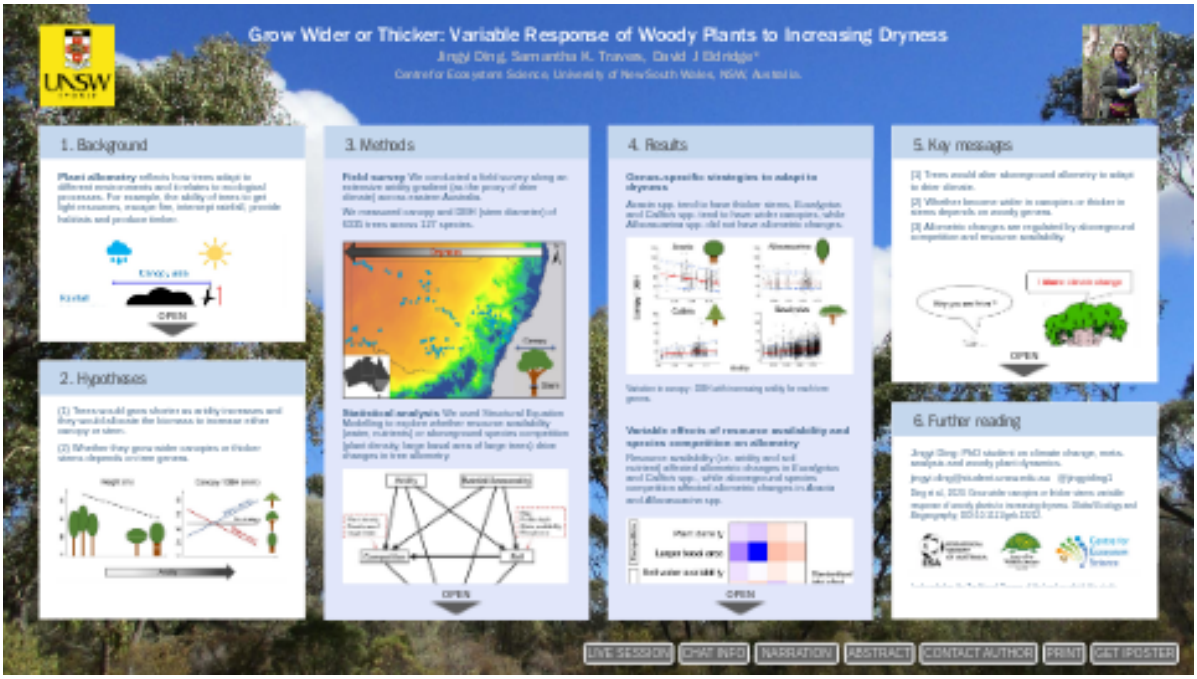
Grow Wider or Thicker: Variable Response of Woody Plants to Increasing Dryness



