Towards defining processes and thresholds of forest mortality: observations from leaf to regional scales

Water and carbon coupling at regional scales: key issues and a new approach

Anthony O'Grady, Pat Mitchell, Libby Pinkard, David Tissue, Don White, Michael Battaglia, Jody Bruce

26 June 2012

Drought and mortality

'1888 was the driest year known since the settlement of the country. A fact in striking contrast is also noted— that the previous year was the wettest on record...So intense was the drought that the native trees on the hills were all in a dying state; and over large areas absolutely dead, a state of matters which it was evident from the age of the trees killed could not have been experienced within the last 50 years.' (Bathurst Free Press and Mining Journal, September 17th, 1889).

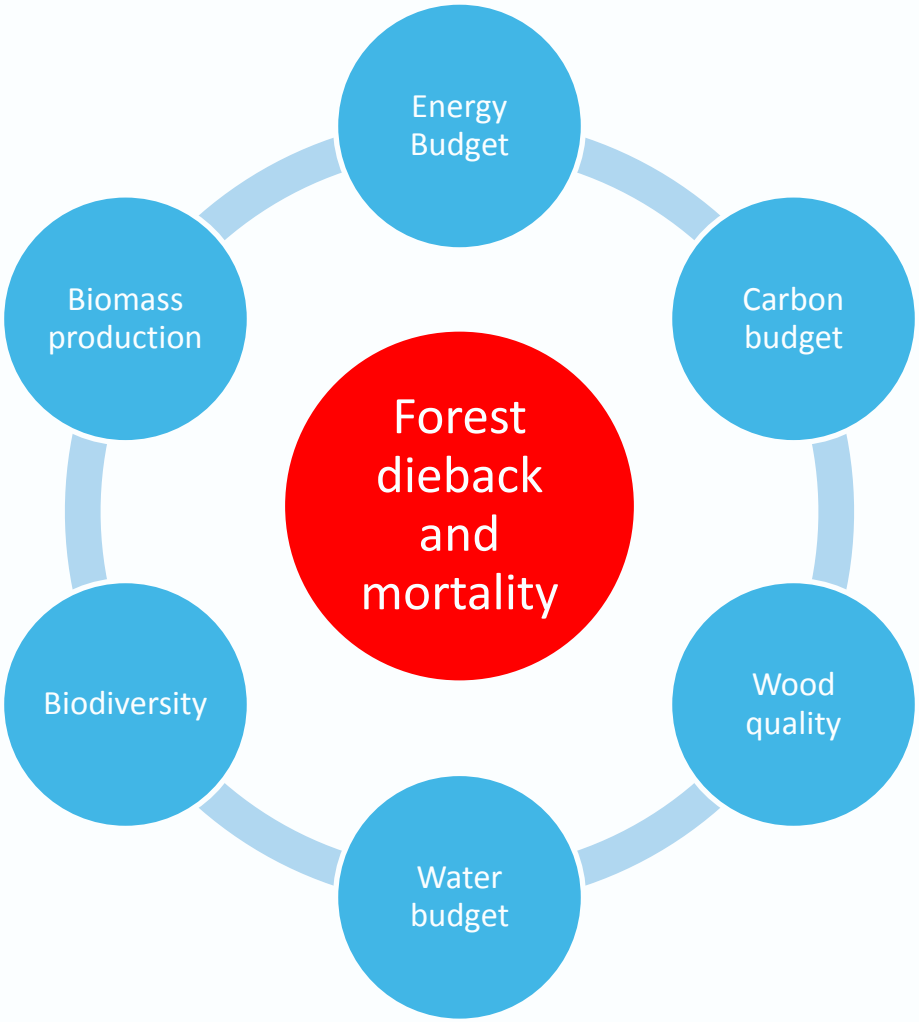
Conditions...had never been worse. Owing to the series of drought years just passed through thousand of acres of mulga and scrub are definitely dead and hundreds of thousands of acres were only just alive.' (The West Australian, 21st July 1938).

