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Biodiversity and Conservation Science

Climate change impacts on forest health

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Climate change in SWWA: chronic

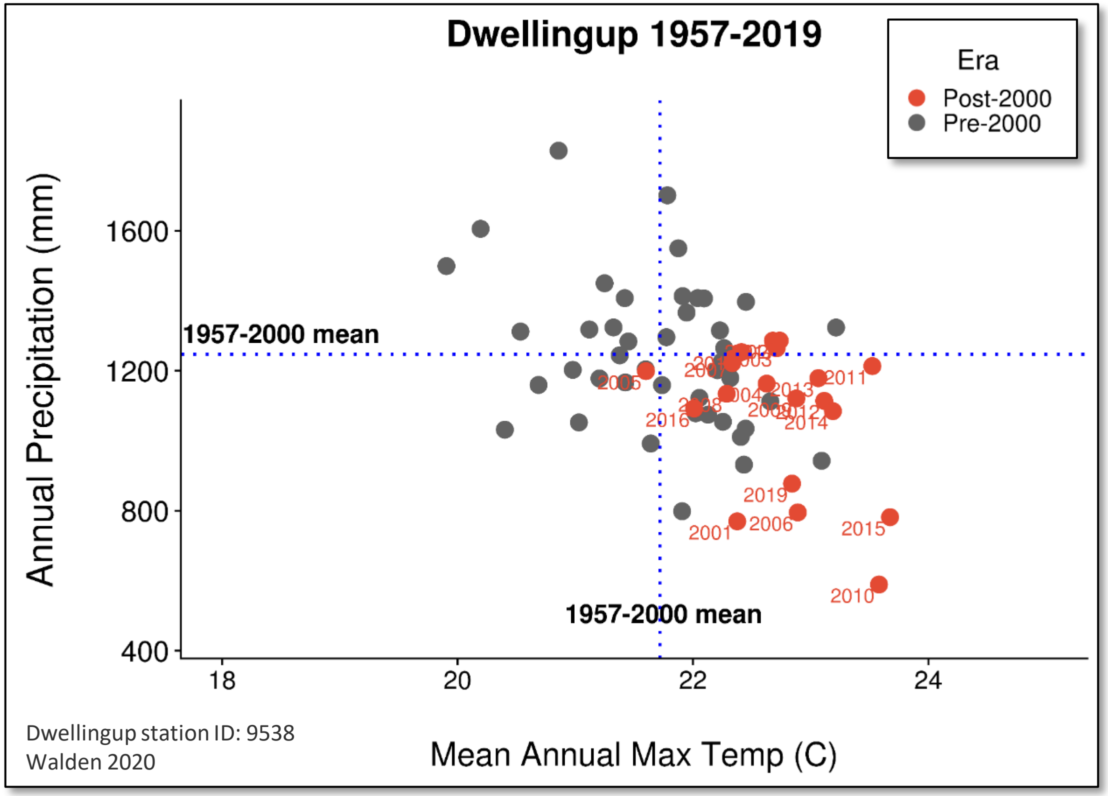
Chronic, long term changes in temperature

