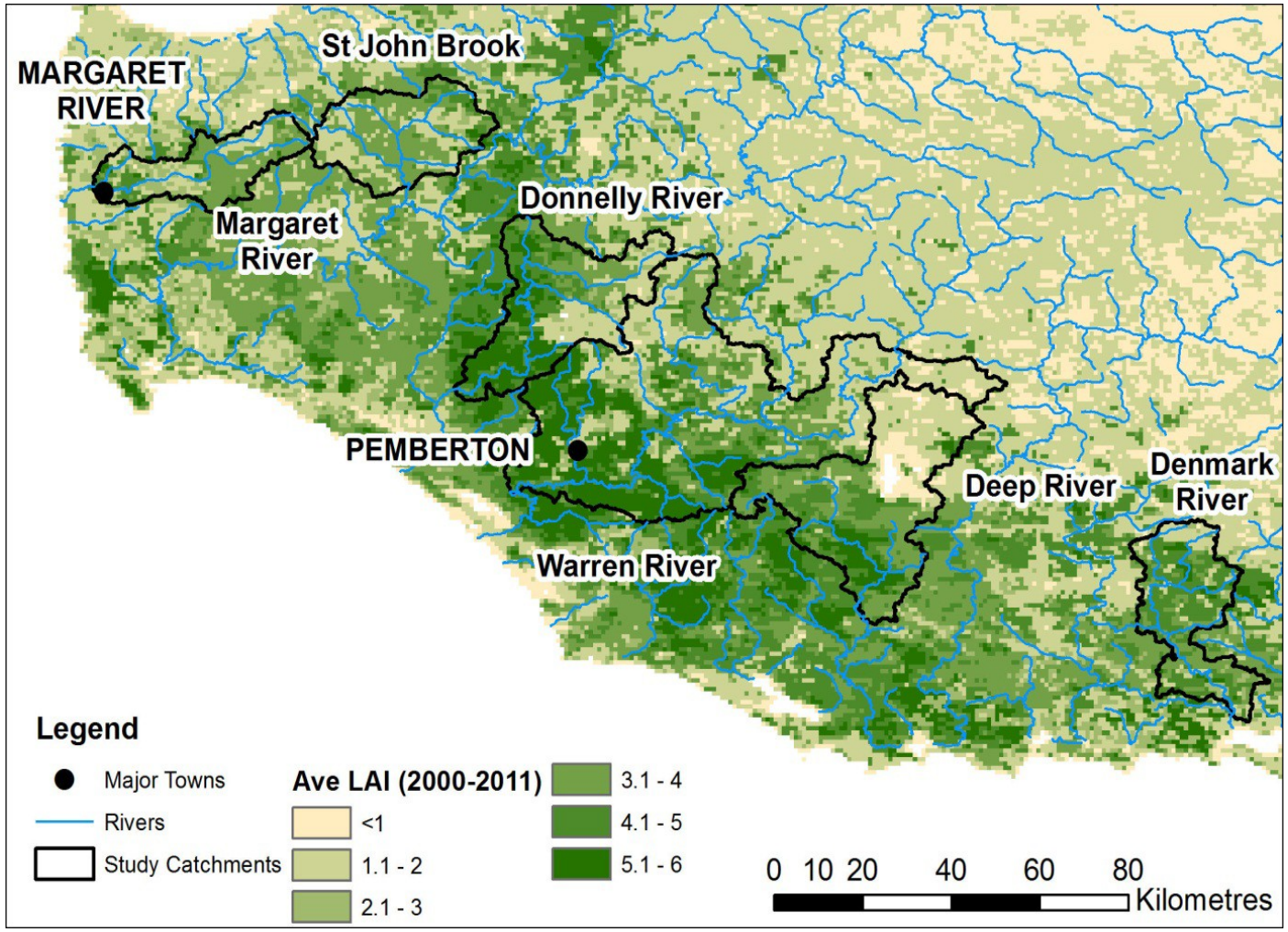
Pook, E.W. 1984. Canopydynamics of Eucalyptus maculata Hook III. Canopy Leaf Area Balance. *Aust. J. Bot*. 32: 405-411.