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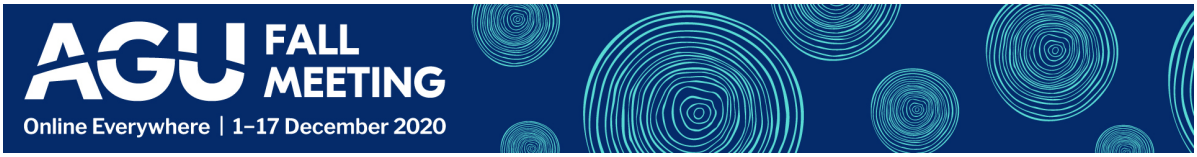
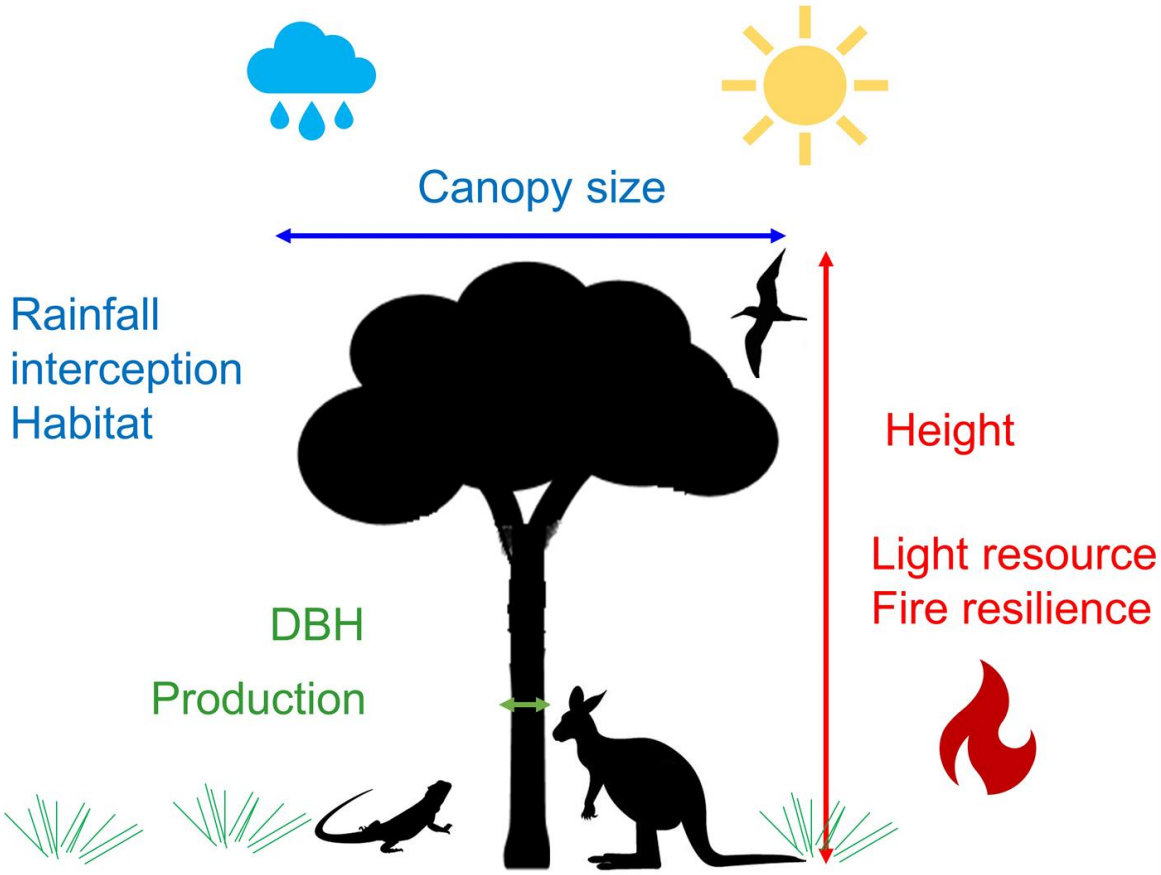
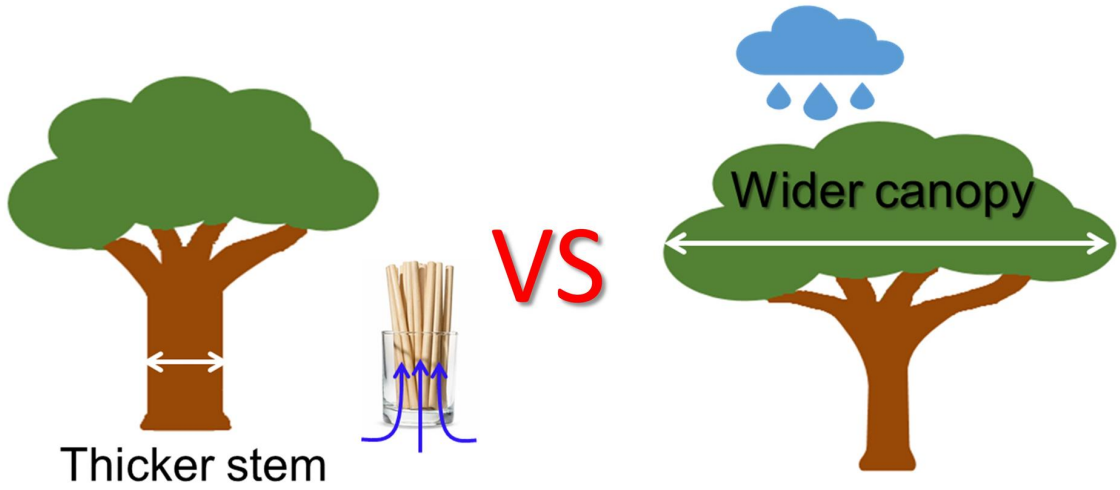