Mortality is being observed globally

C.D. Allen *et al.* (2010) Forest Ecology and Management

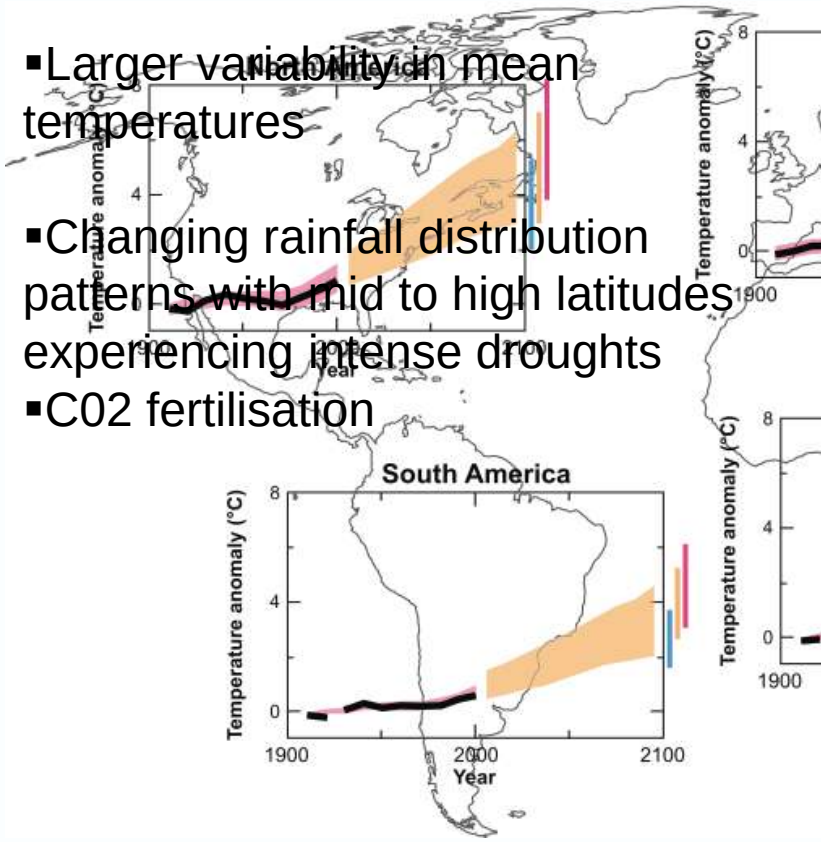
Are forests more vulnerable to climate change?
Are these stochastic events or shifts to new ecological states?

