Climate proofing - genetic diversity

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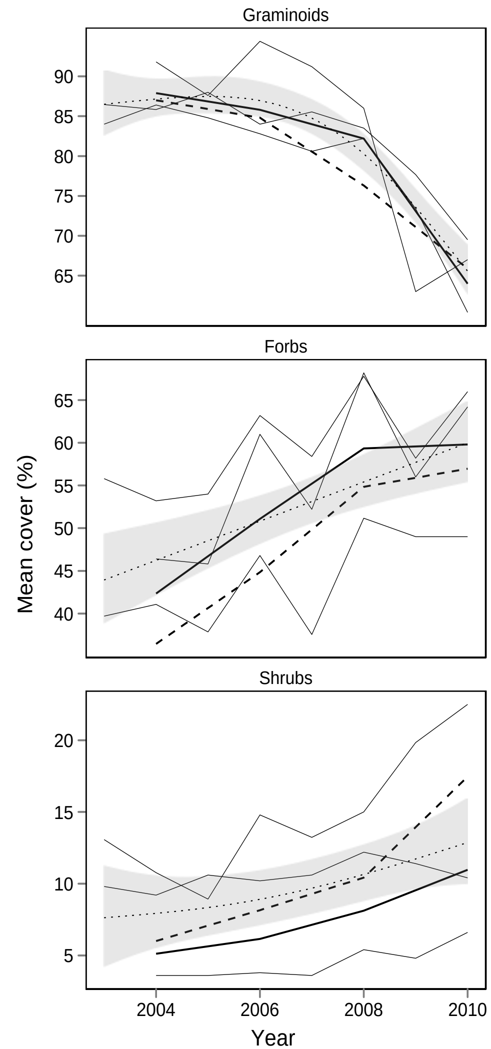
Landscape with fire and comet Peter Booth



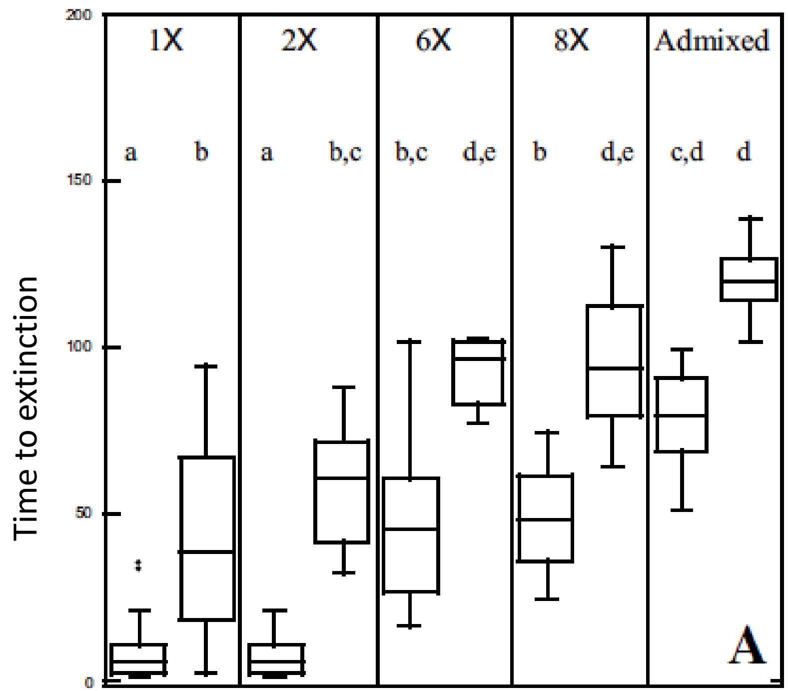
Wahren et al Australian J Botany
2013

Nardoo Hills (photo Garry McDonald)

Evolutionary adaptation as an important way dealing with environmental change

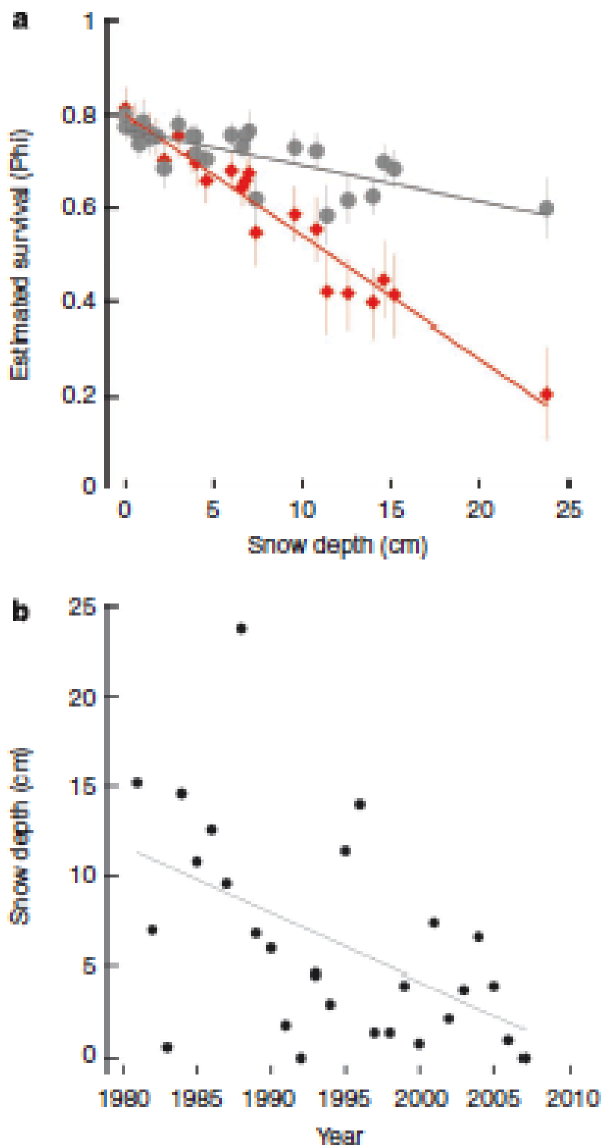
- Individuals have the potential to adapt by evolution
- Many populations of widespread species are locally adapted = genetically different to deal with local conditions
- Evolutionary adaptation can happen very quickly (large changes across just a few generations)
- Having large amounts of variation within a population is critical in rapid adaptation
- Introduction of new genes into populations is a key component of adaptation

Adaptation in the lab



Losses of genetic diversity of 30% led to a significantly greater chance of extinction in stressful environment (Markert et al. 2010).