1. BACKGROUND

Plant allometry reflects how trees adapt to different environments and it relates to ecological processes. For example, the ability of trees to get light resources, escape fire, intercept rainfall, provide habitats and produce timber.



Thicker or wider? Trees can adapt to drier climate by thickening stems to pipe more water or expanding canopies to increase water interception.



Questions

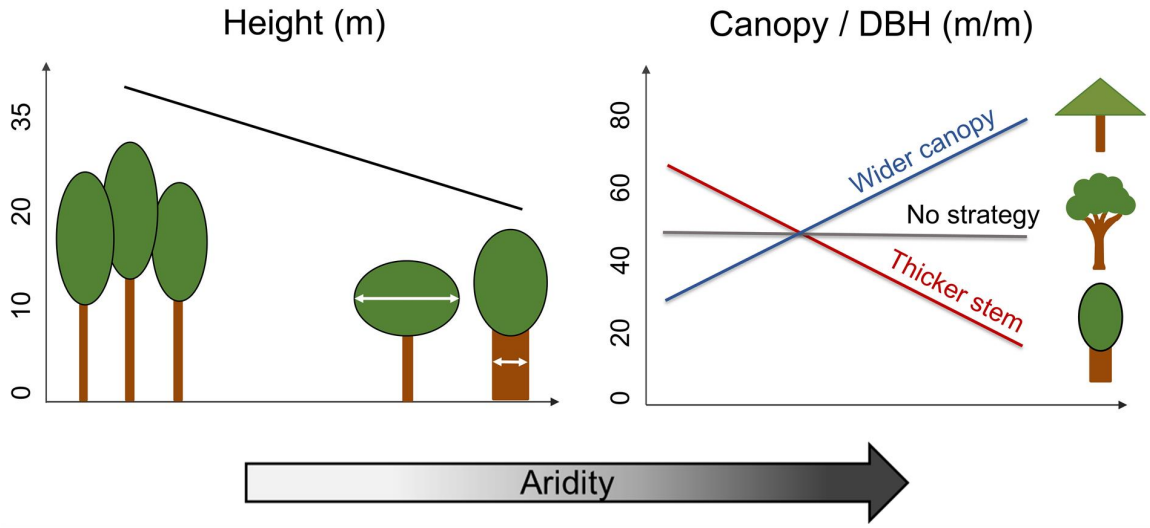
1) Which strategy will trees choose under drier climate?

2) Whether resource availability or species competition drives tree allometry?

2. HYPOTHESES

(1) Trees would grow shorter as aridity increases and they would allocate the biomass to increase either canopy or stem.

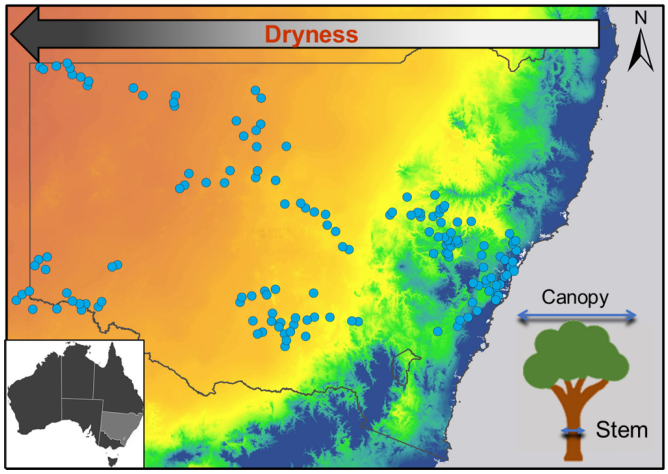
(2) Whether they grow wider canopies or thicker stems depends on tree genera.