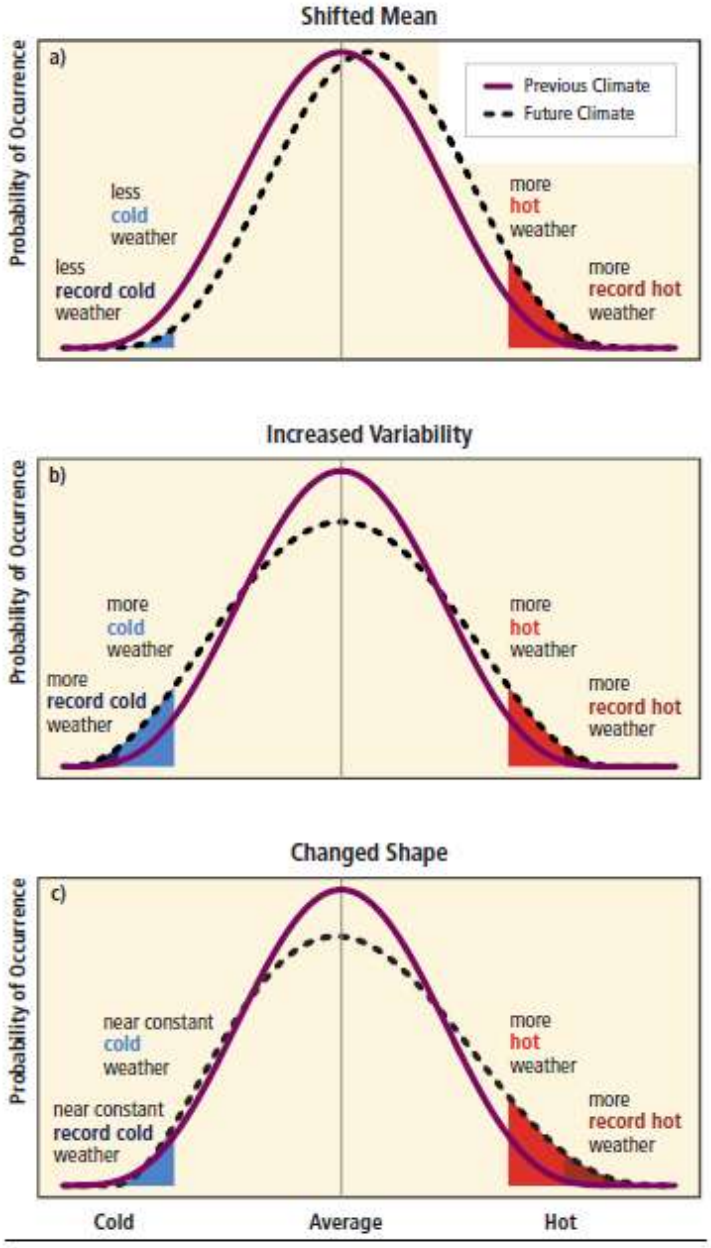
Impacts on carbon and water fluxes



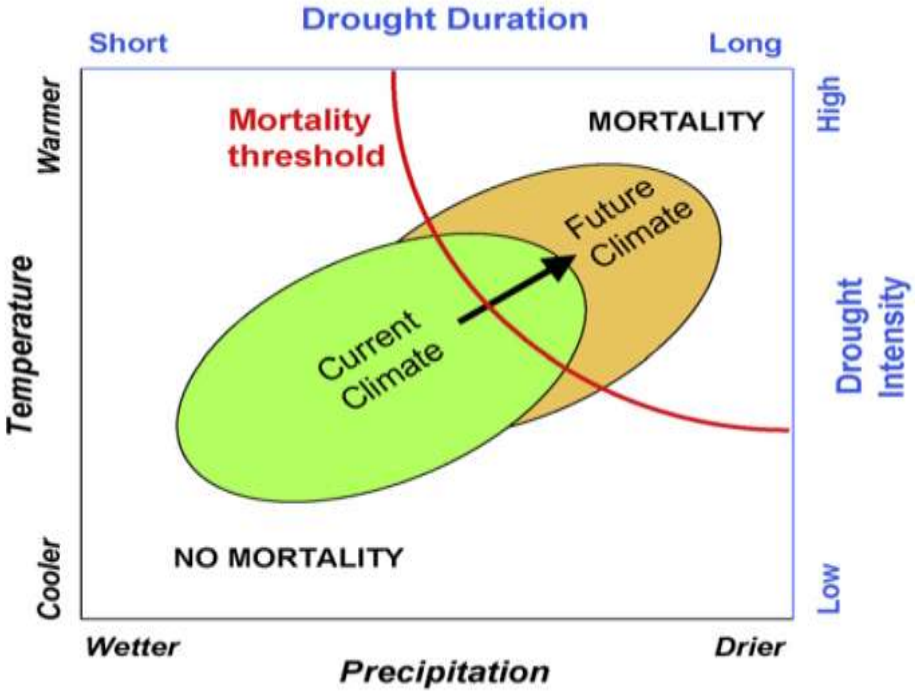
Climate is changing

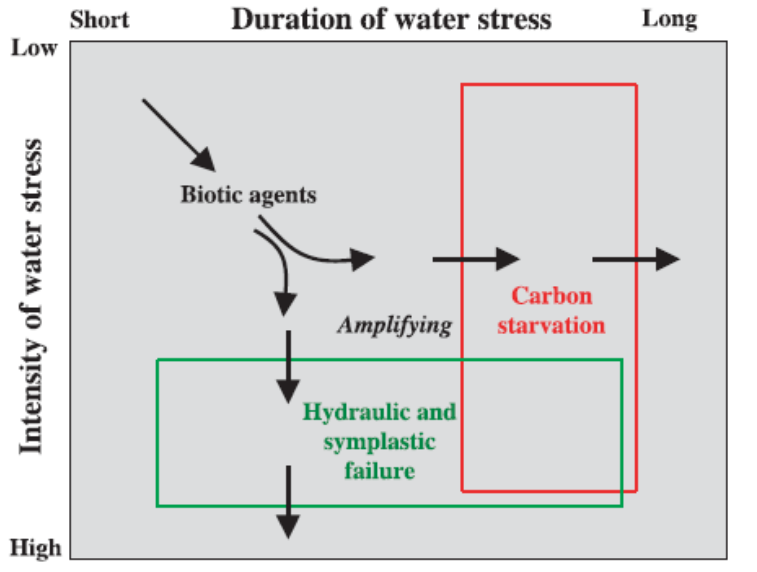
- Higher average temperatures
- Larger variability in mean temperatures
- Changing rainfall distribution patterns with mid to high latitudes experiencing intense droughts
- C02 fertilisation





How will these interact?