- +0.15°C/ decade

Chronic changes in rainfall

- 30-50% reduction in winter rainfall

Shift since the mid 1970s



Climate change in SWWA: acute

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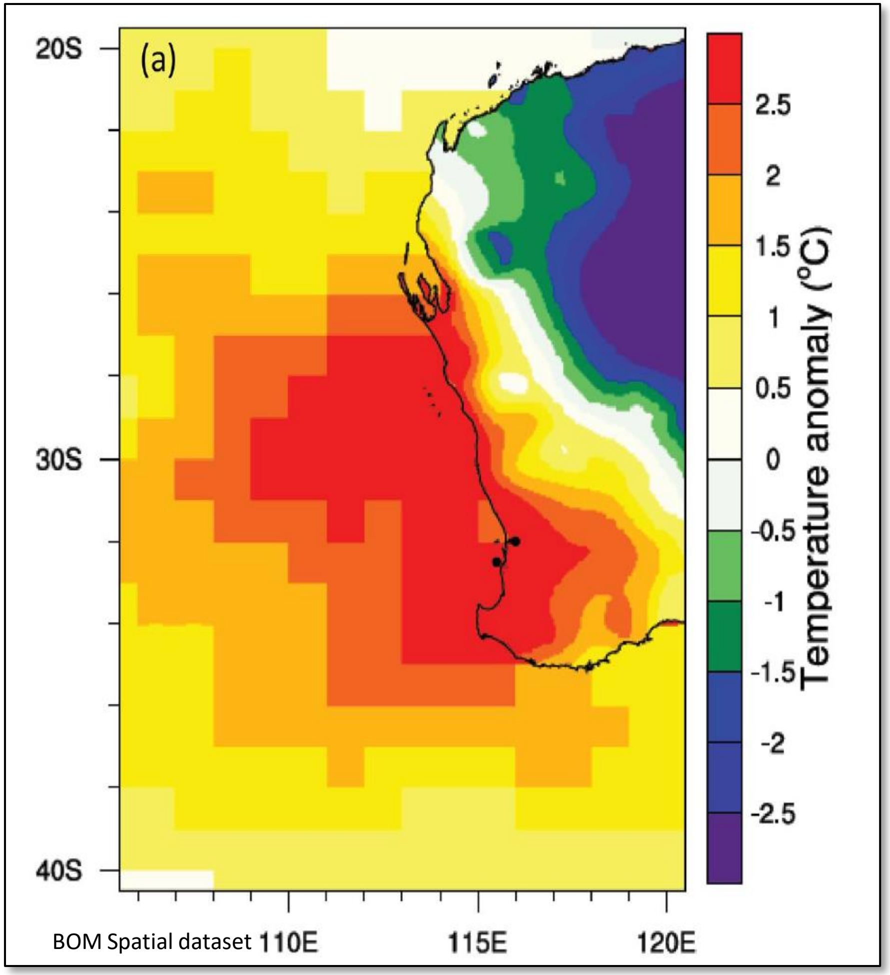
Acute changes in temperature – heatwaves

- 2011: marine and terrestrial
- ~2°C higher relative to long term average

Acute changes in rainfall – severe droughts

- 2010: driest year on record
- 40-50% below average



Ruthrof et al. (2018)

- Stacked, ecologically relevant events
- Predicted to increase in frequency, intensity and duration

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Sudden forest die-off

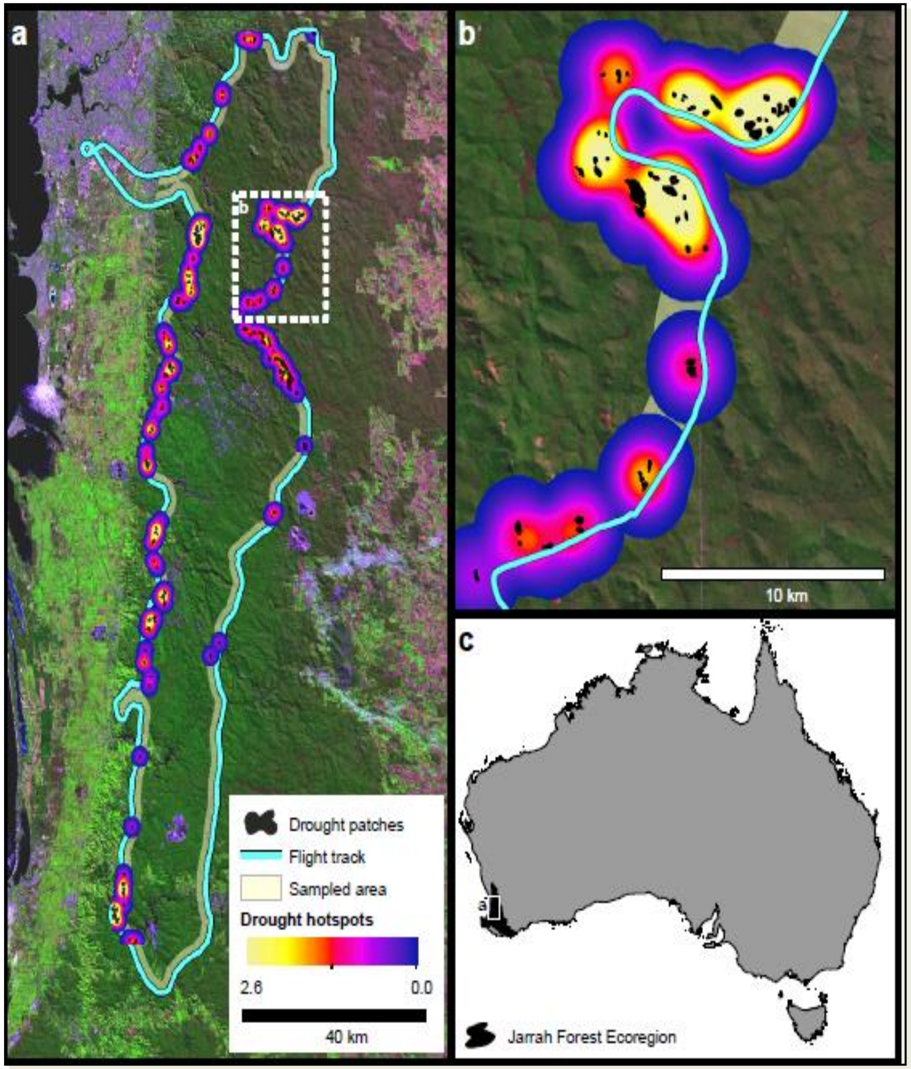
The Jarrah Forest is typically a highly resilient forest