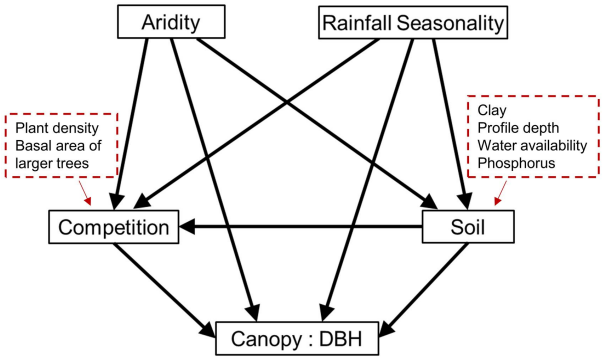
3. METHODS

Field survey We conducted a field survey along an extensive aridity gradient (as the proxy of drier climate) across eastern Australia.

We measured canopy and DBH (stem diameter) of 6335 trees across 127 species.



Statistical analysis We used Structural Equation Modelling to explore whether resource availability (water, nutrients) or aboveground species competition (plant density, large basal area of large trees) drive changes in tree allometry.

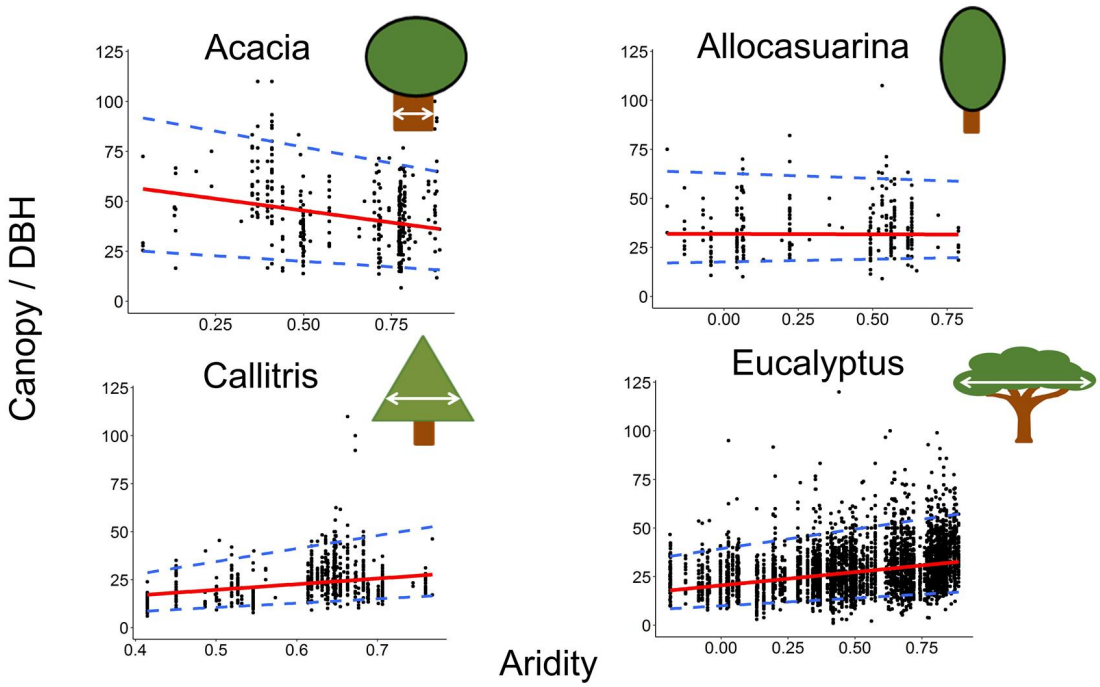


A prior model for the driving mechanisms of tree allometric changes.