Allen *et al.* (2010) FEM 259:660-684

McDowell et al. 2008 New Phytologist 178, 719-739

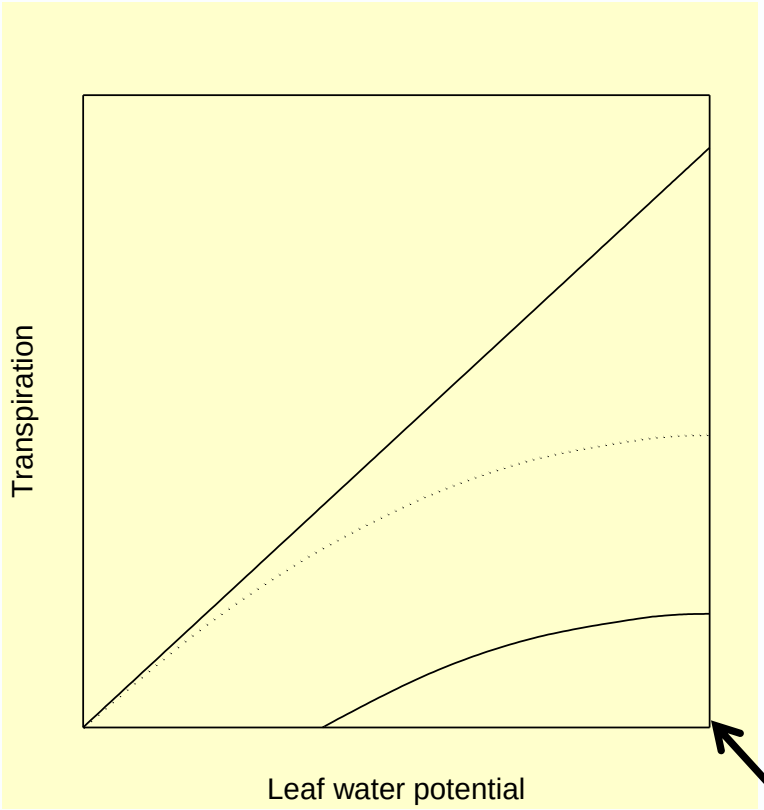
Towards defining mortality functions

A combination of Field and glasshouse studies

Examine in detail changes in whole plant hydraulics and carbon balance

Examine these changes in the context of intensity and duration

Identify critical water potentials



$E=K_P(\Psi_s-\Psi_l)$

Ψ_{crit}

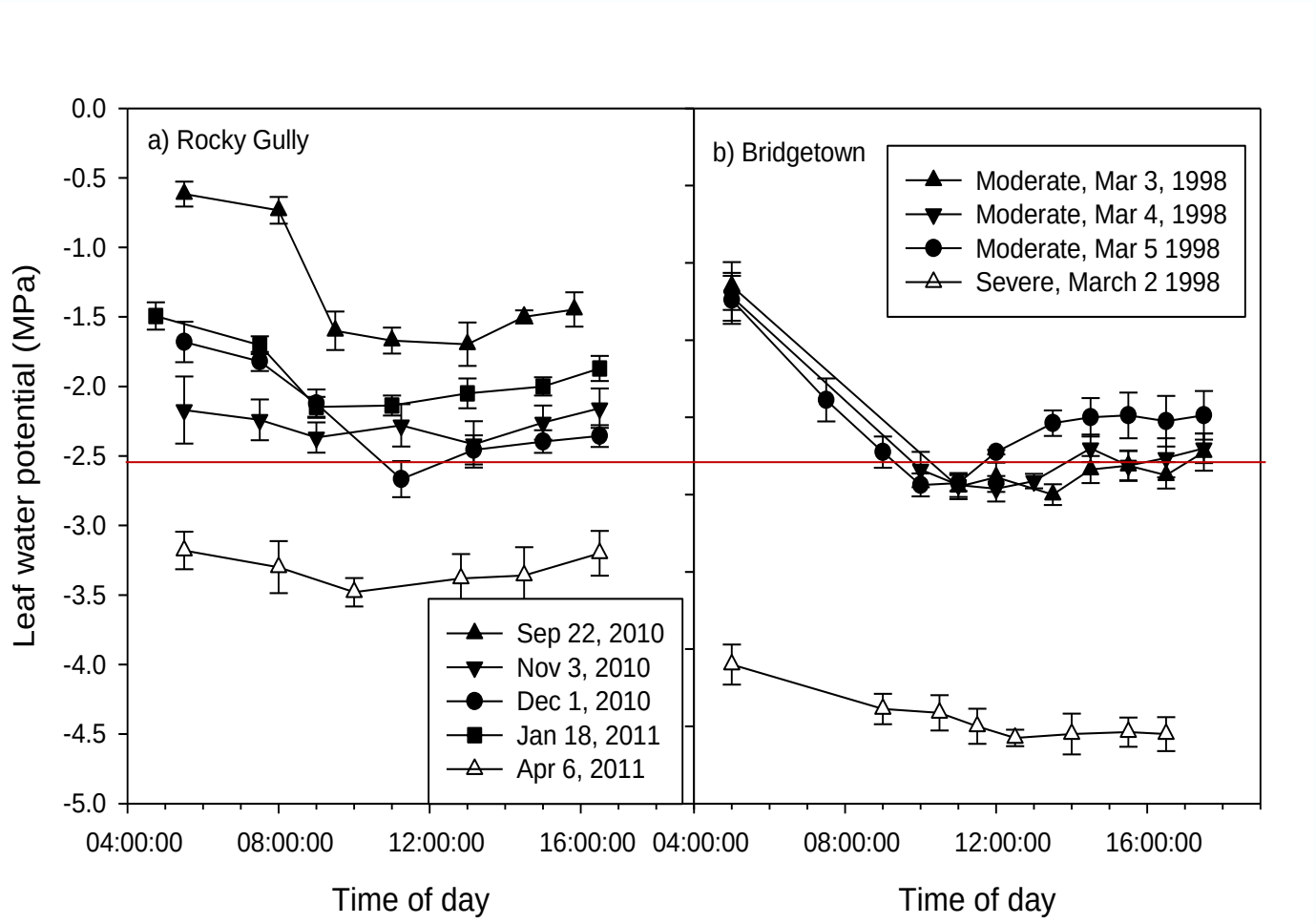
Plants regulate plant water status to avoid critically low water potentials (species specific)

Maintain a safety margin

Can we identify these threshold water potentials?

What about extreme drought?

