Can carbon biomass capture threaten our water resources?

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THEORETICAL PAPER

A critical appraisal of a combined stomatal-photosynthesis model for C_3 plants

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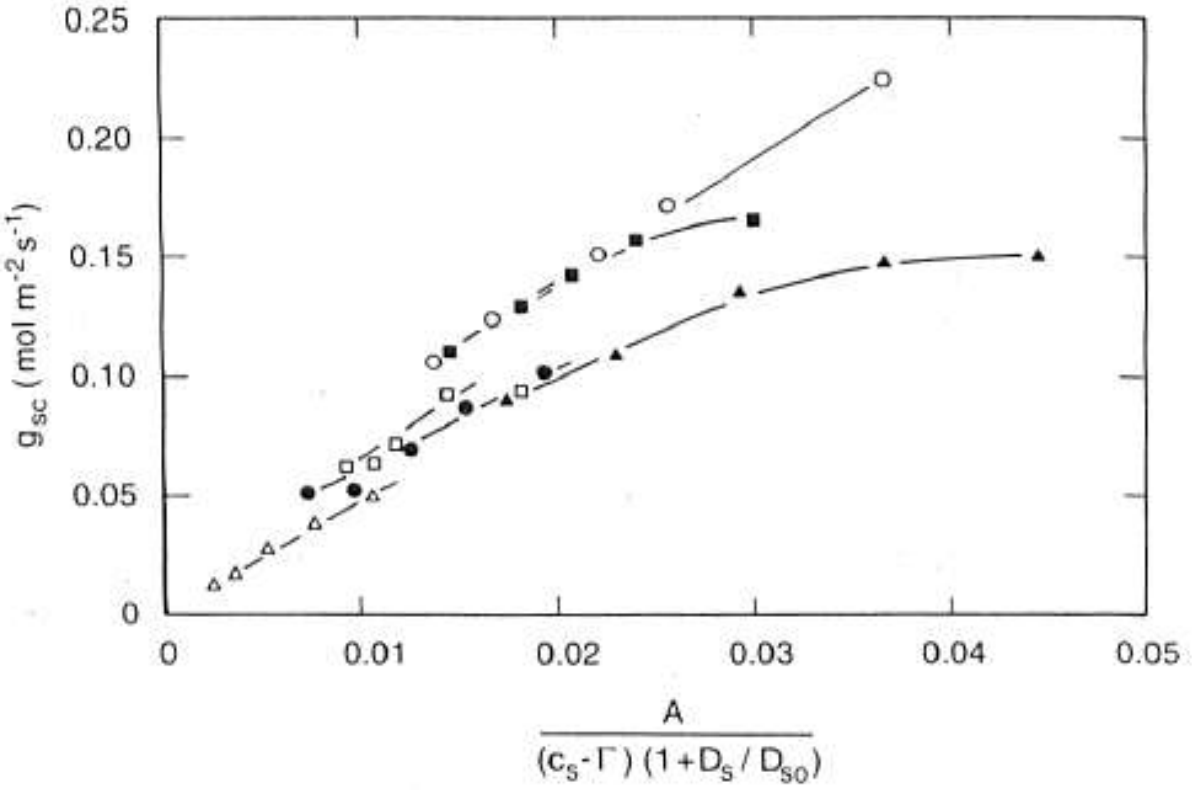


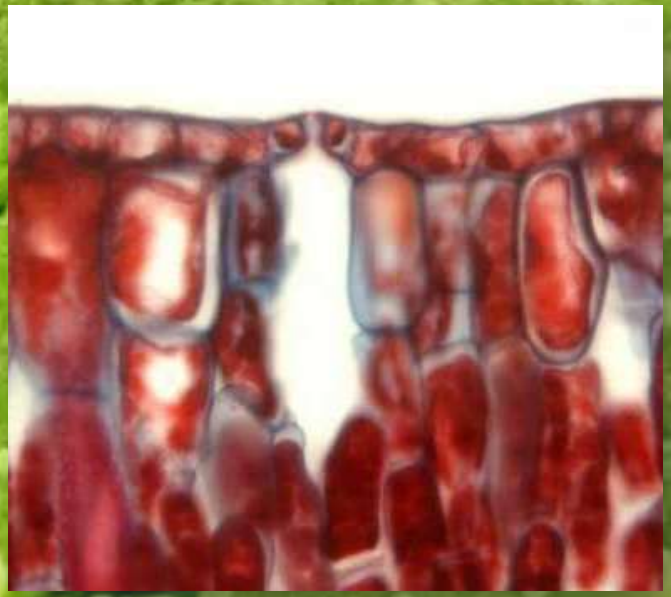
692 citations

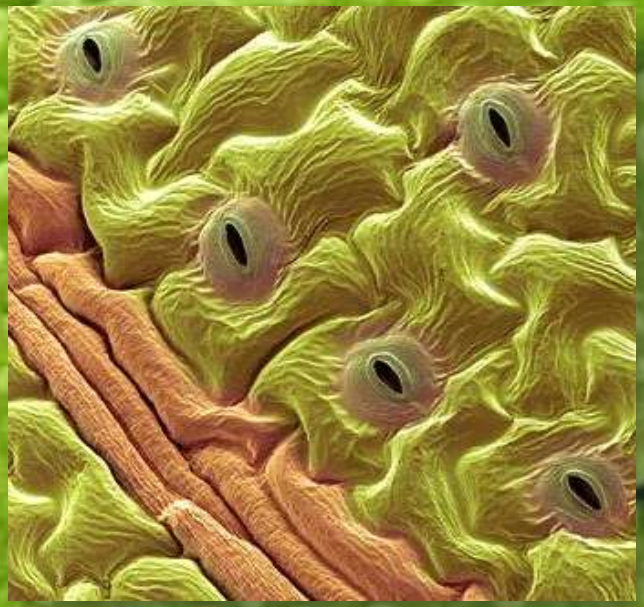
“Stomata have evolved physiological control mechanisms to satisfy the conflicting demands of allowing a net carbon gain by leaves while restricting water loss to acceptable levels, under a range of environmental conditions.

The literature on stomatal behaviour is extensive, testimony to the fascination of this topic for many researchers working from the scale of guard cells to those of leaves, single plants and whole communities.”