However, in early 2011:

- Distinct patches (0.3-86 ha) collapsed in the western forest
- 1.5% of the aerial sample = 1,350 ha
- This translates to >16,000ha impacted to varying degrees

Matusick et al. (2013)

Site associations



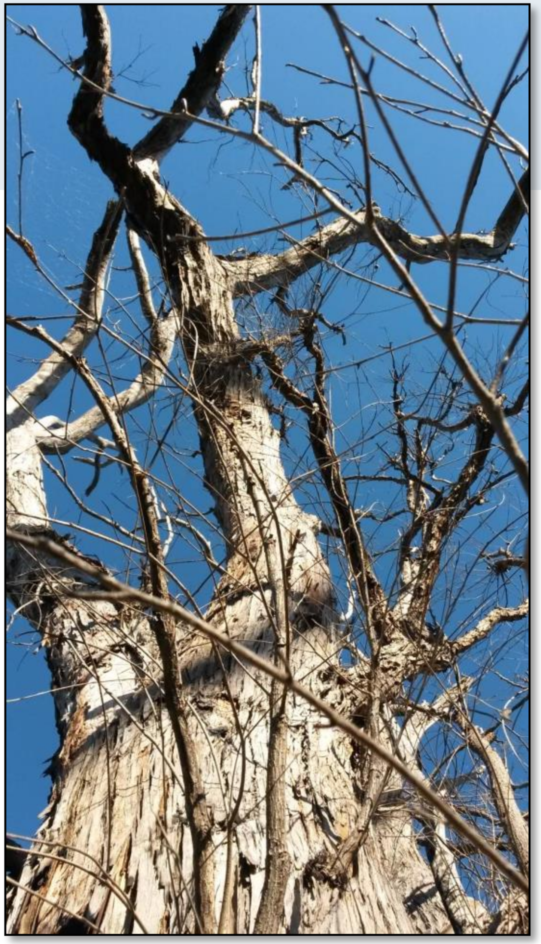
Die-off was associated with:

- Rocky outcrops
- Higher elevations
- On steep slopes
- Rocky soils with low water holding capacity
- Water shedding sites

Brouwers et al. (2013)

- Patches were larger and more clustered in xeric (dry) areas
- These areas could be more vulnerable in the future

Andrew et al. (2016)