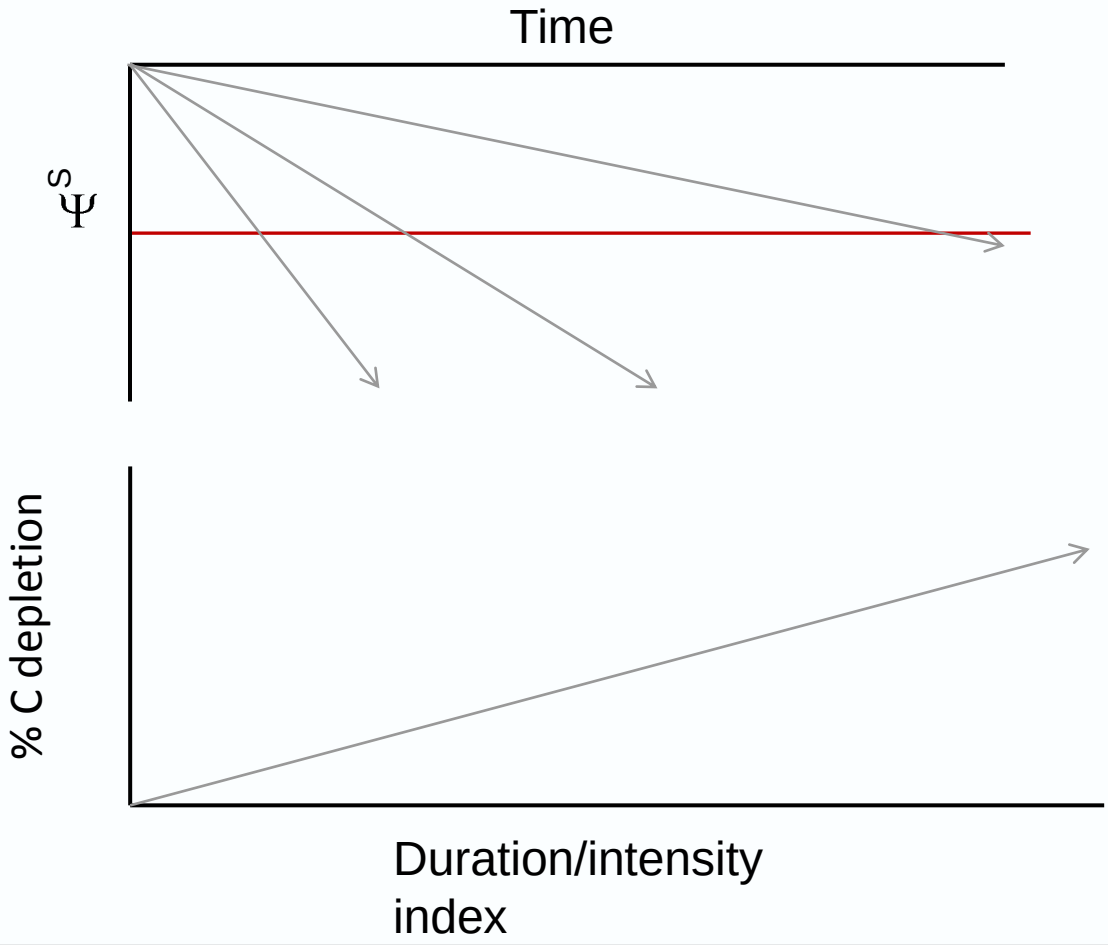
Sperry (2000). Agricultural and Forest Meteorology 104:13-23



White et al. New Phytologist (submitted)

White et al. New Phytologist (submitted)

Intensity v duration (Hydraulic failure or Carbon starvation)