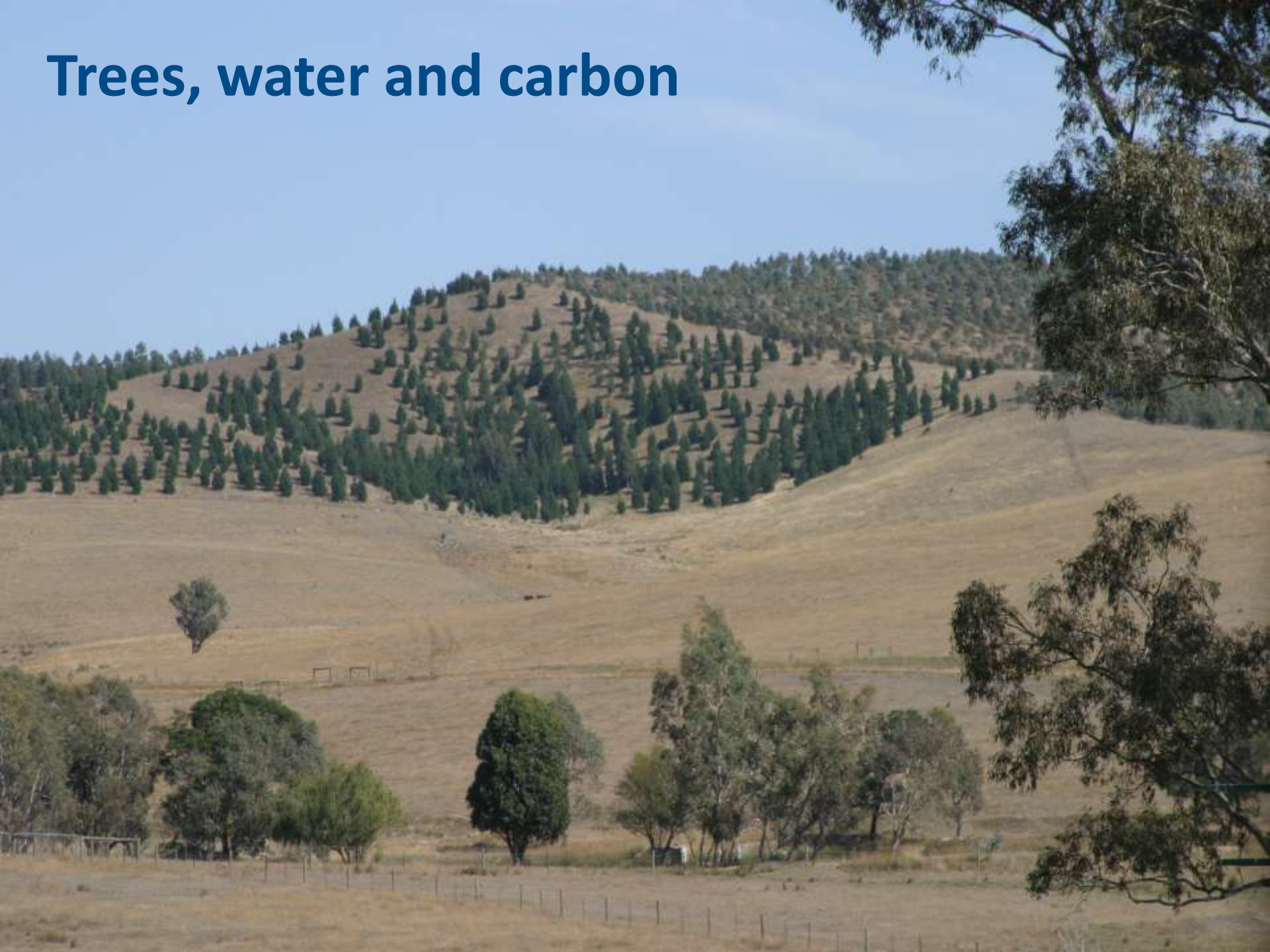
Leuning (1995)

Figure 1. Stomata





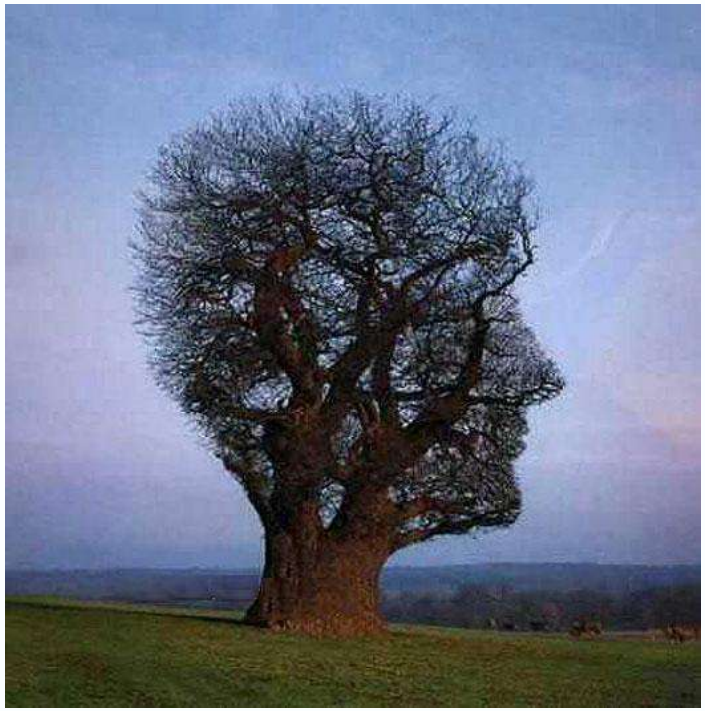
Trees, water and carbon



Factoids

It takes about:

- 3 trees to sequester the CO_2 exhaled by 1 person
- 1 tree to intercept the amount of water drank by 4 persons



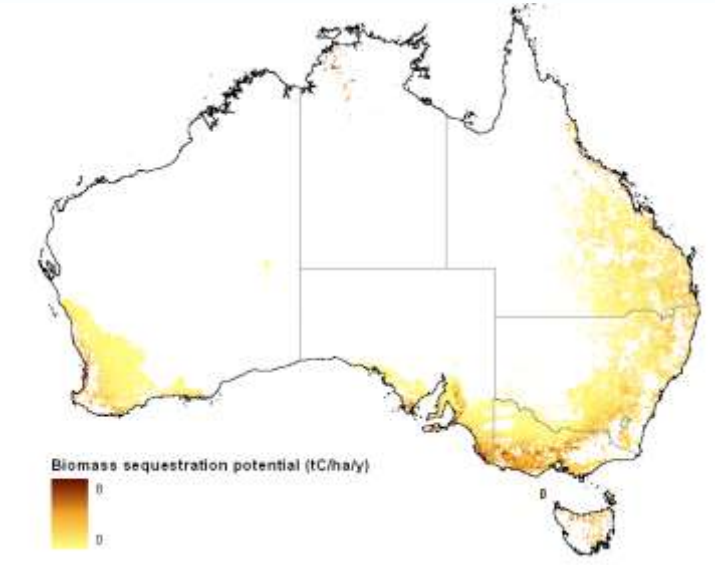
© puzzles

But also it takes:

- 200 trees to sequester the CO_2 emitted by 1 Australian
- 200 trees to intercept the water resources used by 1 Australian

The difference is **food** and **energy**..