Adaptation in time



NATURE COMMUNICATIONS | DOI: 10.1038/ncomms1213

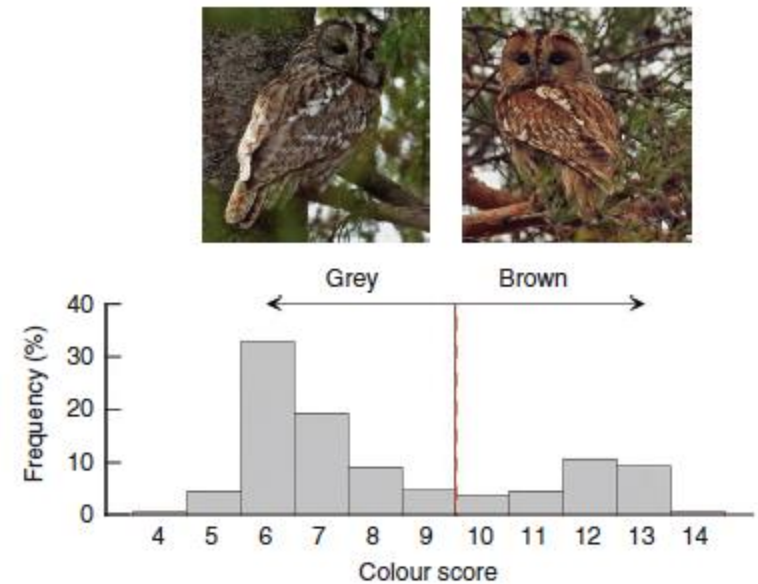


Figure 1 | Frequency distribution of tawny owl colouration in the study population. Colour scoring is based on scorings of brown pigmentation on four different parts of the plumage and ranges from 4 to 14 points in 491 individuals scored in 1978–2008. The frequency of colouration is bimodal and the two morphs can be classified into a grey and a brown morph at the cut point between scores 9 and 10. The cut point (red line) was determined visually as the lowest intermediate point between the two models[18]. A grey (left) and a brown (right) tawny owl colour morph are shown above the graph (photography courtesy of: Dick Forsman).

Karell et al 2011 Nature Communications

Adaptation in space

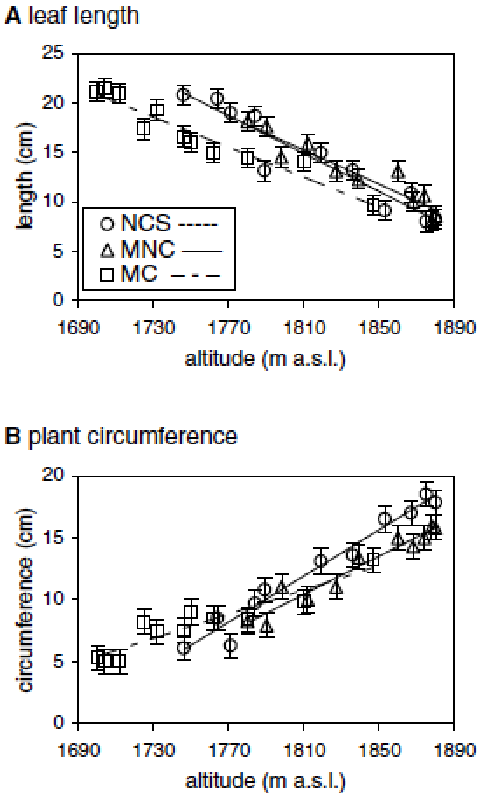


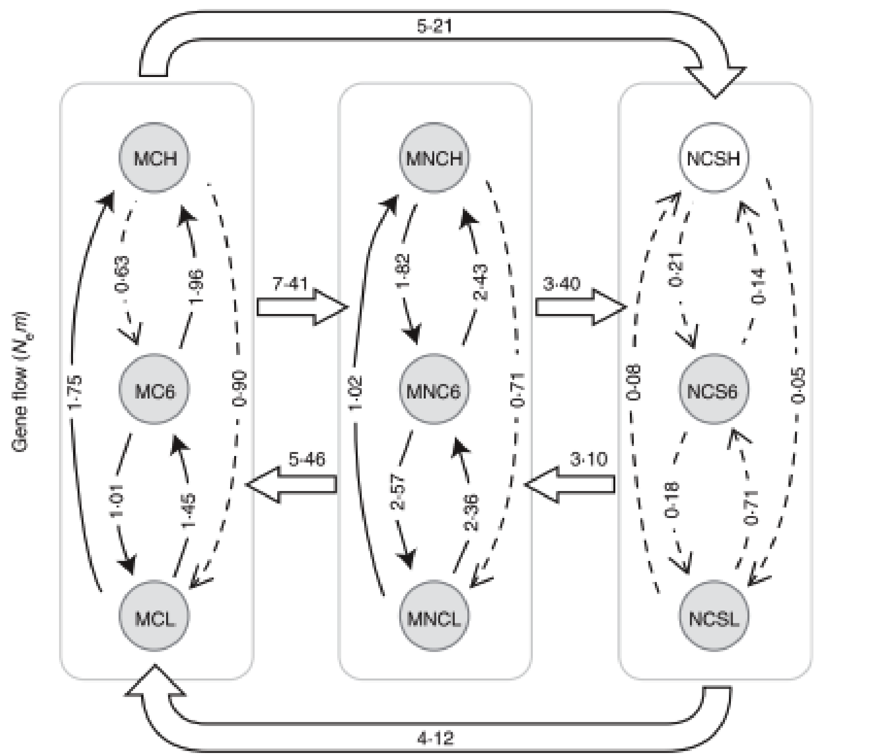
Figure 2. Linear regression of leaf length (A) and plant circumference (B) against altitude (m a.s.l.) for *Poa hiemata*. Values are mean (± SE mean) at each of the three sites. Key: NCS (New Country Spur), MNC (Mount Nelse Central), and MC (Mount Cope).

Byars, Papst, Hoffmann Evolution 2007

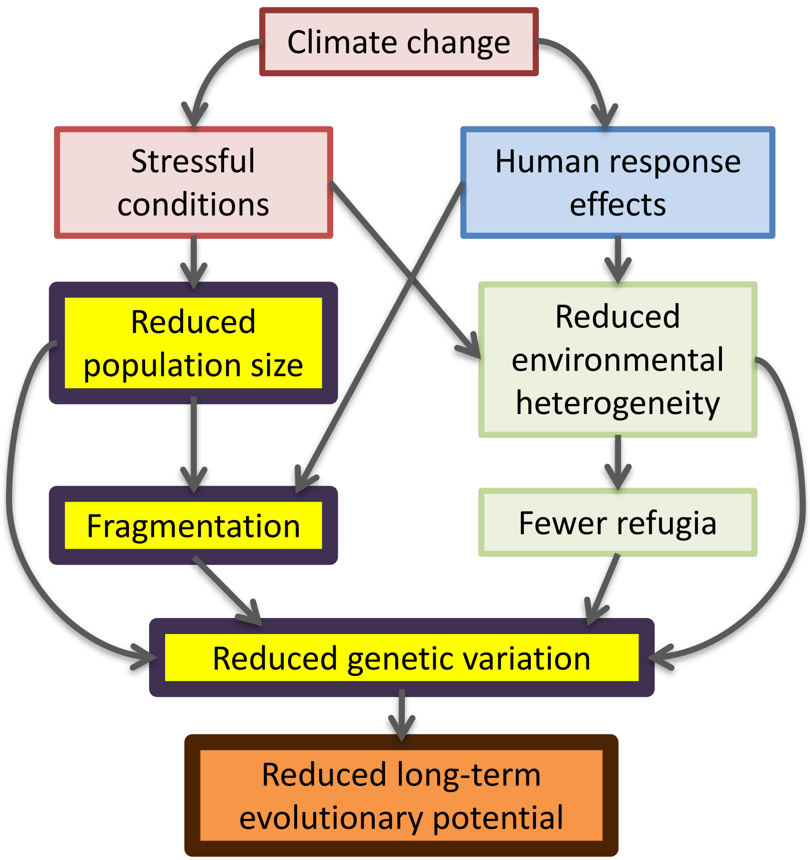
Poa hiemata – gene flow helping adaptation