Precipitation Gradient

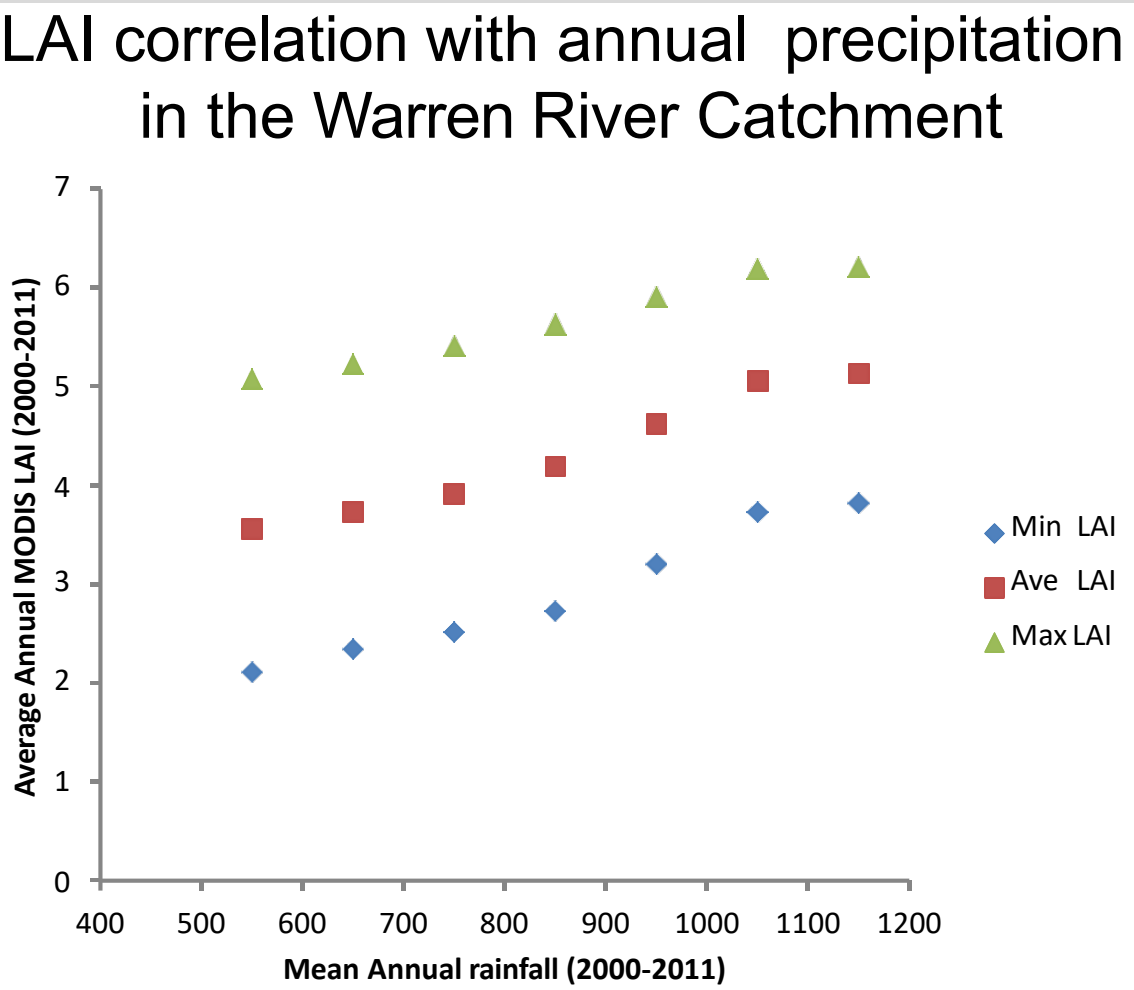
400-1400 mm/year



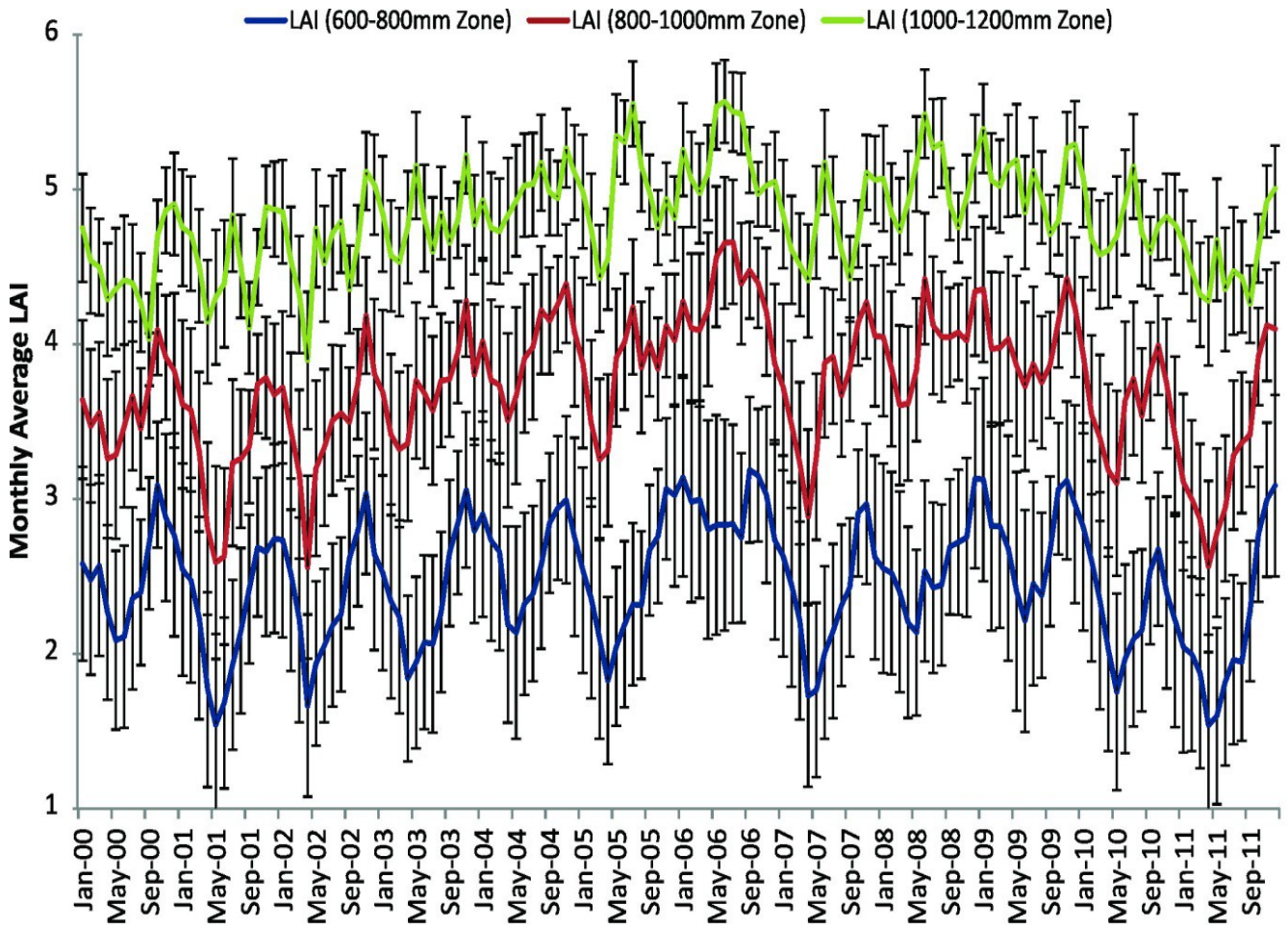
LAI is Correlated With Precipitation



LAI is Correlated With Precipitation