Trees store carbon – good trees!



Biomass sequestration potential
(AWRA-L+C model estimates)

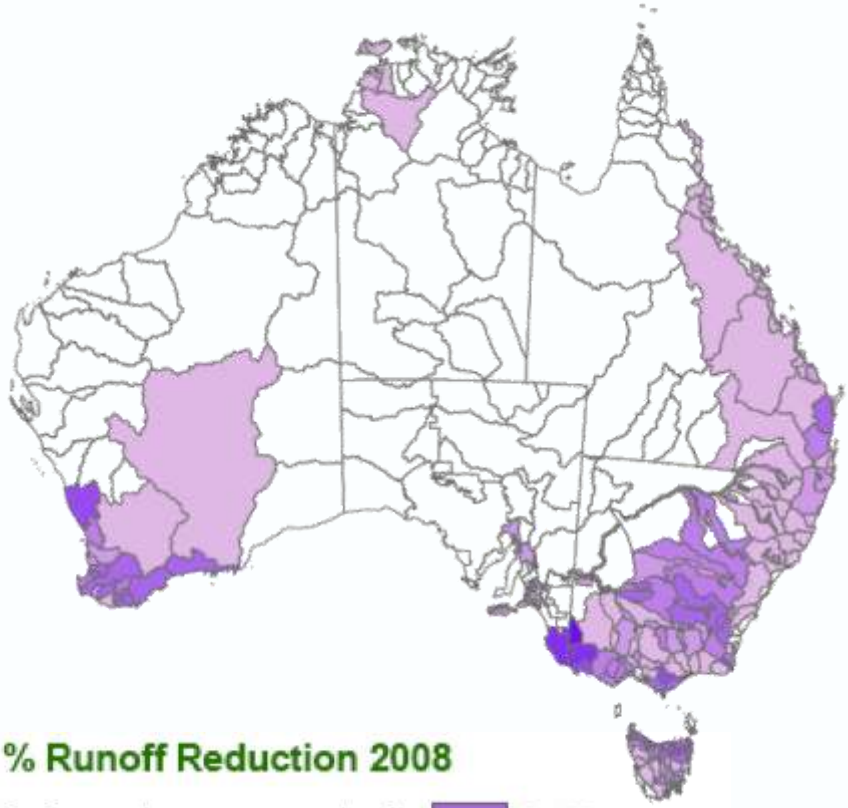
- About 10% of Australia could be re/afforested (*in theory* - but what would we eat?)
- Theoretical potential 143-750 m tCO_2-e /y (Garnaut report; CSIRO, 2009)

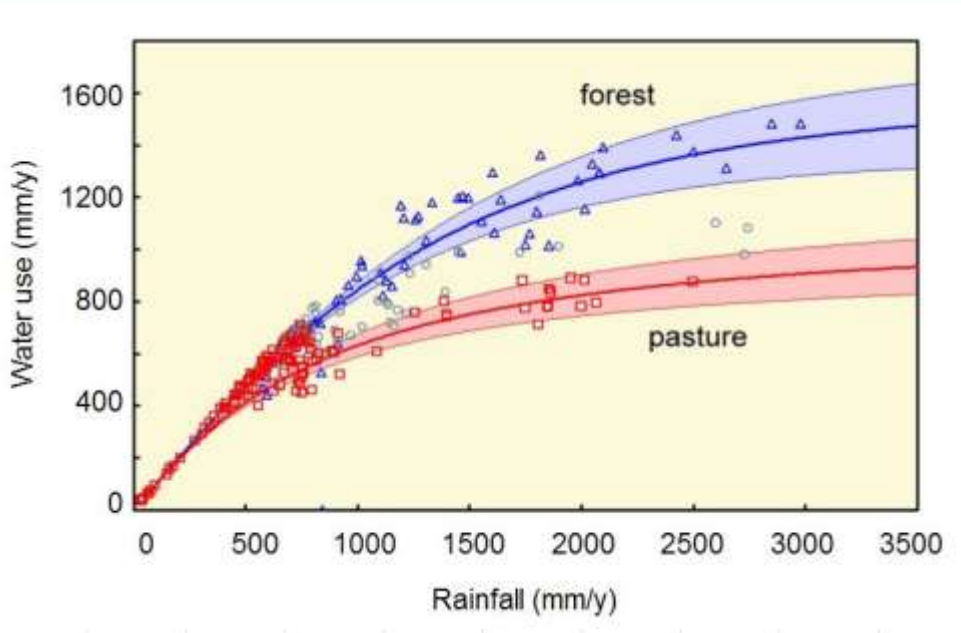
This represents:

- 7 ±5 % of current continental biological uptake
- 70 ± 50% of Australia's annual emissions

Trees use water – bad trees!