4. RESULTS

Genus-specific strategies to adapt to dryness

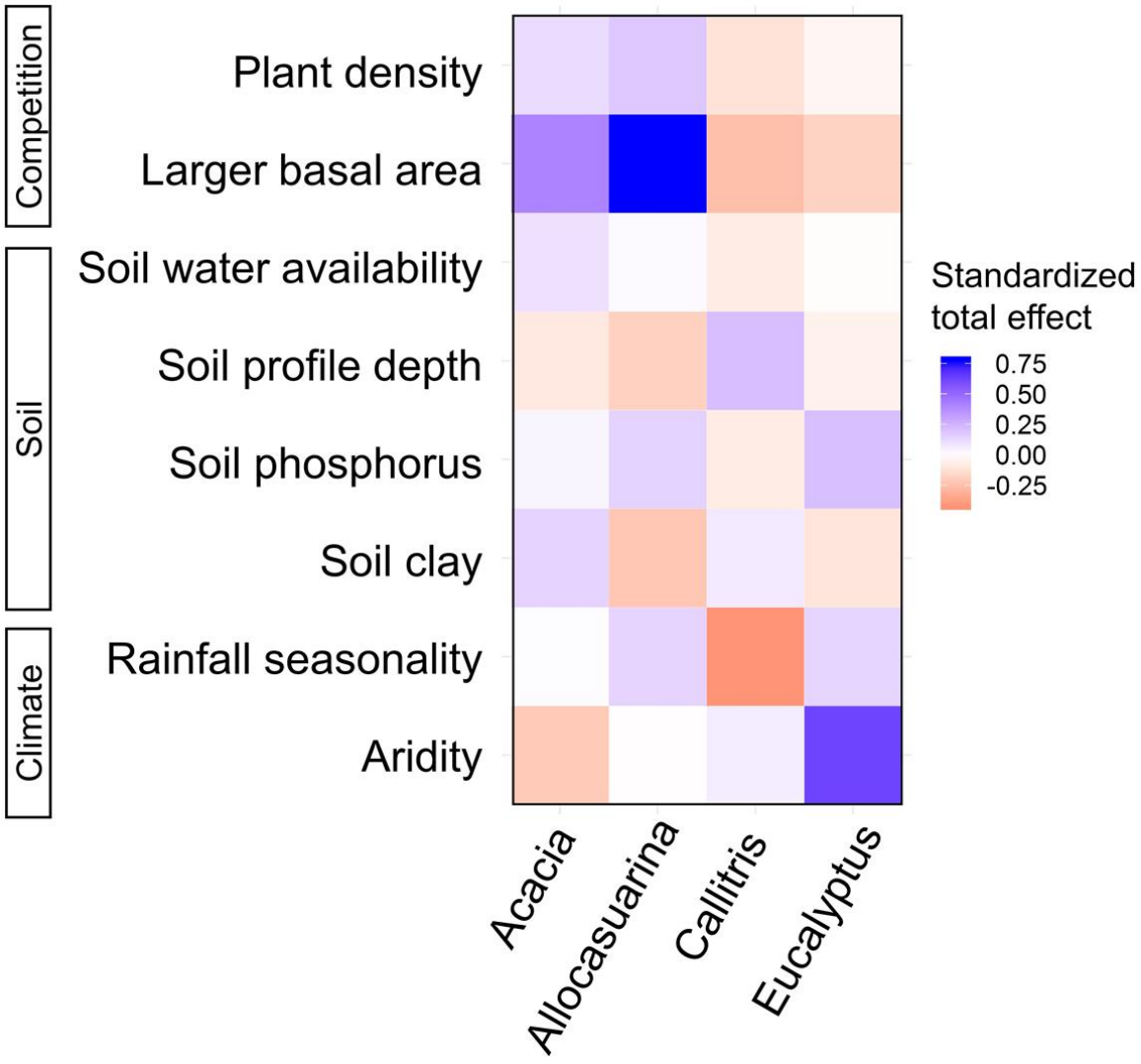
Acacia spp. tend to have thicker stems, *Eucalyptus* and *Callitris* spp. tend to have wider canopies, while *Allocasuarina* spp. did not have allometric changes.