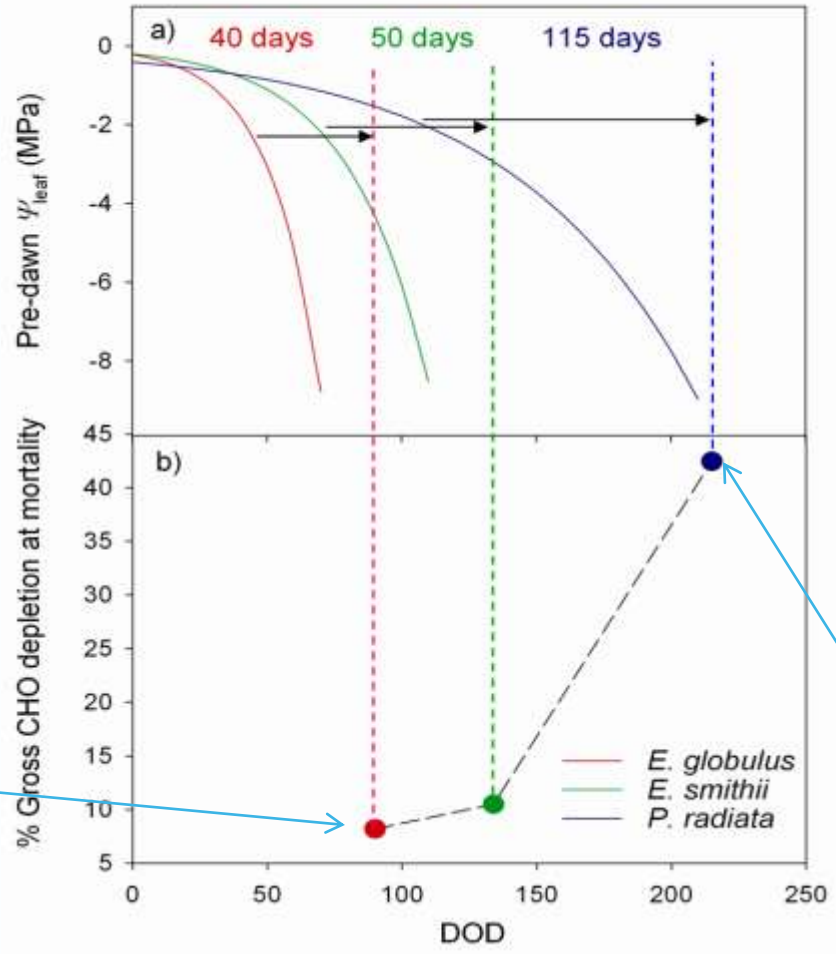
Drought duration

3 species (contrasting life histories)

Two treatments

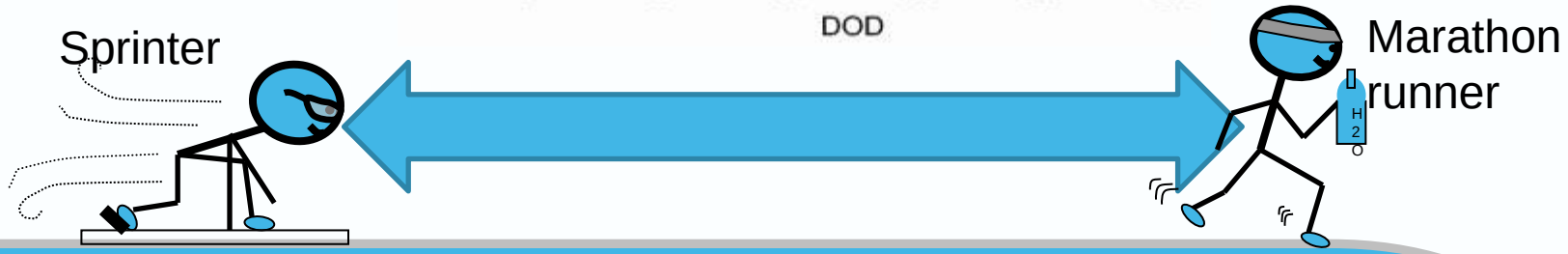
- (well watered, slow dry down

Monitored a range of leaf and whole plant physiological responses



Eucalyptus globulus
-High growth rate
-High rates of water use
-**Greater vulnerability to hydraulic failure**

Pinus radiata
-Low growth rate
-Low rates of water use
-Greater vulnerability to carbohydrate starvation