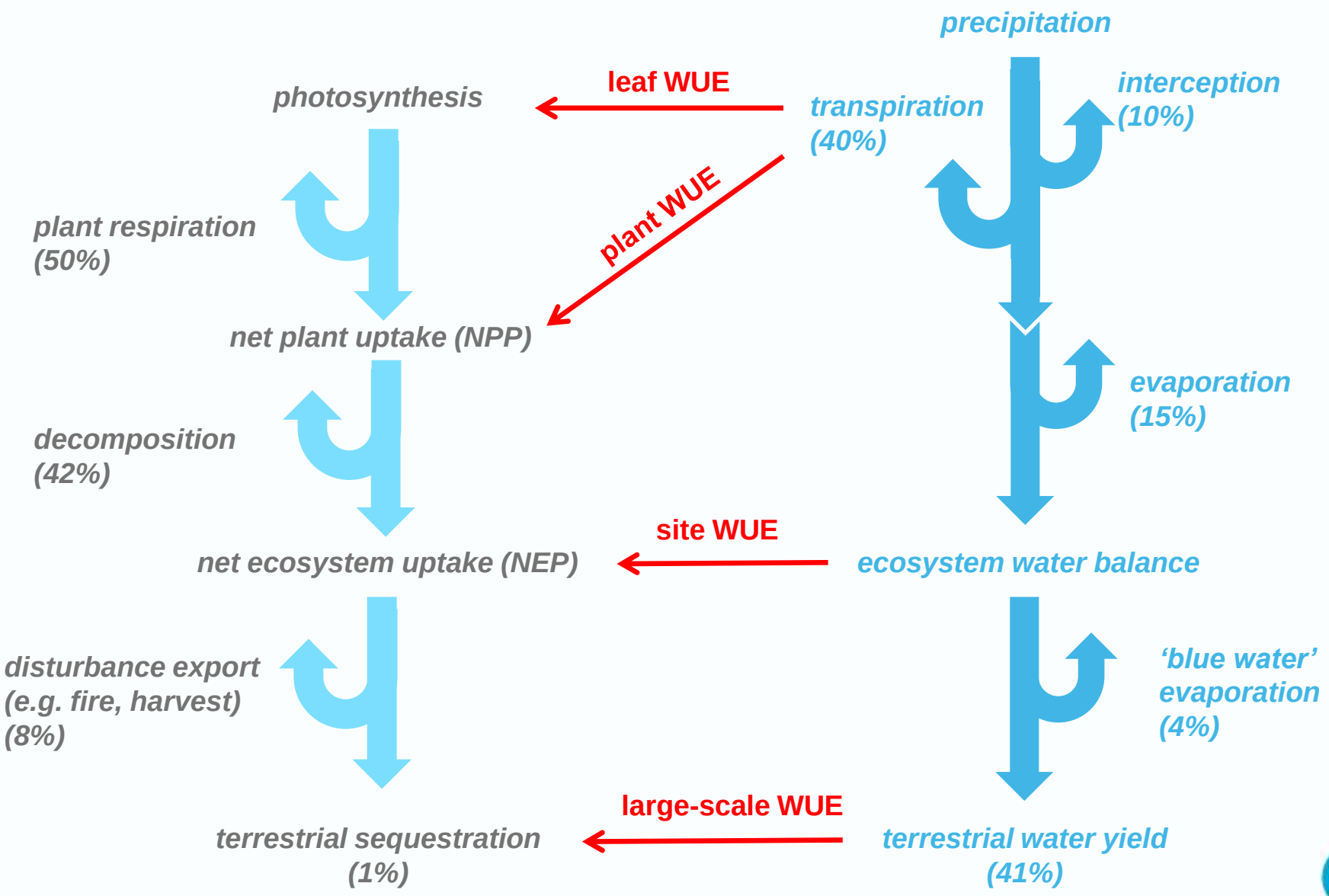
"Forestry plantations use approximately 2,000 GL/yr"
(SKM/CSIRO/BRS for NWC, 2010)





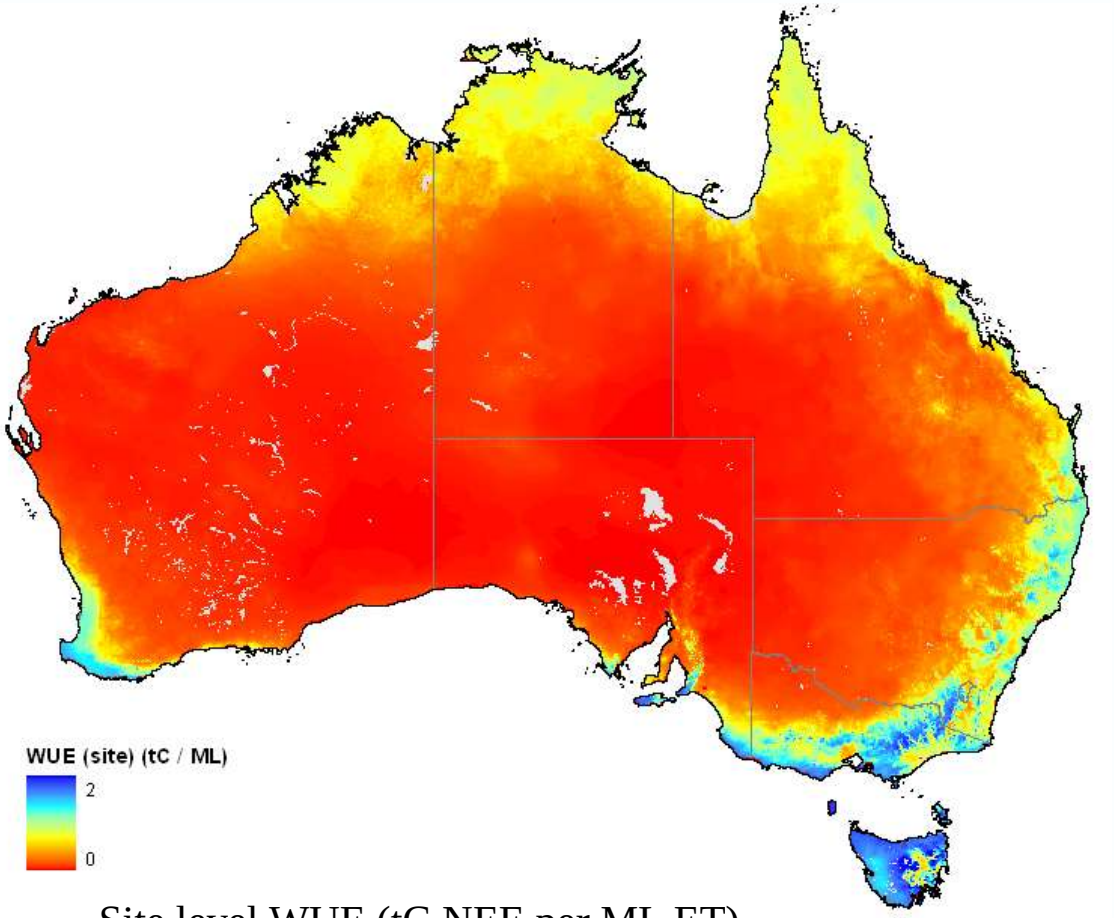
Zhang et al. (2001)

Water use efficiency at different levels



Oki & Kanae, 2007; Steffen, 1998

Site-level WUE



Site level WUE (tC NEE per ML ET)

(AWRA-L+C model estimates)

- Model-estimated site-level WUE for deep-rooted vegetation
- Site-level WUE is very different from leaf level WUE
- Winter-dominant precipitation enhances WUE
- (WUE increases +0.5% each year)