High elevation sites

Low elevation sites

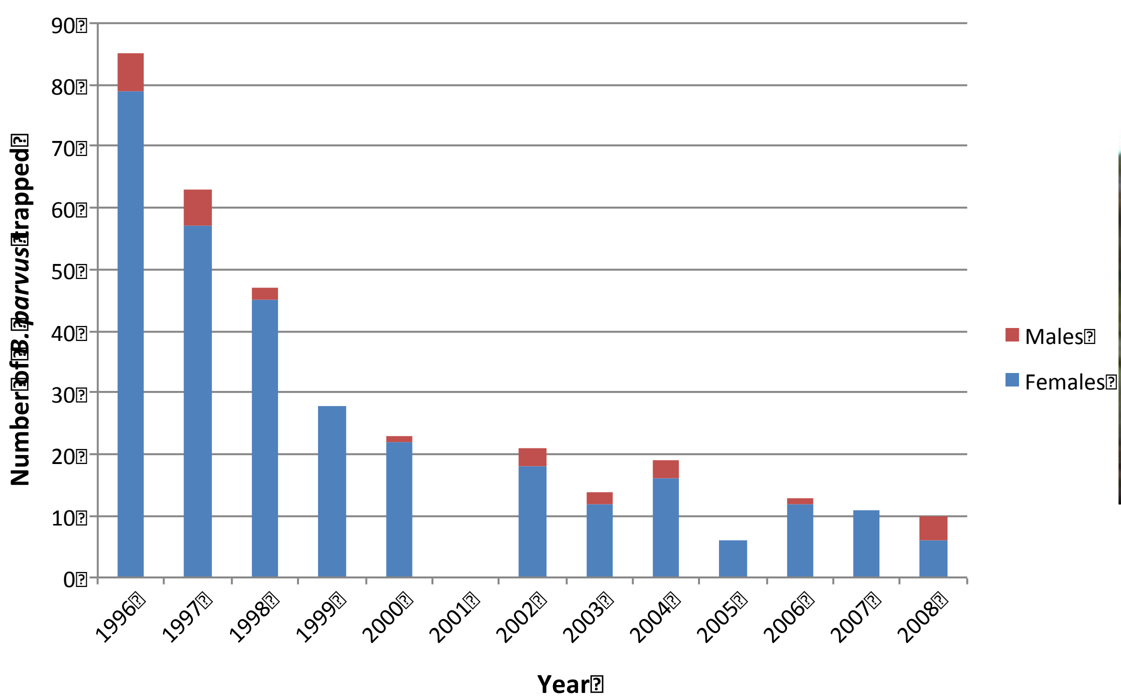


Byars, Parsons, Hoffmann 2009 Annals of Botany

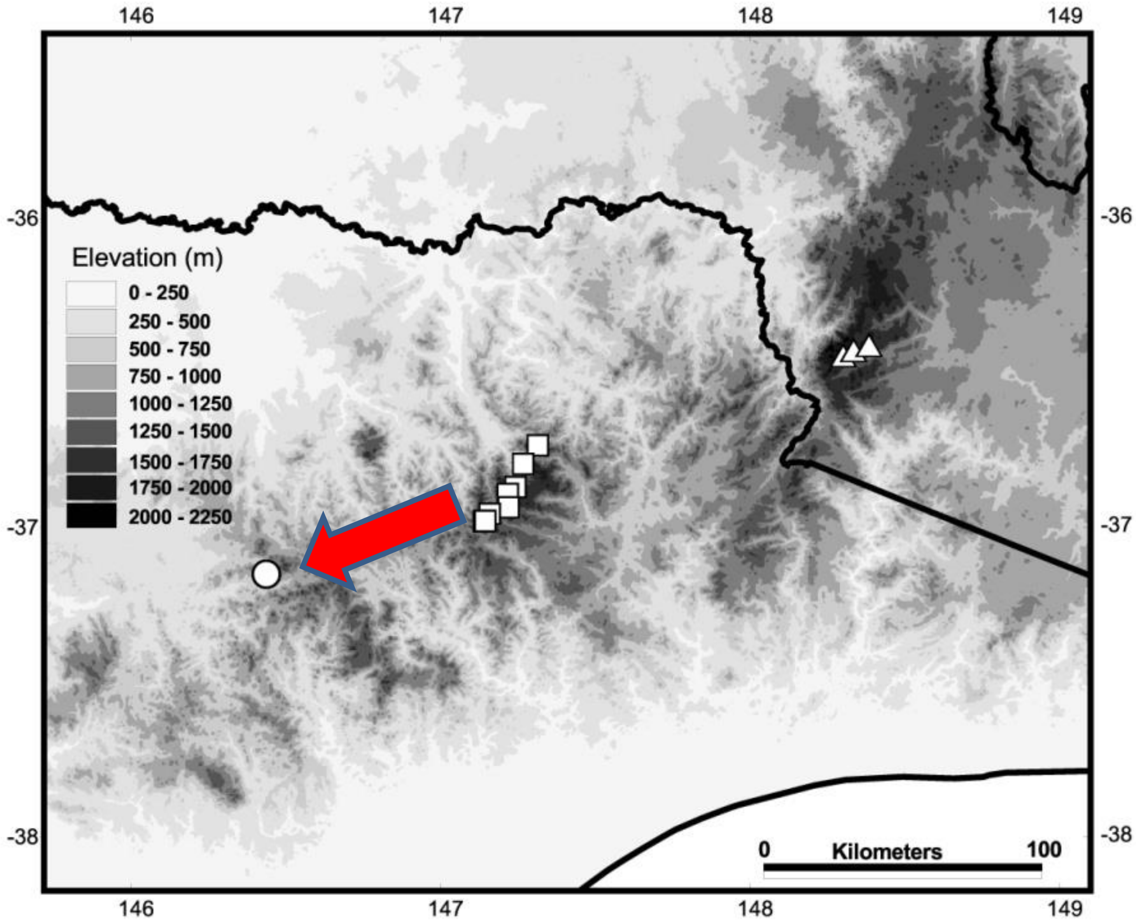


Adapted from Fig 1, Hoffmann, Griffin, Dillon
et al. (2015) Climate Change Responses