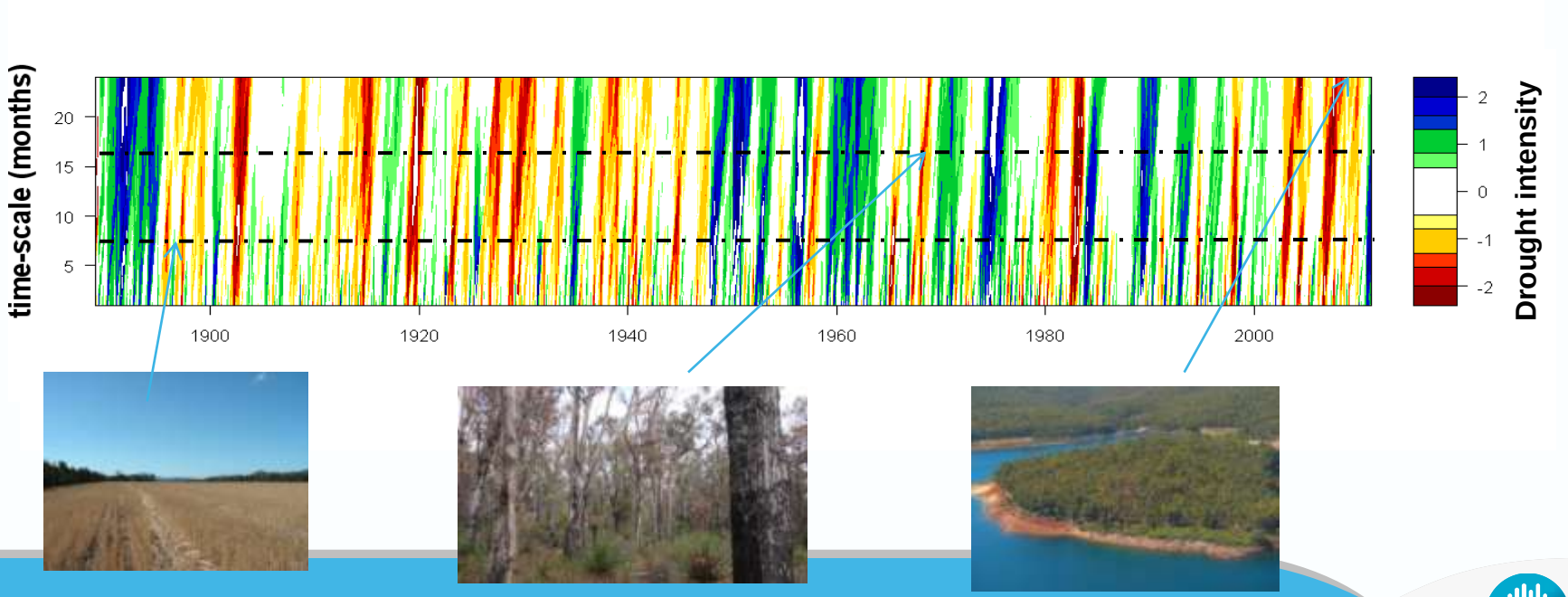


Drought in the landscape

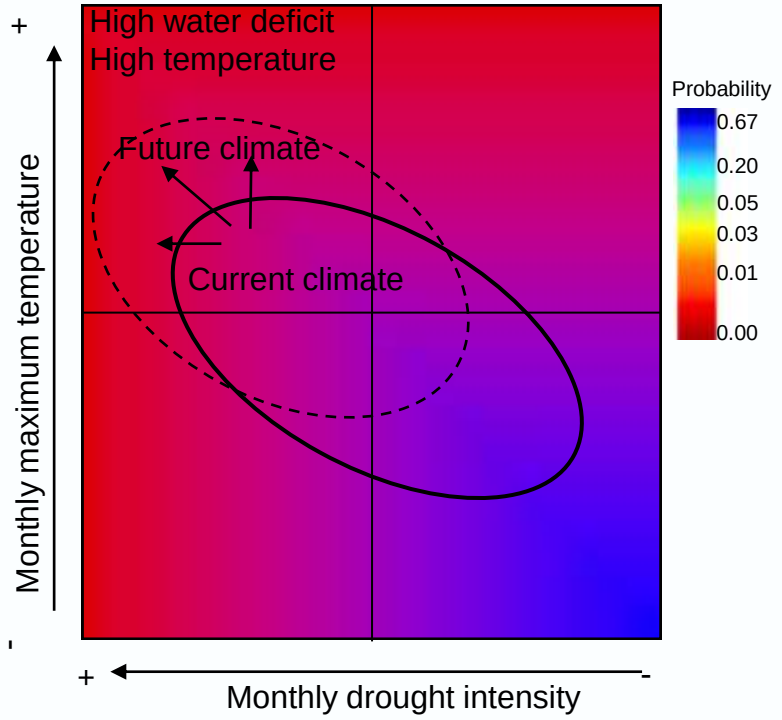
It is a stochastic process that is a large factor in shaping plant distribution and composition across many biomes

It is a human construct and difficult to define – period of exceptionally large deficit between precipitation and evaporation

- It occurs at different scales and affects components of ecosystems to different degrees