Marta Yebra

OCE post doc

Figure 1. Stomata

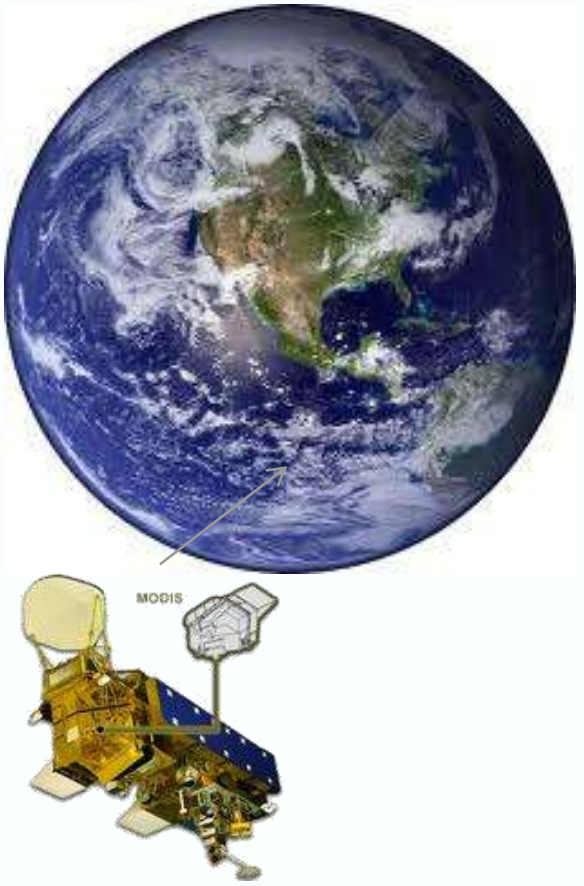
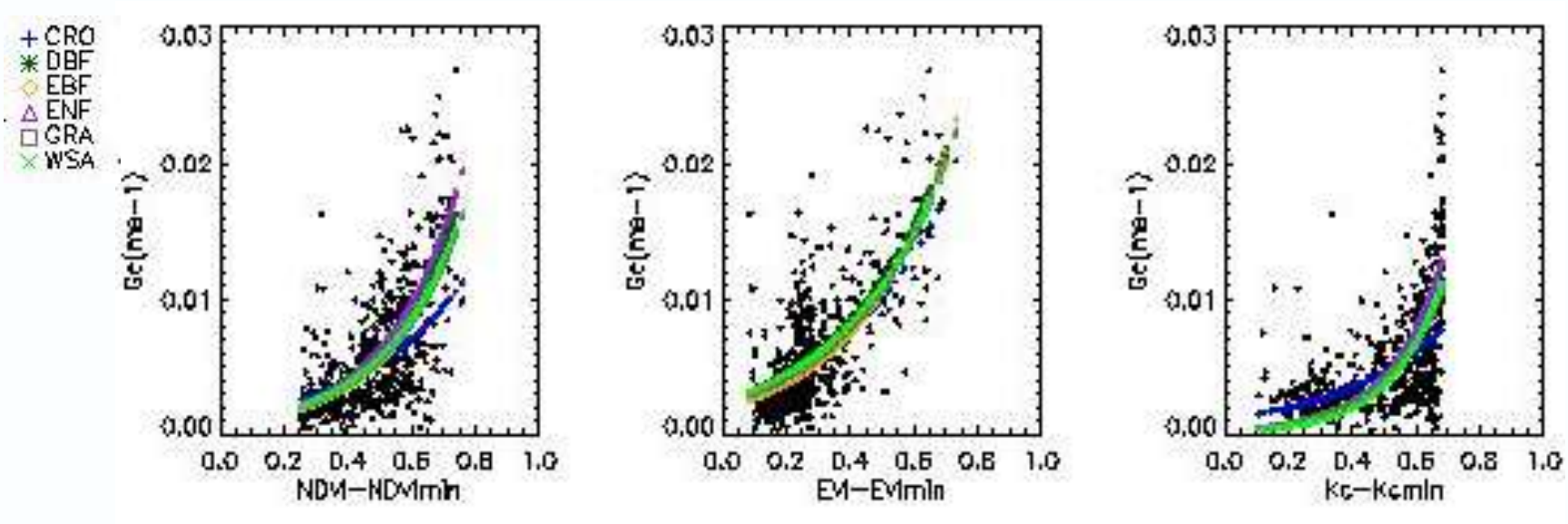


