

Climate Change in Southwest Australian Shrublands:  
Response to Altered Rainfall and Temperature

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This thesis is presented for the degree of Doctor of Philosophy of Murdoch  
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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

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## ABSTRACT

On-going climate change through the 21<sup>st</sup> century projects increasingly warmer and drier conditions for Mediterranean-type ecosystems (MTEs), creating threats to species persistence in these biodiversity hotspots. For the highly biodiverse kwongan of southwest Australia, this means a climate shifting towards semi-arid conditions, yet how this unique vegetation type will respond to a novel hotter and drier climate is largely unknown. Therefore, this study examined the effects of altered rainfall and temperature on demographic processes of woody kwongan in post-fire (0 - 3 years since last fire) and mature (12 - 15 years since last fire) stands across a soil depth gradient in the northern sandplains of southwestern Australia, seeking to identify the consequences for plant species and functional trait composition. To achieve this, a selection of commonly occurring species (*Banksia attenuata*, *Banksia hookeriana*, *Melaleuca leuropoma* and *Beaufortia elegans* as primary focal species) were used to form a plant functional trait scheme, with fire-response strategy (resprouter, non-resprouter) as a trait of key interest due to the fire prone nature of MTEs, and leaf type (broad, needle, small), growth form (shrub, subshrub) and seed size (large, medium, small) as traits of interest due to their potential roles in drought and temperature responses. Passive rainout shelters were used to reduce rainfall, and drip irrigation to increase rainfall, by ~ 30 %. Open top chambers were used to increase temperature, with daytime temperature increased by an average of 2.9°C.

Seedling germination, survival and growth, and adult survival, health, flowering and fruiting were reduced by drought and warming, with increased rainfall producing little change. Greater magnitude of reduction was observed under experimental warming, however experimental drought resulted in greater level of change in functional trait composition. Despite the general higher resistance of adult resprouters, it was non-resprouters that showed potential to become the dominant fire-response strategy in a drier environment, through higher seedling resilience and similar resistance as adults to resprouters. With a decline in survival for both post-fire resprouts and seedlings, resprouters could be at risk of population decline in the long term. Subshrub and small leaf traits were the most successful in drought conditions due to their drought tolerant nature, while broad leaf and shrub traits will likely suffer population decline. In warmer conditions, significant decline in resprouter seedling survival was matched by equally large decline in non-resprouter adult survival, indicating little change in dominance of non-resprouters at the seedling stage and resprouters at the adult stage, and thus little

change in their relative abundances. The needle leaf trait was most competitive in warmed conditions performing well relative to other traits both in seedlings and adults. Shallow soil profiles, reflecting lower water availability, negatively affected demographic rates, suggesting decreases in diversity and density on shallow soils as less drought tolerant species retreat to deeper soil profiles with greater water stores.

Results here show potential for large scale change in MTEs in projected warmer and drier climates, through decline in vulnerable functional traits, and thus reduced density of woody species and losses to biodiversity. Further investigation is needed into the combined effect of warming and drought, in addition to impact of altered fire regime, with changes in fire behaviour projected for MTEs as a result of warmer and drier conditions. Investigation that encompasses a broader range of Mediterranean species is also necessary to provide greater accuracy to conclusions drawn here on functional trait responses.

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**Plate 3.3** Aerial image showing location of study sites ~ 10 km north of Eneabba, W.A. in March 2012. Deep sand dune sites are identifiable by taller vegetation with small trees showing up as spotted areas, compared to the uniform smooth appearance of vegetation in shallow sand swales. The outline of the 2010 prescribed burns can be seen, but the 2012 natural fire occurred after this image and was thus not visible here (Image © 2013 DigitalGlobe, Google Earth).

**Plate 3.4** Growth form of focal species: a) *Banksia hookeriana* b) *Banksia attenuata* c) *Beaufortia elegans* d) *Melaleuca leuropoma*. Note: single stem of nonsprouters and multiple stem form of resprouters (reflecting presence of a below-ground lignotuber).

**Plate 5.1** Colour tie position for branch growth on a) shrub (*Banksia hookeriana*), and b) subshrub (*Beaufortia elegans*) at Eneabba. Colour tie for the shrub is blue and marks the branch on which growth initiated at the base of the terminal infructescence (indicated by arrow) was measured. Yellow colour tie on the subshrub marks the fruit above which all growth (indicated by circle) was measured.