Population decline at Mt Buller of mountain pygmy possum

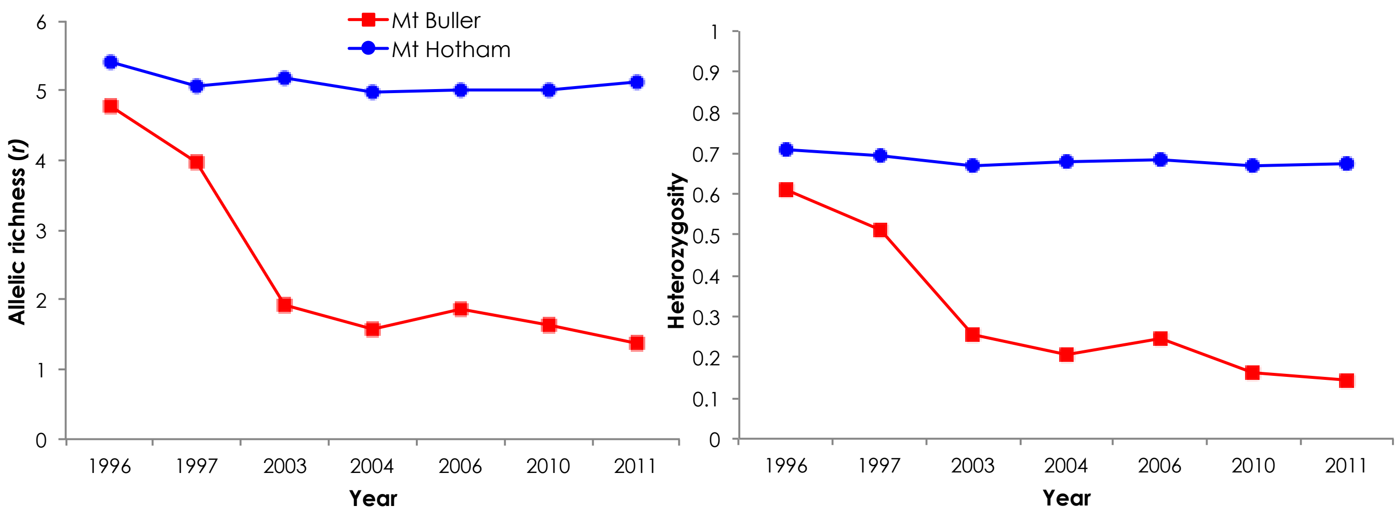


Andrew Weeks et al

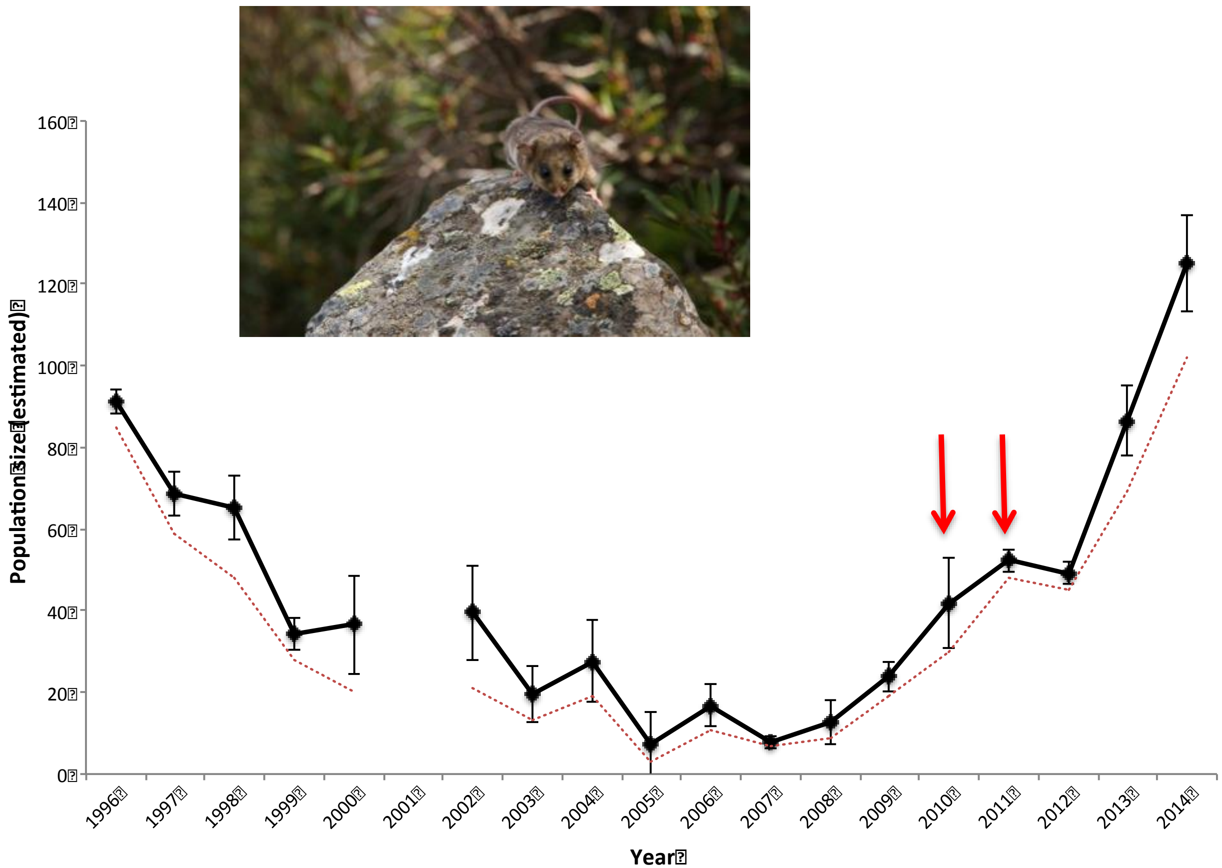


146
147
148
149
-36
-37
-38
Elevation (m)
0 - 250
250 - 500
500 - 750
750 - 1000
1000 - 1250
1250 - 1500
1500 - 1750
1750 - 2000
2000 - 2250
0
Kilometers
100