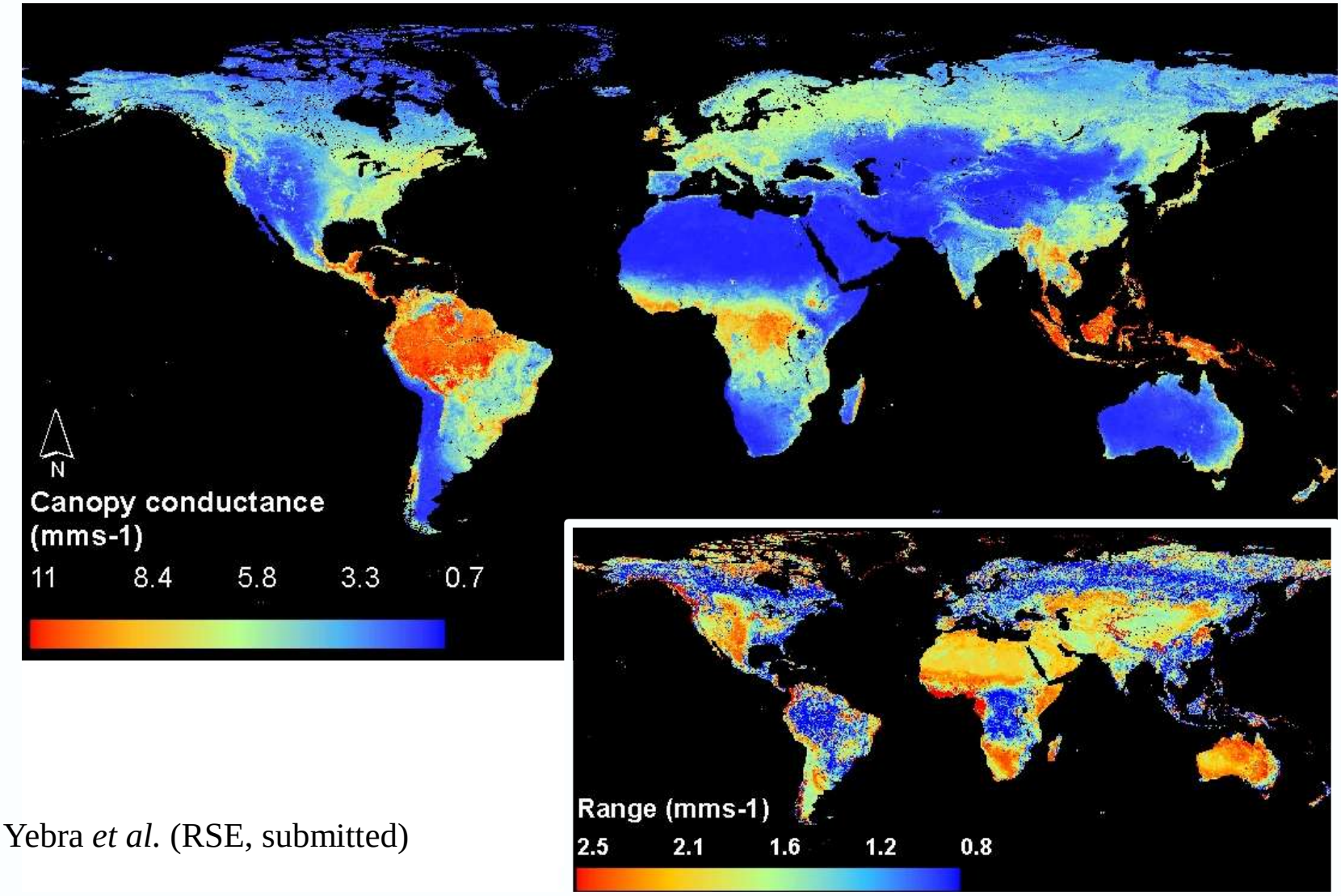
Figure 2. **Planet**

10^{-4} m

10^{7} m

$$G_s = \left[\frac{\varepsilon A}{\lambda E} - (1+\varepsilon) + \frac{(\rho C_\rho/\gamma)\times D}{\lambda E}\right]^{-1}$$



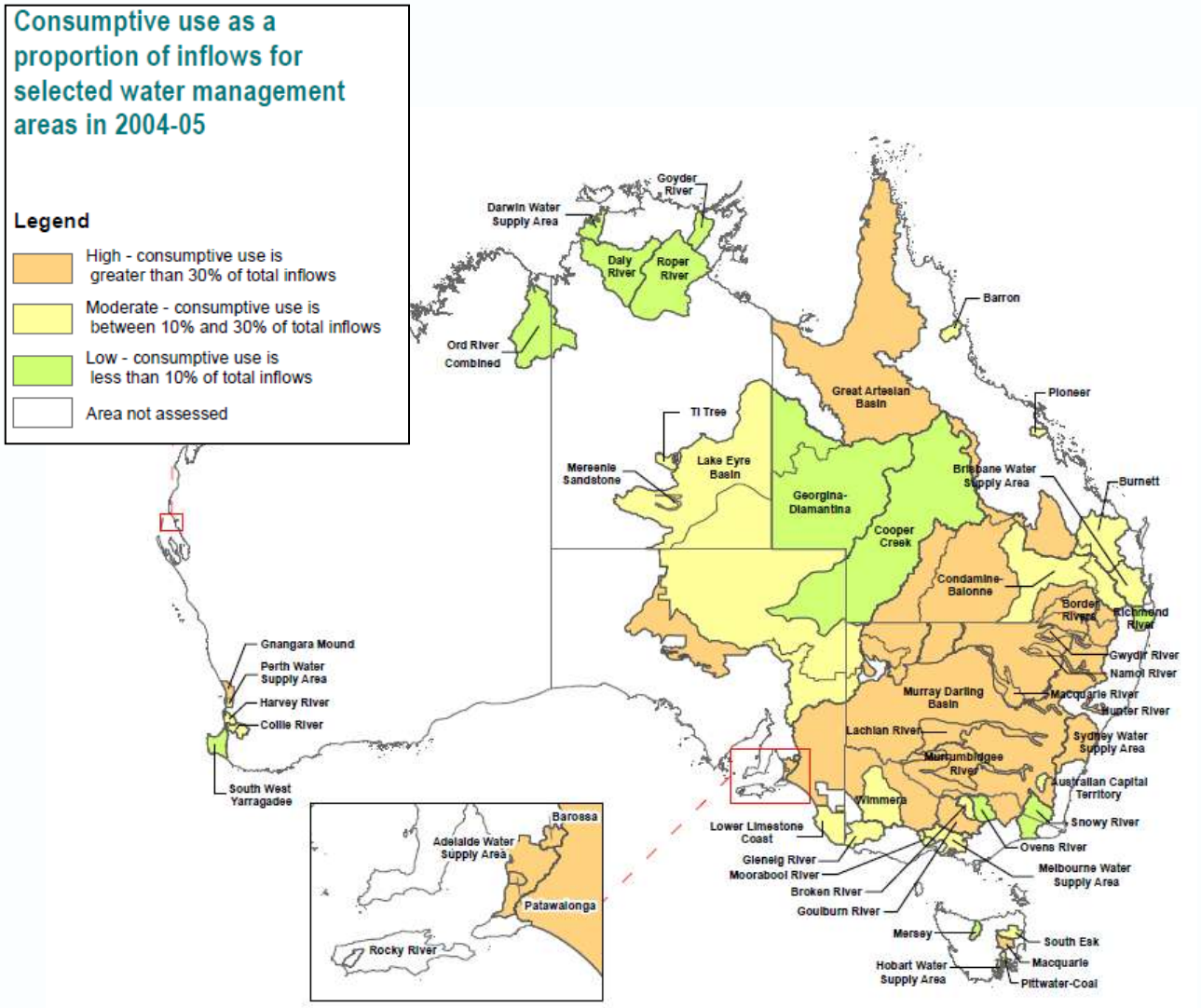


Yebra *et al.* (RSE, submitted)

So, can carbon biomass capture threaten our water resources?

Complicating factors

Water resources are not very mobile



- Many water systems are underdeveloped
- Others are fossil
- Realistic impacts negligible in basins <2,000 km^2
- Small catchments: Afforestation usually improves water quality and restores pre-European flow regime.