Interannual variation in LAI within three precipitation zones



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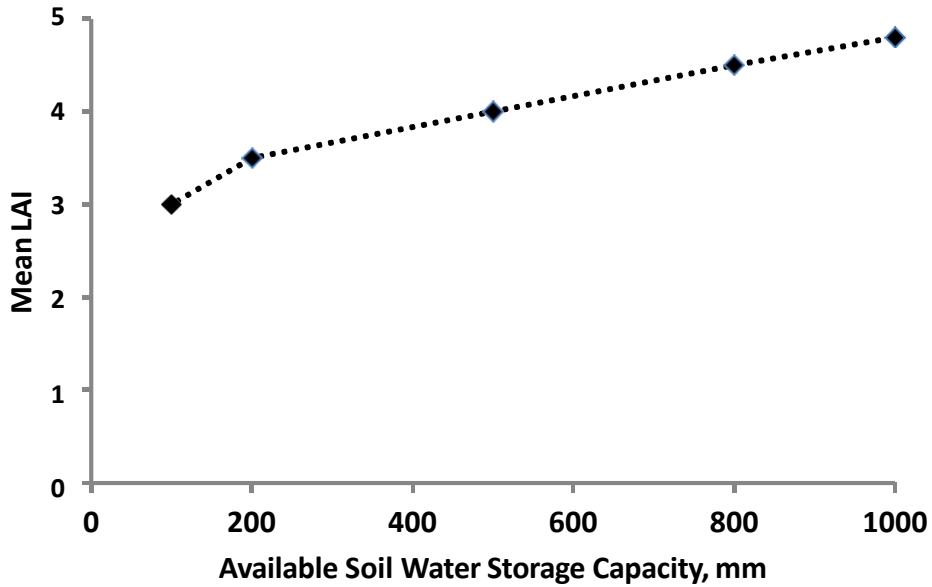
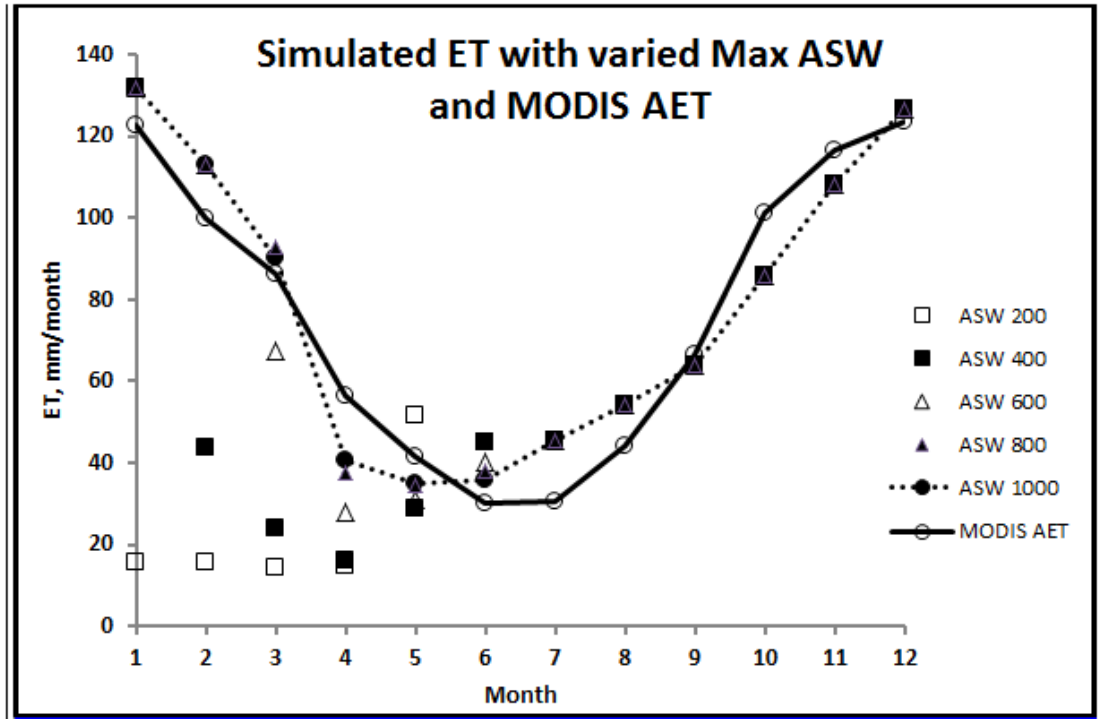
3-PG Model