Decline in genetic variation



Mitrovski et al. 2008. Biol. Letters

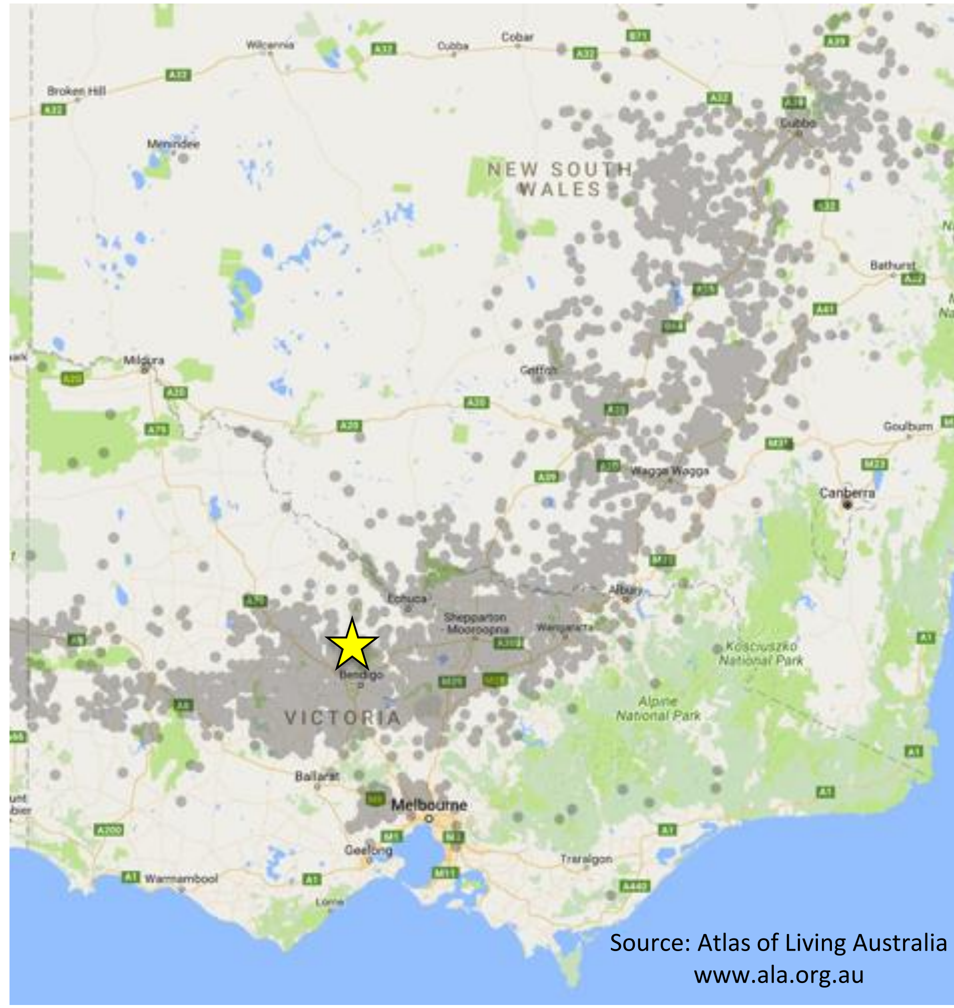


Red arrows indicate breeding seasons where 6 males were translocated from Higginbotham to Mt Buller

Andrew Weeks, Dean Heinze et al

Natural fragmented stands: *Eucalyptus microcarpa* (Grey Box)

Photo: Rebecca Jordan



Source: Atlas of Living Australia
www.ala.org.au

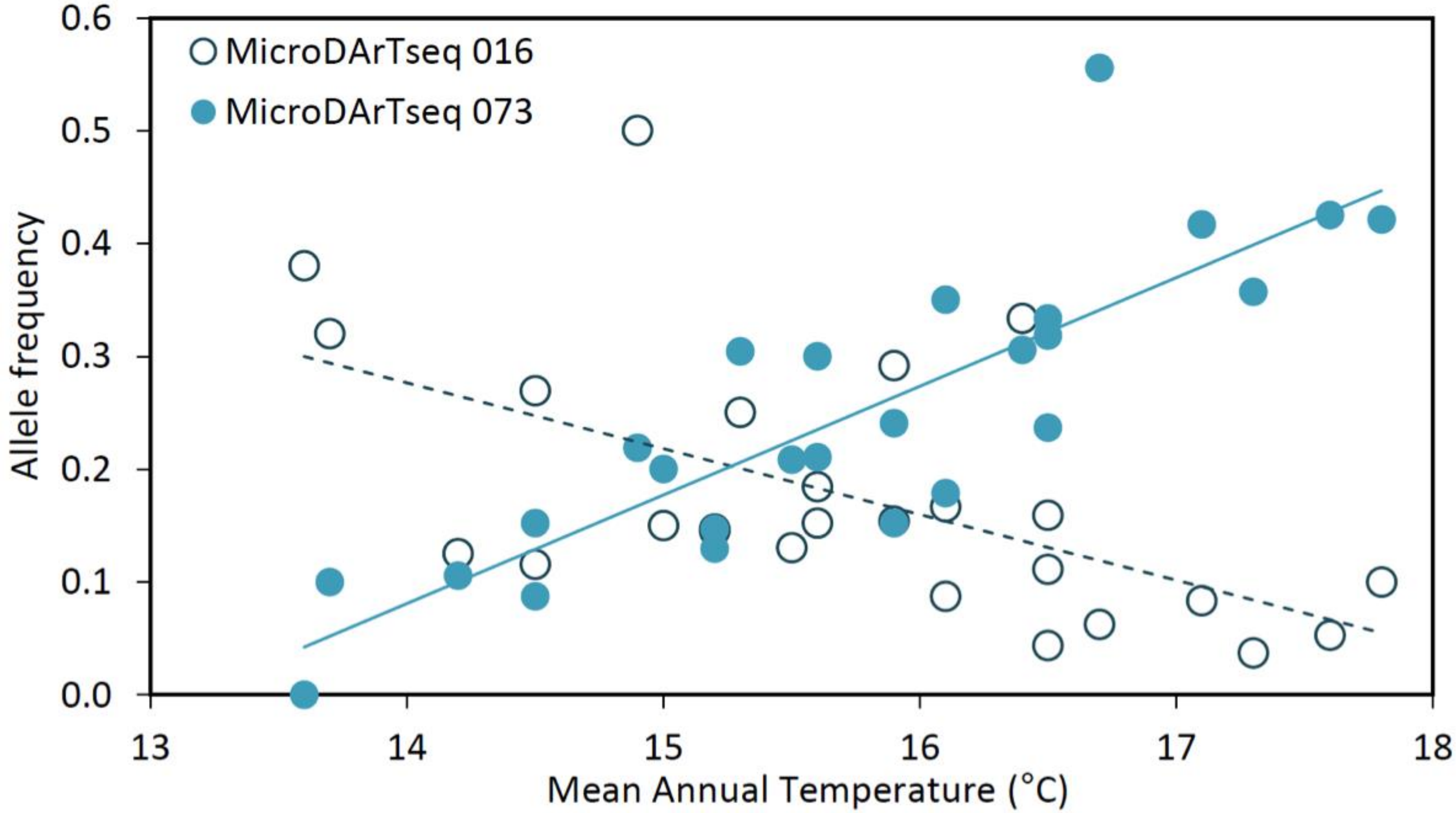
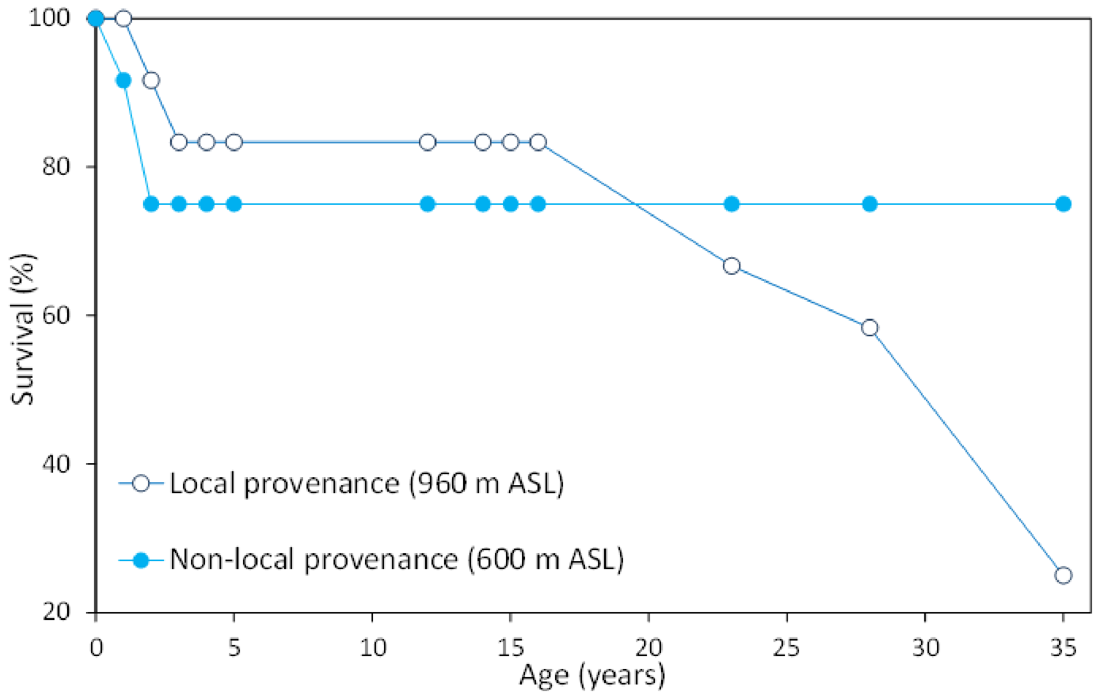