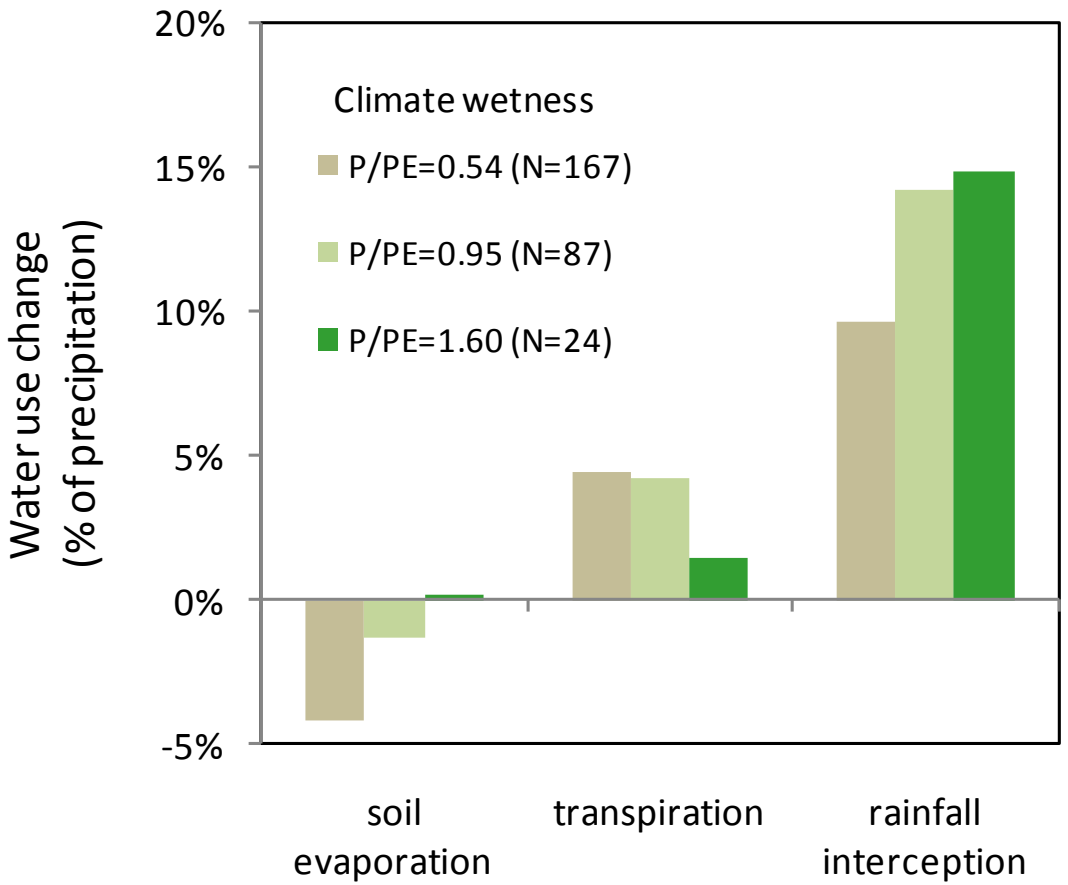
(Van Dijk *et al.*, For. Ecol. Man. 2007)

Australian Water Resources 2005, *http://www.water.gov.au*

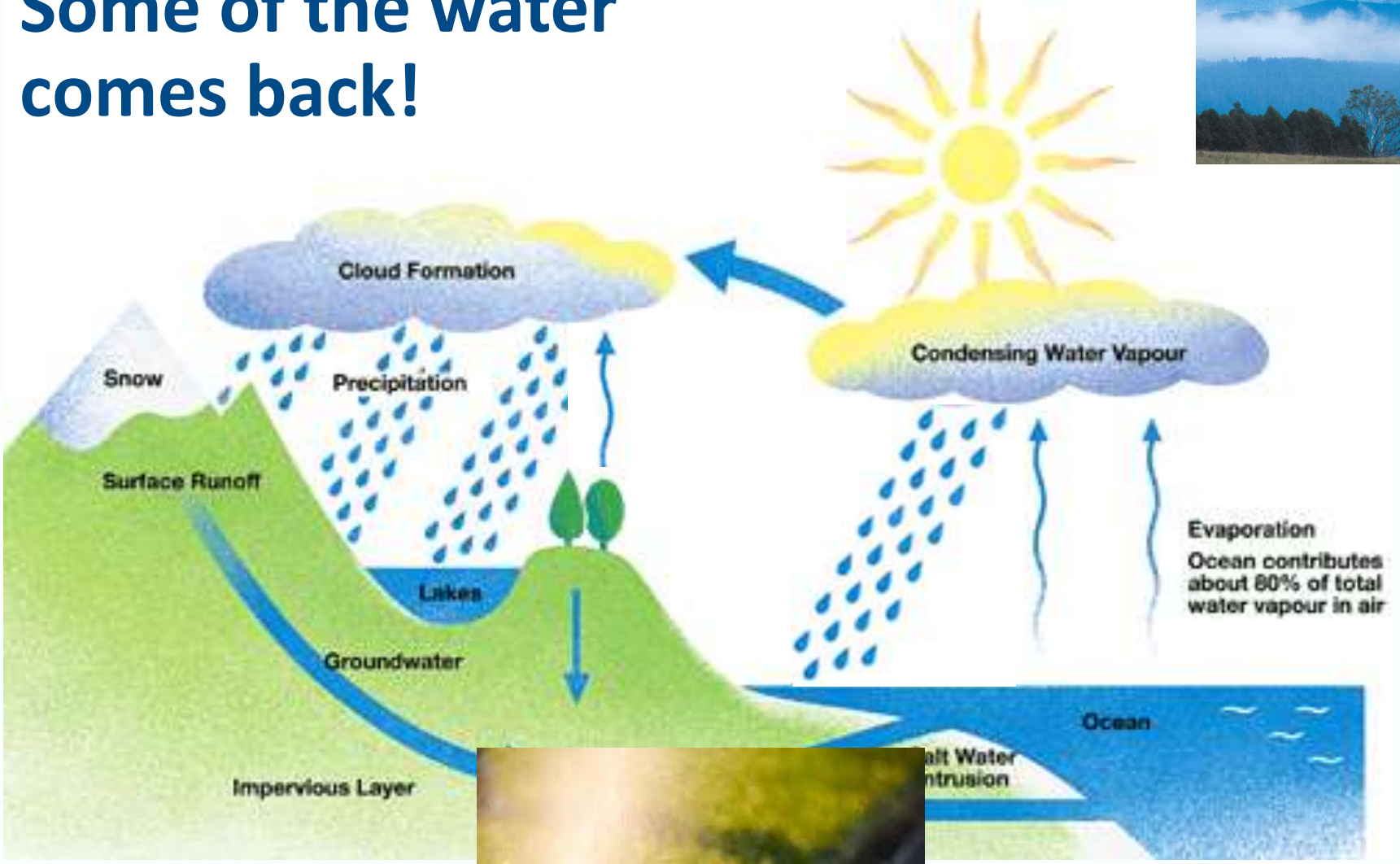
Why do forests ‘intercept’ water?

Estimated changes in evapotranspiration components after afforestation

(Van Dijk *et al.*, HESSD, 2012)



Some of the water comes back!