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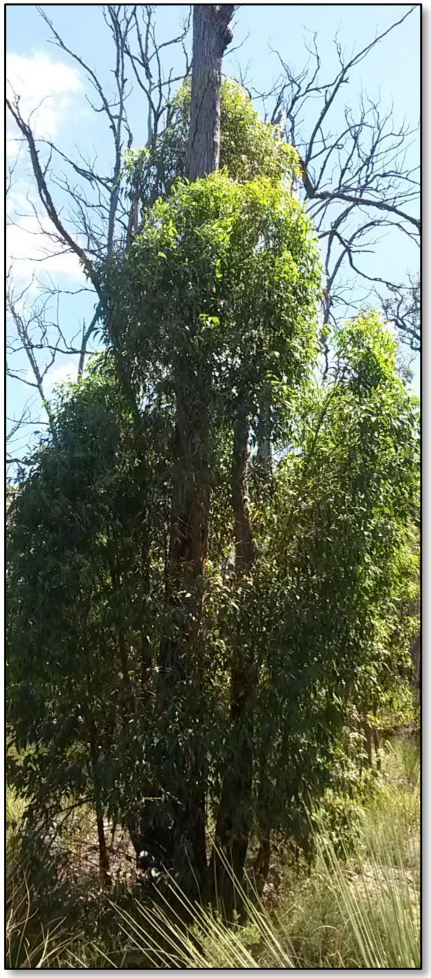
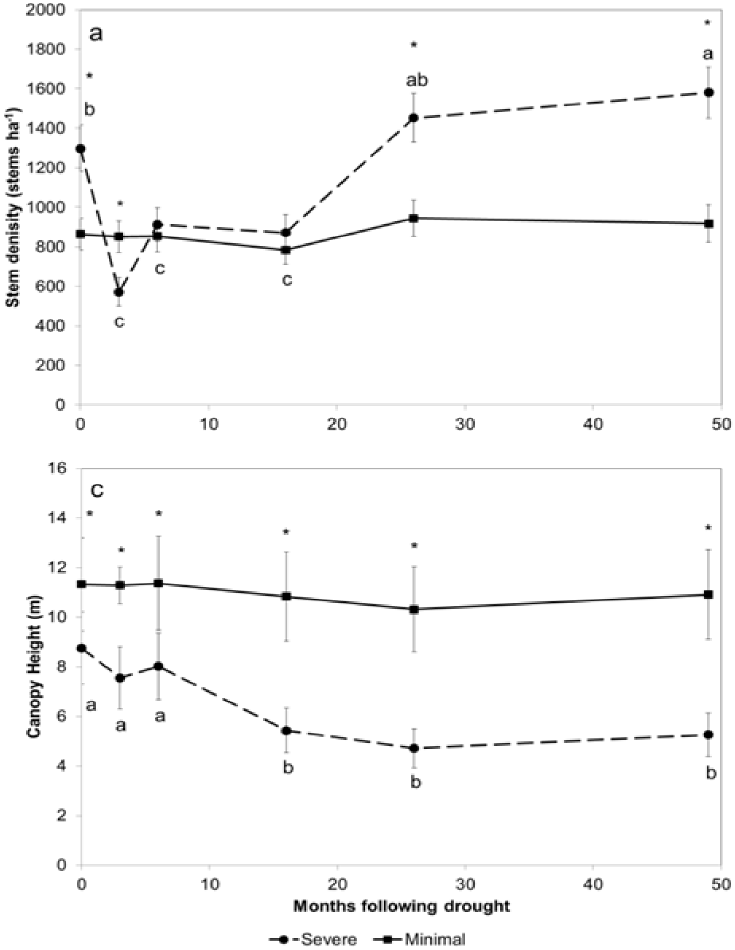
Stand scale responses





Matusick et al. (2016)

Structural changes:

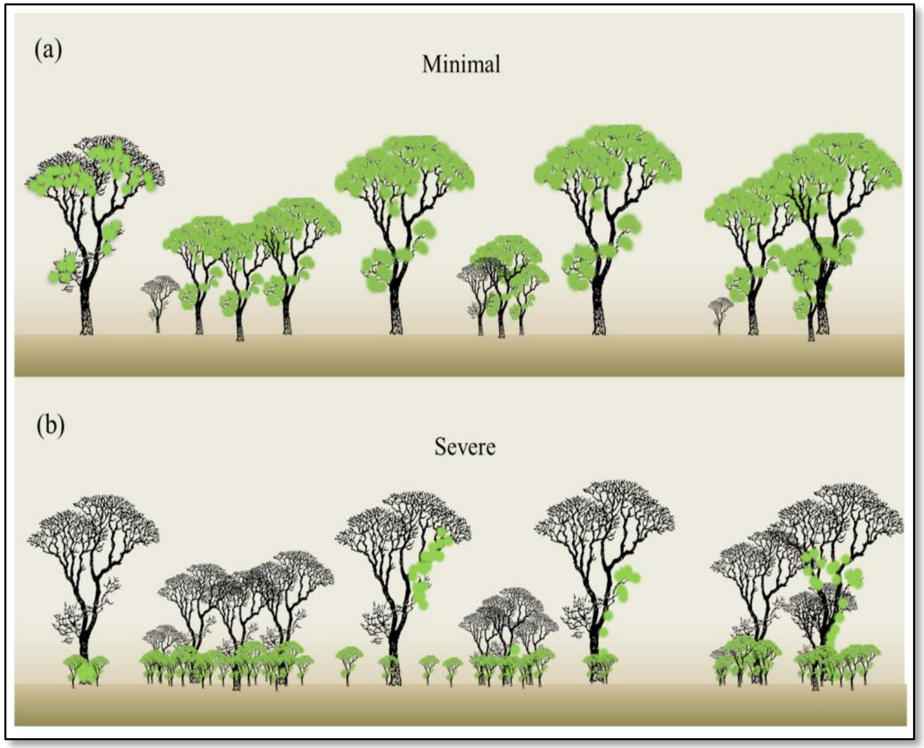
- Increase in live stem density due to resprouting
- Decrease in live tree heights

Loss of larger (> 20 cm DBH) trees and replacement with smaller (< 10 cm DBH) stems during recovery

Implications of sudden die-off

A divergent structure

- Small stems have more sapwood/area and use more water than larger stems (Macfarlane et al. 2010)
- Very little self thinning occurs
- Are these dense stands predisposing themselves to another collapse?
- Susceptible to pests and pathogens (Seaton et al. 2015, 2020)
- Transitioning to an open woodland?