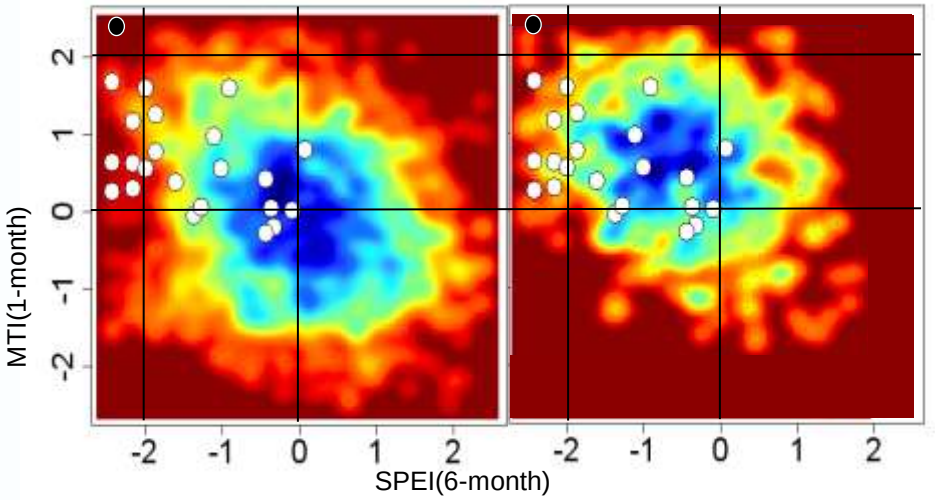


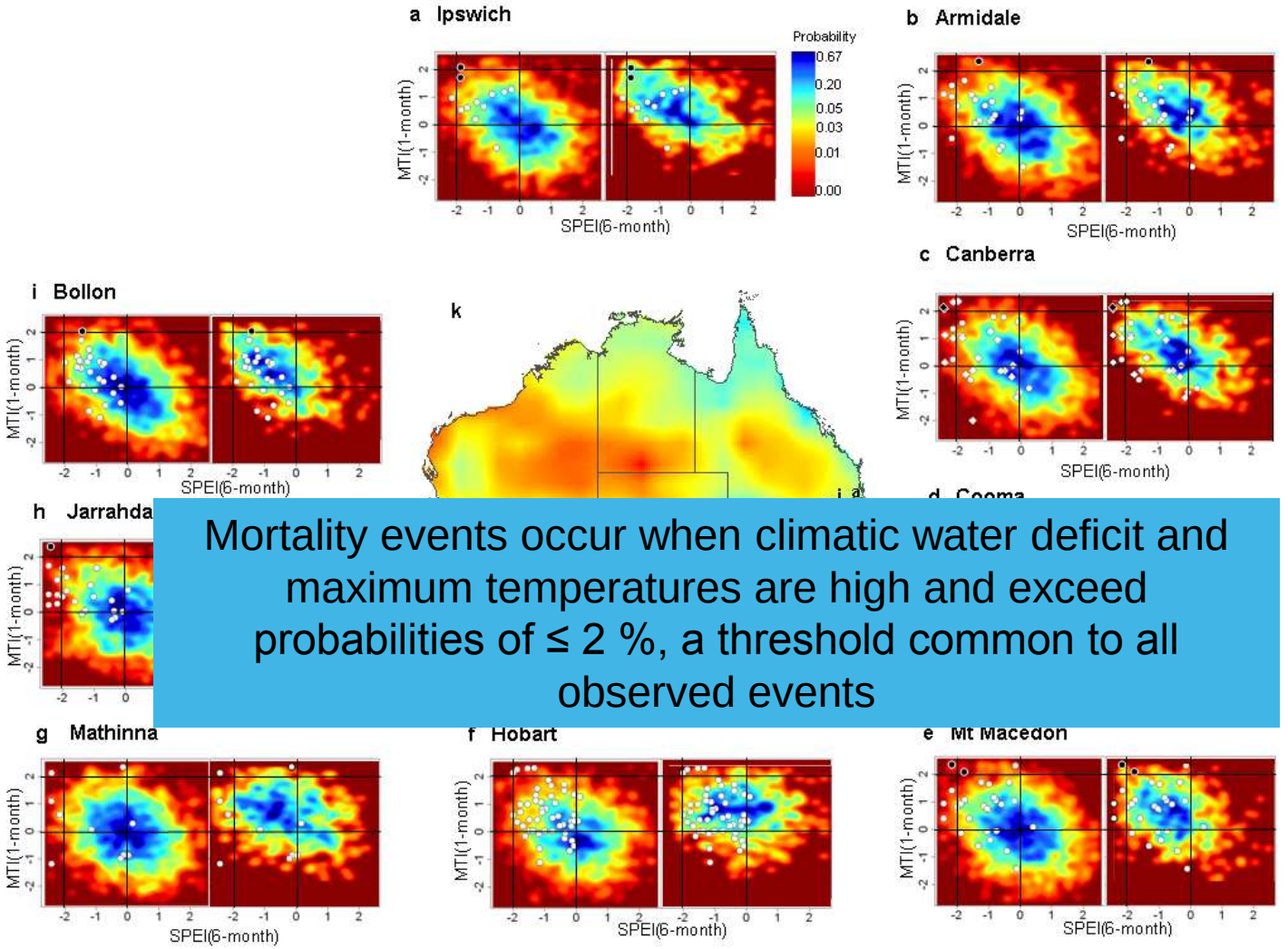
Recent mortality in SW Western Australia



Jarrah forest, WA – 2010-2011

Historic





Mortality events occur when climatic water deficit and maximum temperatures are high and exceed probabilities of ≤ 2 %, a threshold common to all observed events

(Mitchell et al. *In Revision Nature Climate Change)*

Summary

- Mortality events do matter:
  - The one in a 100 yr drought in the Amazon turn large tracts into a source (and was followed up by an more intense drought in 2010 (Lewis et al Science 2011)
- We're starting to make good progress on understanding the processes regulating the carbon and water balance under drought and starting to untangle the processes of hydraulic failure and carbon starvation
  - Should be possible to define physiological thresholds defining species vulnerability to mortality in response to drought.
- Long duration droughts of medium to high intensity are likely to have significant impacts on forest composition and function and the risk can be driven by temperature changes alone

Thank you

Division/Unit Name
Presenter Name
Presenter Title

t +61 2 9123 4567
e firstname.surname@csiro.au
w www.csiro.au/lorem

Division/Unit Name
Presenter Name
Presenter Title

t +61 2 9123 4567
e firstname.surname@csiro.au
w www.csiro.au/lorem