Figure 5: Examples of correlations between putatively adaptive DArTseq markers and climate variables in forest and woodland eucalypts: change in frequency of two alleles across an aridity gradient in (a)

Prober et al 2016

Revegetated stands: *E. microcarpa*

Photo: Rebecca Jordan

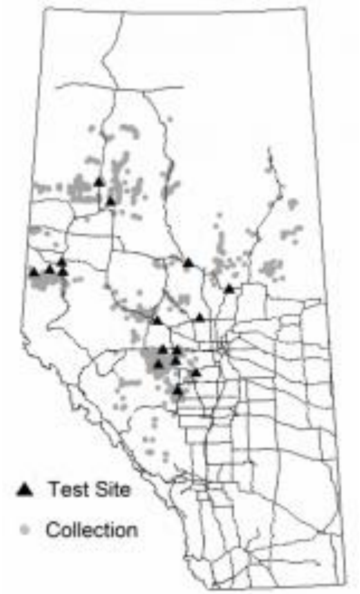


Data from Brad Potts, Prober et al 2016 Proc RS Vic

Main messages

- There is genetic diversity that matters (Potts plus animal example)
- Genomic efforts are also showing this and we don’t have to wait around for years
- Genetic variation occurs within populations and between populations: connectivity is critical for the latter
- But gene flow too slow: Local provenances are not going to be sufficient a lot of the time
- Translocation provides a potential answer

Climate Future Plots



http://www.ualberta.ca/~ahamann/teaching/various/adaptation/4-genetic-testing.html

Climate Future Plots

- Climate-resilient habitat
  - site & wider landscape
  - ‘Derisk’ restoration
  - nursery site

VicNature2050
“Creating resilient habitat for the future: Building Climate Future Plots”
Jordan, Hoffmann *et al.* 2017
www.vicnature2050.org

Why CF plots?

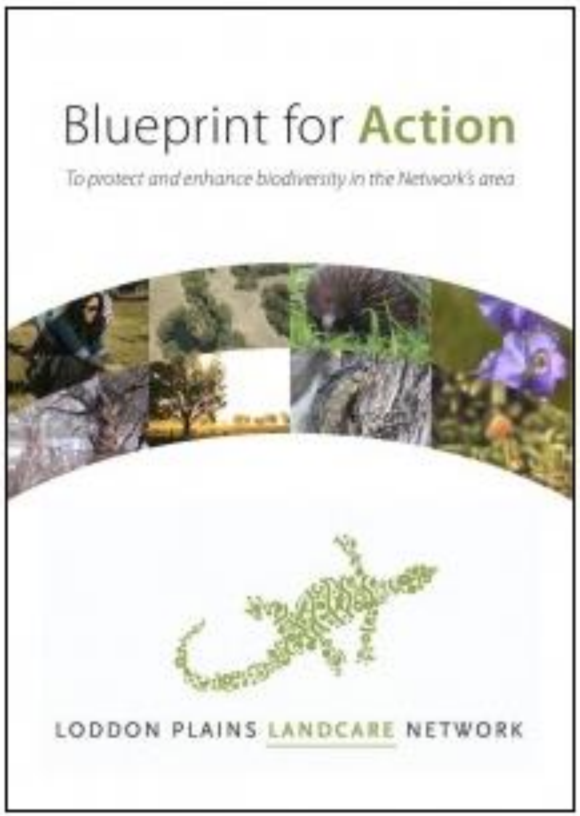
" [the] overall aim and application of conservation genetics is to **preserve species not simply as static forms, but as dynamic entities** capable of responding to and coping with environmental change over time." F. van Dyke (2008)

Protecting Victoria's Environment – Biodiversity 2037

“…. **increasing the amount of genetic diversity in a population and giving it greater ability to adapt, or 'climate resilience'**, through artificial introduction of new genetic material to increase fitness, fertility and reproduction”

“Introducing genetic variants or new species from other suitable areas that can continue to play important ecological roles under climate change”