(Matusick et al. 2016)

- These sites illustrate what happens when the forest runs out of water
- Critical to understand as stacked, ecologically-relevant disturbances continue

1. ISSUE:

Some parts of the forest are 'divergent' in structure with dense regrowth (>1000 stems/ha vs ~100 stems/ha).

These do not progressively self thin readily, can collapse, and could become a fire hazard

2. HOW DID THIS HAPPEN?:

Climate change, and harvesting without active management of regrowth.

Losing large trees that exerted dominance over smaller stems

3. IMPACT:

These dense regrowth stands use more water than non-regrowth stands

44% vs 20% of annual rainfall (MacFarlane et al. 2010)

4. SOLUTION: FOREST RESTORATION

It may seem counter-intuitive, but ecological thinning is needed (in certain sites) to increase resilience and habitat values such as surface water.

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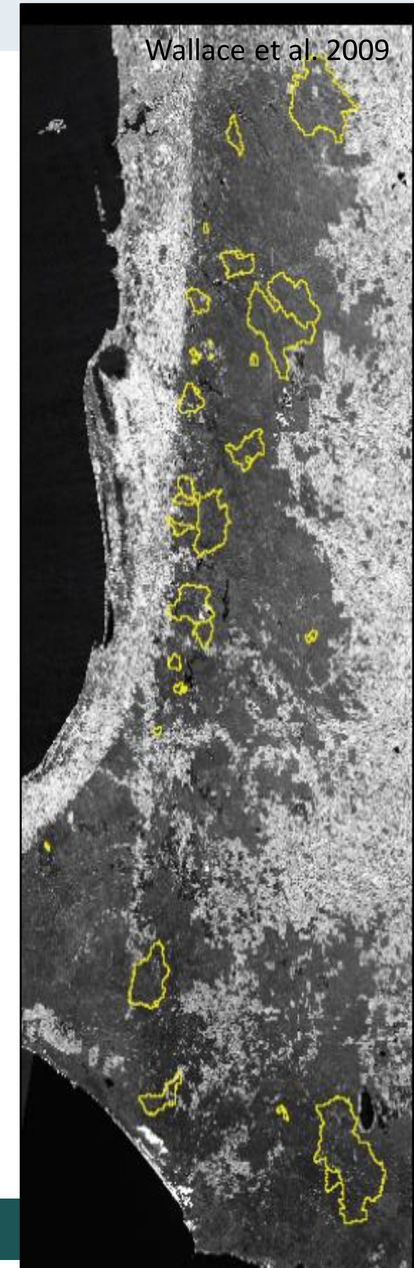
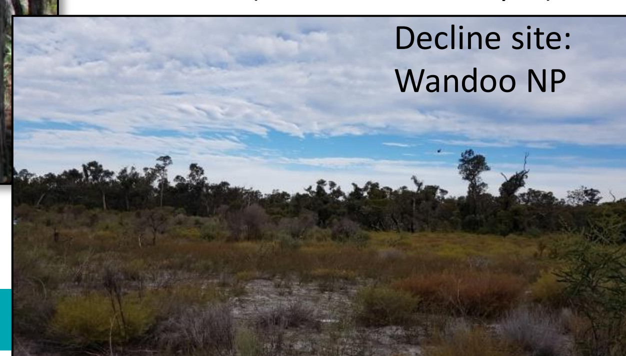
Future management

- Certain ecosystem types and positions in the landscape are vulnerable to die-off or decline
- Some sites contain dense regrowth, including mine-site rehabilitation – may also be vulnerable
- Stand-specific management intervention may be required
- Research catchments in SWWA can inform options



High density rehabilitation: Turner (Photo: M. van Rooyen)