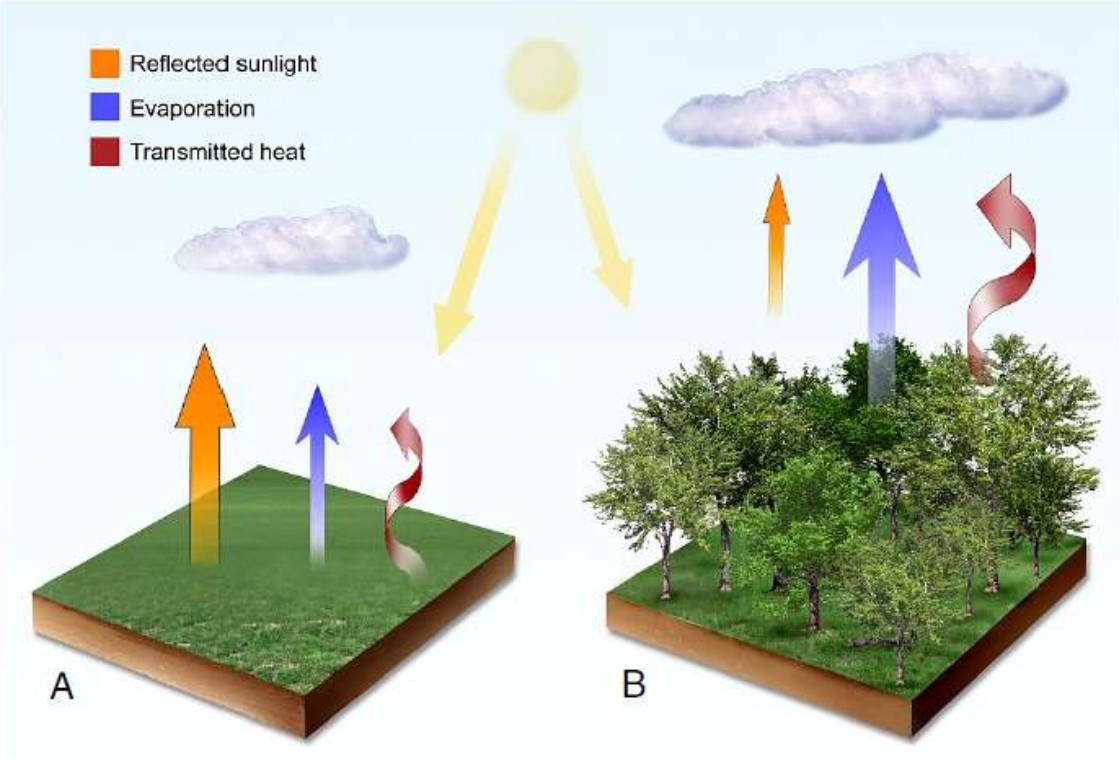


Government of South Australia

SA Water

CSIRO

Afforestation also influences global warming in other ways



Afforestation can cause:

- ✘ less radiation reflection
- ✘ more air moisture
- ? more volatile compounds
- ? reduced wind speed
- ✓ more cloud formation
- ✓ local cooling
- ✓ increased rainfall

Jackson et al., 2008

Good trees...

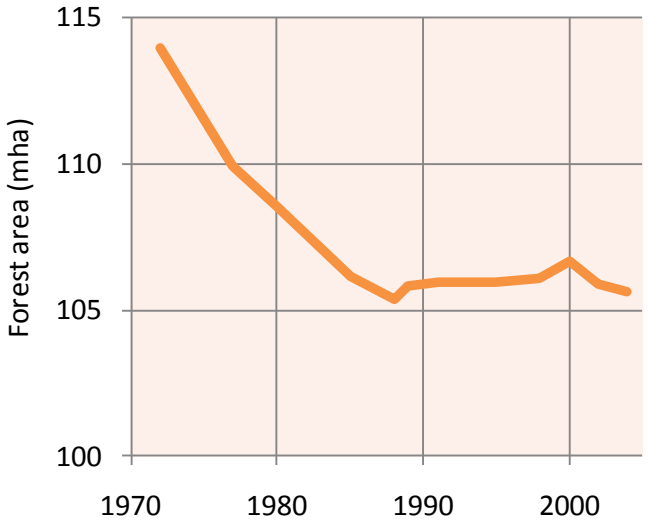
Water resource use!

Bad trees!

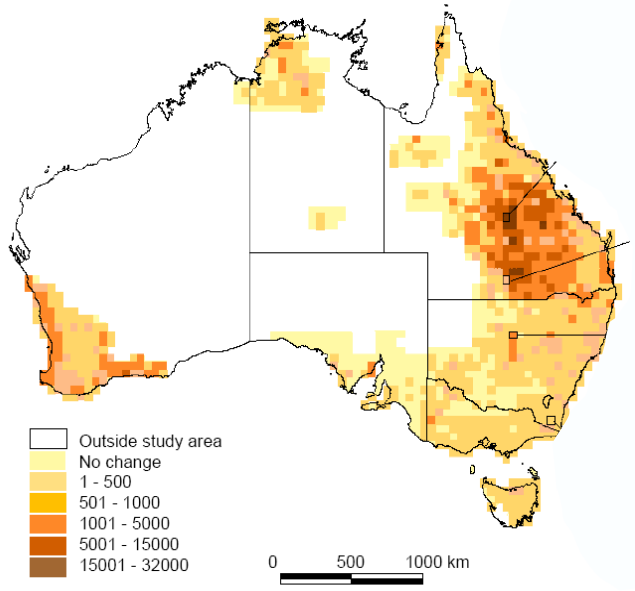
Carbon emission! (CFI)

Deforestation vs. afforestation

- The area of forest has reduced >8m ha (>7%) since 1973
- 1999-2008 clearing rates ca. 300k ha/y (6x afforestation rates)
- 13% to Australia's total emissions
- Reverting this 8m ha may reduce annual emissions by ~5%



NCAS, 2007



Can carbon biomass capture threaten our water resources?

1. The water-carbon tradeoff (water use efficiency) can be defined in several ways, leading to different patterns.
2. Canopy conductance is a key variable. It can be derived from satellite observation.
3. **The impact of afforestation tends to be overstated**: *both* on carbon sequestration and water resources.
4. Water 'interception' by forests can increase water availability downwind.
5. Afforestation affects local and global climate in several other ways.
6. Regrowth and avoided deforestation may be better means of carbon sequestration than plantation forestry.
7. Views and policies on trees tend to be irrational and contradictory. There are no 'good' or 'bad' trees!

Where’s the good tree?