Variation in canopy : DBH with increasing aridity for each tree genera.

Variable effects of resource availability and species competition on allometry

Resource availability (i.e. aridity and soil nutrient) affected allometric changes in *Eucalyptus* and *Callitris* spp., while aboveground species competition affected allometric changes in *Acacia* and *Allocasuarina* spp.



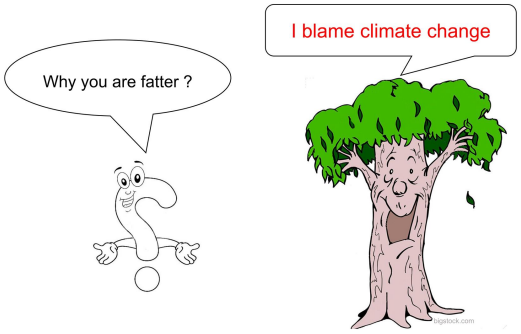
Heatmap illustrating the standardized total effects (sum of direct plus indirect effects) of driving factors derived from the structural equation modelling.

5. KEY MESSAGES

(1) Trees would alter aboveground allometry to adapt to drier climate.

(2) Whether become wider in canopies or thicker in stems depends on woody genera.

(3) Allometric changes are regulated by aboveground competition and resource availability.



6. FURTHER READING

Jingyi Ding: PhD student on climate change, meta-analysis and woody plant dynamics.

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Ding et al., 2020. Grow wider canopies or thicker stems: variable response of woody plants to increasing dryness. *Global Ecology and Biogeography*, DOI:10.1111/geb.13212.

I acknowledge the Traditional Owners of the land on which this study was conducted (NSW Australia). I pay my respects to their elders, past, present and emerging.

ABSTRACT

Woody plants vary greatly from tall trees to branching shrubs with increasing dryness. Variations in plant allometry are driven by both biotic and abiotic factors, reflecting different plant adaption strategies in different environments. While much is known about the response of plant functional traits to declining rainfall, less is known about how aboveground allometry (e.g. canopy size, height, stems, branching) of woody plants might respond to increasing dryness, limiting our ability to predict changes in woody plants and associated ecosystem functions under future climate change scenarios. Here, we explore how aboveground allometry of different woody genera responds to increasing dryness at 150 sites long an extensive aridity gradient from humid to arid areas. We used regression analyses and Structural Equation Modelling to explore the variation in woody allometry with increasing aridity, and the abiotic (resource availability) and biotic (competition) mechanisms driving such changes. Our results showed that plant height declined, but branching, and canopy width and depth increased with increasing aridity. Woody responses to dryness varied among genera, with increasing aridity associated with wider canopies in *Eucalyptus* and *Callitris*, thicker stems in *Acacia*, but no clear differences in *Allocasuarina*. Biotic and abiotic factors exerted different effects on the allometry of different genera, with *Eucalyptus* and *Callitris* spp. constrained by resource availability, while *Acacia* and *Allocasuarina* spp. were regulated mainly by competition. Our results highlight the genus-specific responses in allometric changes and driving mechanisms (resource availability cf. competition) with increasing dryness. Rather than merely shrinking, plants would allocate resources to either canopies or stems to cope with increasing dryness. Under predicted hotter and drier climates, increasing stem or canopy size, and altering branching might be a useful strategy for woody plants to compensate for biomass reduction and maintain ecosystem functions while growing shorter as dryness increases.