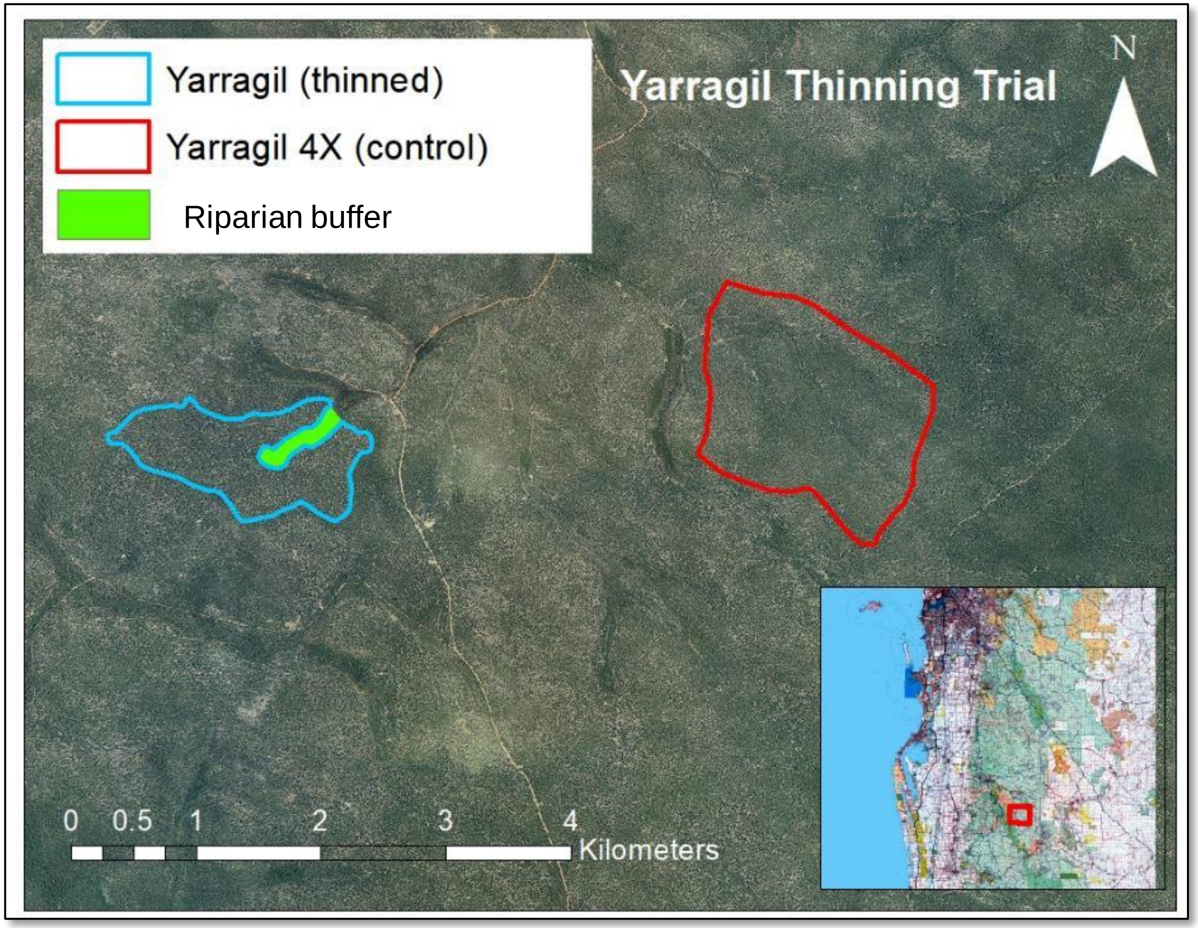
Dense regrowth: Inglehope, unthinned plots (Photo: M. Rayner)



Decline site: Wandoo NP

Yarragil Catchment

- Operational thinning: 128ha in 1983, 2019
- $35m^2$ to $11m^2$
- Cover: 55% to 22%
- Regrowth controlled after two years



Stand info from Bari and Ruprecht (2003)