Use 3-PG model to assess whether access to ground water buffers LAI response to variations in precipitation & to model the water balance



3-PG Model

1st test with 3-PG to find max ASW that produces monthly ET values
in agreement with (Precip.-Runoff-storage) and Satellite-based estimates of ET



Mean Annual Precipitation = 1100 mm
Mean Annual LAI =4.8

3-PG Model

Simulations with the 3-PG Model to estimate Maximum Available Soil Water Storage (max ASW) with varying mean annual precipitation (PR), and mean LAI values: (1) with Max ASW set at 1000 mm and soil fertility (FR) and canopy quantum efficiency (alpha) adjusted (-15% and -23%) to obtain mean LAI values for PR of 900 and 700 mm, and (2) Max ASW required to match LAI values with the adjustments.

Mean PR	LAI	Run No.	FR	Alpha	Max ASW
1100	4.8	1	0.15	0.04	1000
1100	4.8	1	0.15	0.04	1000
900	3.7	1	0.128	0.034	1000
900	3.7	2	0.128	0.034	700
700	2.5	1	0.1	0.027	1000
700	2.5	2	0.1	0.027	550

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Conclusions

1. **In drought-prone areas, we expect LAI to be in balance with available water supply & trees to experience water stress and reduction in transpiration**

2. **If LAI appears relatively unresponsive to large variations in precipitation, consider possibility that trees have access to groundwater**

3. **Can verify tree access to groundwater by measuring predawn-plant water potential, stable isotopes of water, and by monitoring sap flux and ET**

4. **Stable isotopes of water in trees should match that of the stream or groundwater if that is the source during periods of drought.**

5. **Process-based models can estimate tree access to groundwater by constructing a soil water balance whereby max ASW values are adjusted until they match remotely-sensed LAI and independent measurements of ET**

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References

Smettem, K.R.J., R.H. Waring, N. Callow, M. Wilson, and Q. Mu. 2013. Satellite -derived estimates of forest leaf area index in South-west Western Australia are not tightly coupled to inter-annual variations in rainfall: implications for groundwater decline in a drying climate. *Global Change Biology* (in press).

O'Grady, A.P., D. Emus, P.G. Cook, & L. Lamontage. 2005. Compative water Use by the riparian trees *Melaleuca argentea* and *Corymbia bella* in the wet- dry tropics of northern Australia. *Tree Physiology* 25:2190228.

Eamus, D., Froend, R., Loomes, R., Hose, G. & Murray, B. 2006. A functional methodology fordetermining the groundwater regime needed to maintain the health of groundwater dependent vegetation. *Australian Journal of Botany* 54, 97–114.

http://lwa.gov.au/files/products/innovation/pn30129/pn30129_1.pdf