Example Climate Future Plot



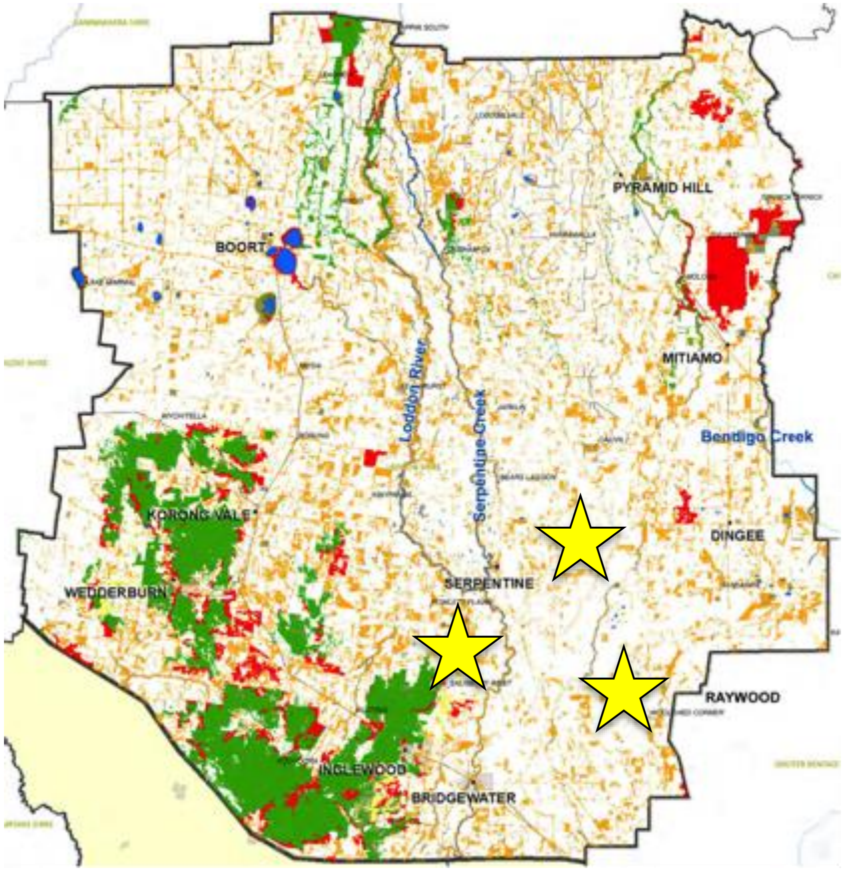
http://www.lpln.org/publications/blueprint-for-action/

GOANNA Project

Project idea:
Link & connect EBPC listed Grey Box Grassy Woodlands

Size & Location

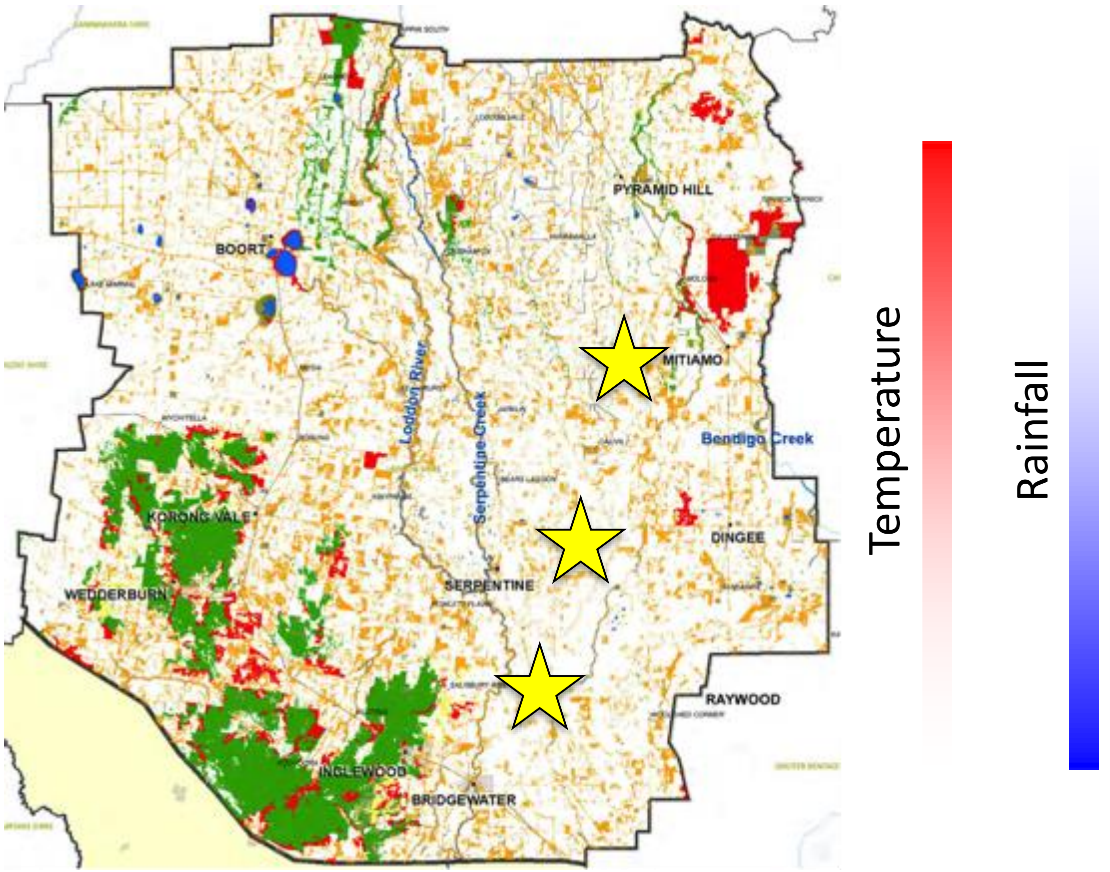
- Size
  - Flexible
  - varies between vegetation type
- Location
  - single plot
  - multiple plots



Source: Blueprint for Action. Loddon Plains Landcare Network.
http://www.lpln.org/publications/blueprint-for-action/

Size & Location

- Size
  - Flexible
  - varies between vegetation type
- Location
  - single plot
  - multiple plots
  - environmental gradients



Source: Blueprint for Action. Loddon Plains Landcare Network.
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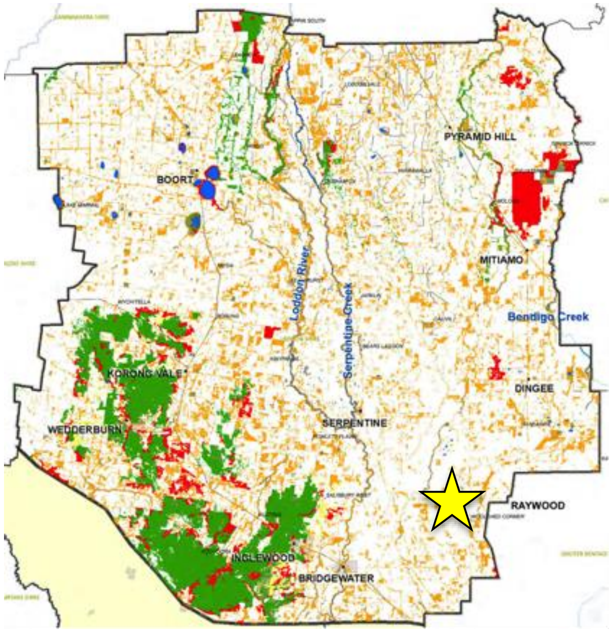
What to include

- Diversity
  - genetic diversity
  - pre-adapted climate diversity
  - species diversity