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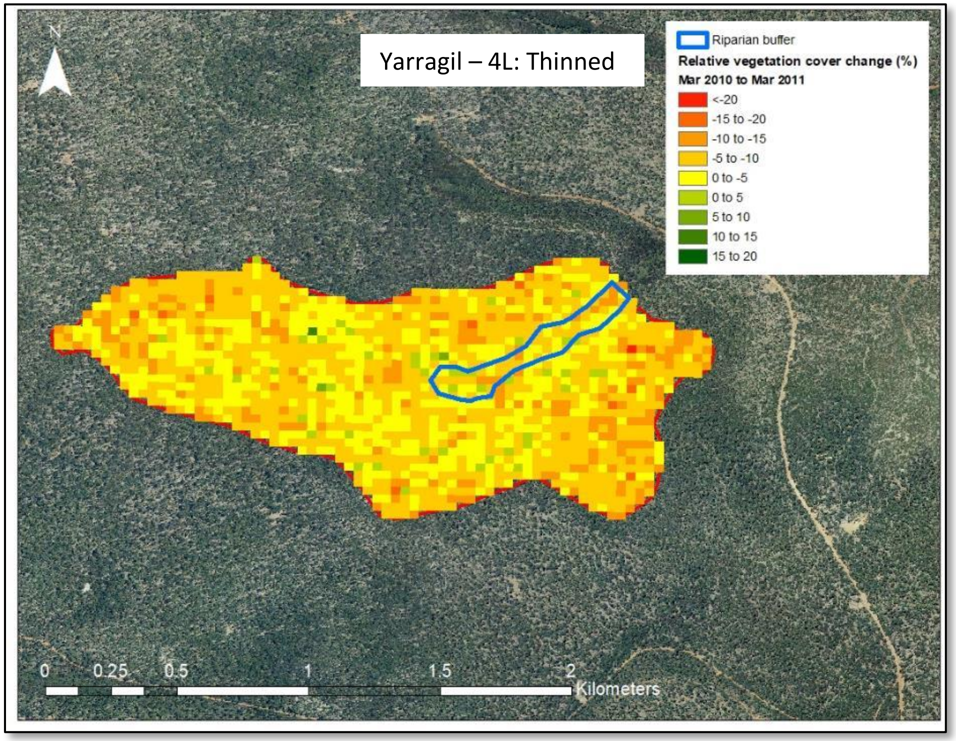
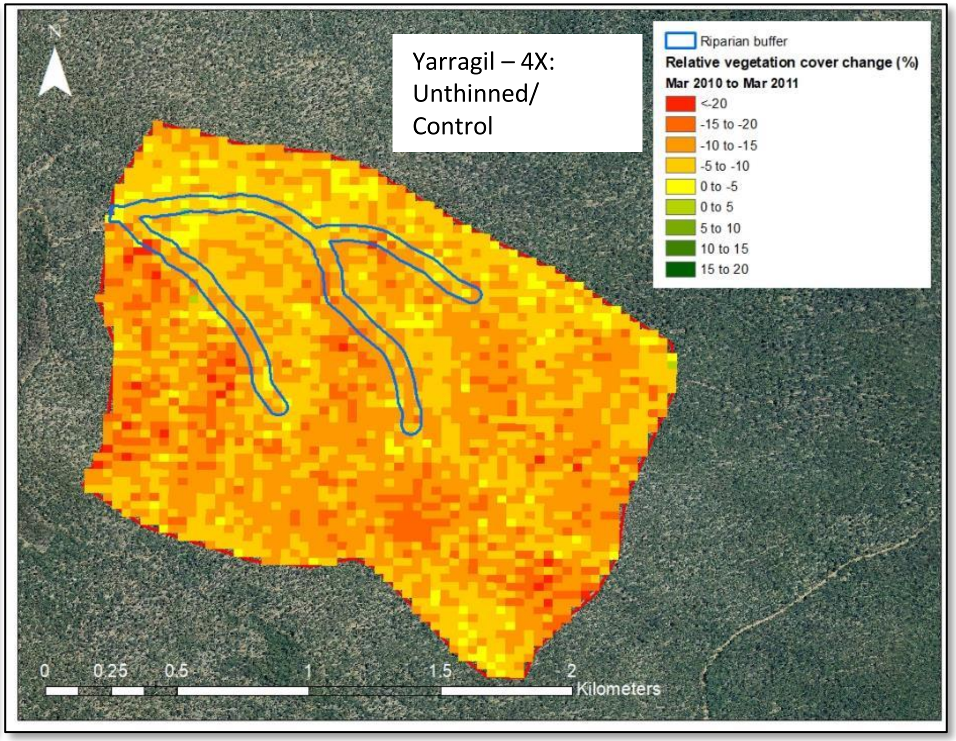
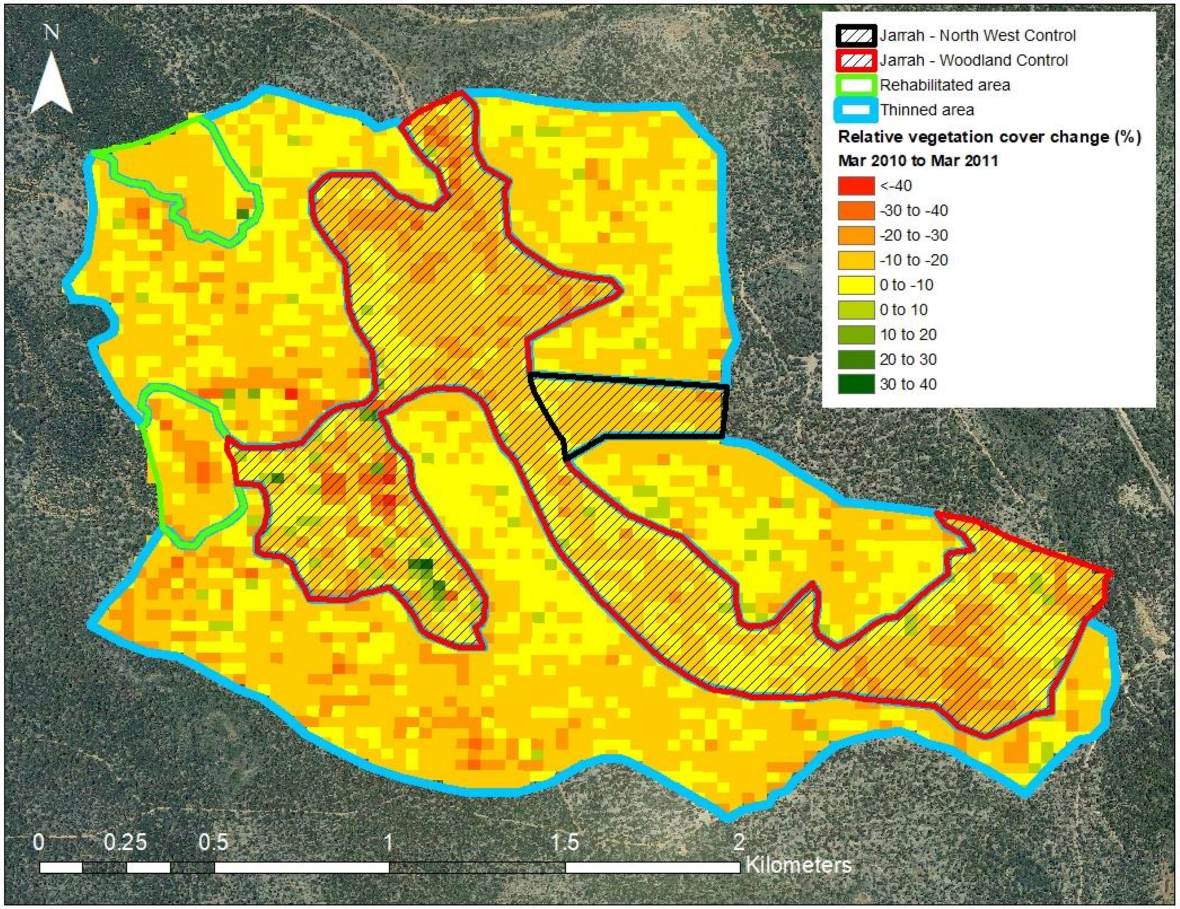
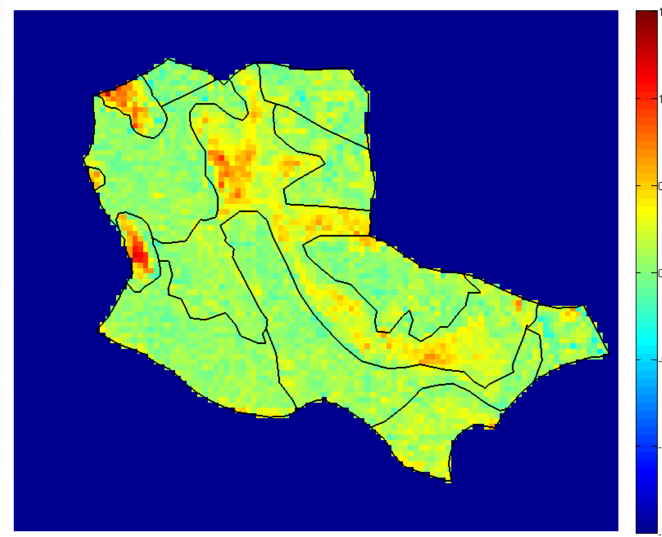
The thinned catchment and the riparian (stream) buffer lost less cover during drought/ heatwave conditions of 2010-2011 (using i35 index of vegetation cover)







Leaf Area Index change between Jan 2010 and Mar 2011 (C. Macfarlane, 2012); red=decrease, blue=increase



Management options

There is no silver bullet for all stands - nuanced, scale and site appropriate planning is key

- No intervention approach: stands will readjust themselves, sometimes abruptly, and riparian areas may retract in vulnerable sites

- Adaptive management:
  - Vulnerable ecosystem types and locations – e.g. increased protection from bushfire, consideration of inter-fire periods

  - Thinning dense regrowth: readjusting structure to reduce sapwood/ competition and increase resilience.
    - Research catchments can inform actions - e.g. Yarragil 4L/ 4X
    - Specific research for thinning from below

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