1. Grey Box



What to include

- Diversity
    - genetic diversity
    - pre-adapted climate diversity
    - species diversity

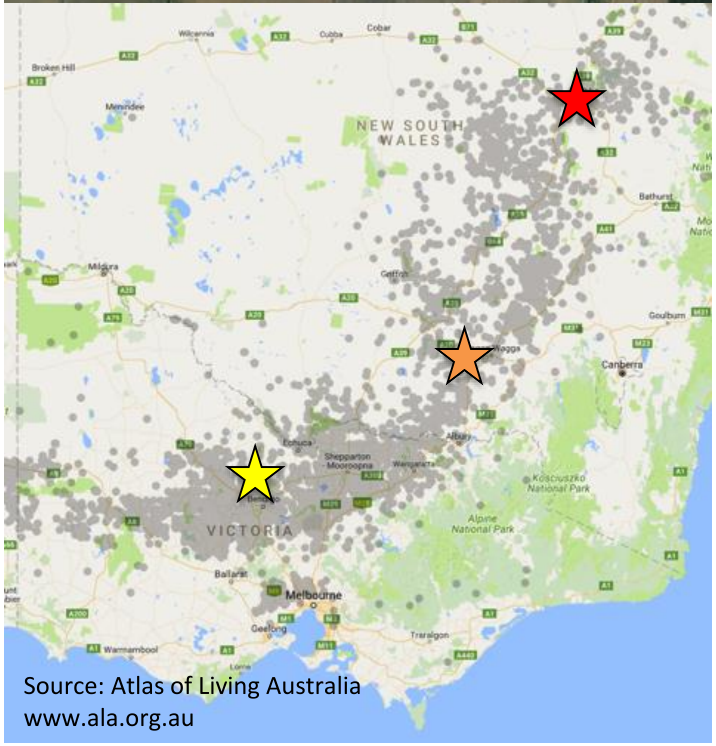
1. Grey Box

   1 local & 2 non-local

   +1 °C: Wagga Wagga (16.2 °C)

   +2 °C: Dubbo (17.3 °C)

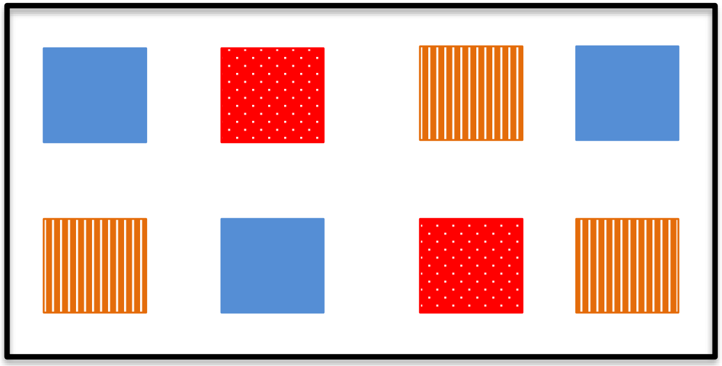
N Hancock, R Harris, L Broadhurst & L Hughes 2016
http://anpc.asn.au/resources/climate_ready_revegetation



Source: Atlas of Living Australia
www.ala.org.au

What to include

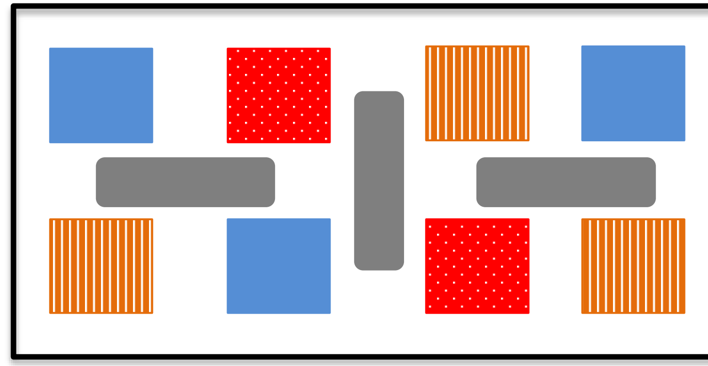
1. Grey Box
   - local (Bendigo)
   - +1 °C (Wagga Wagga)
   - +2 °C (Dubbo)



What to include

1. Grey Box
   - local (Bendigo)
   - +1 °C (Wagga Wagga)
   - +2 °C (Dubbo)

2. Alternative species
   - Yellow Box (*E. melliodora*)
   - Blakely’s Red Gum (*E. blakelyi*)
   - Buloke (*Allocasuarina luehmannii*)



John Edwards
(ALA http://www.ala.org.au)

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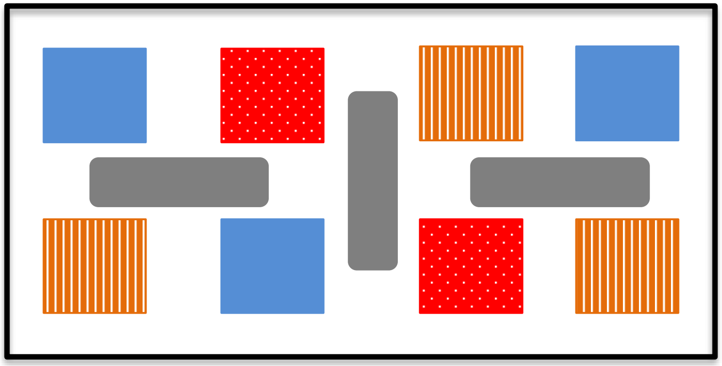
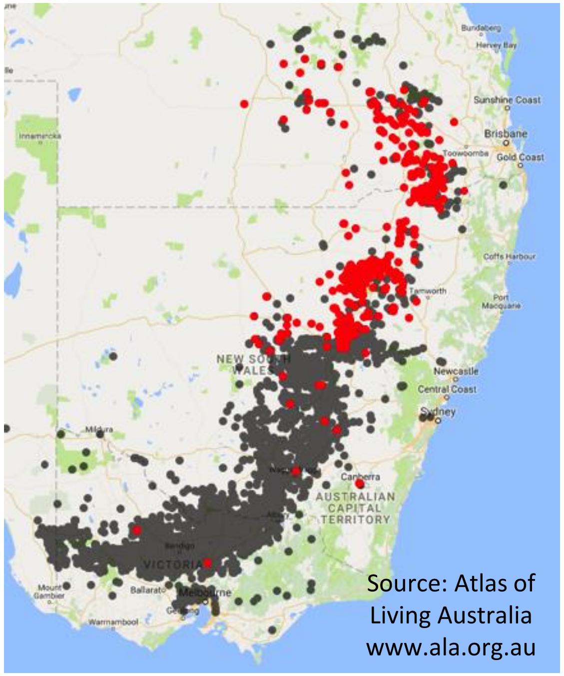




- Grey Box (*E. microcarpa*)
- *Eucalyptus woollsiana*

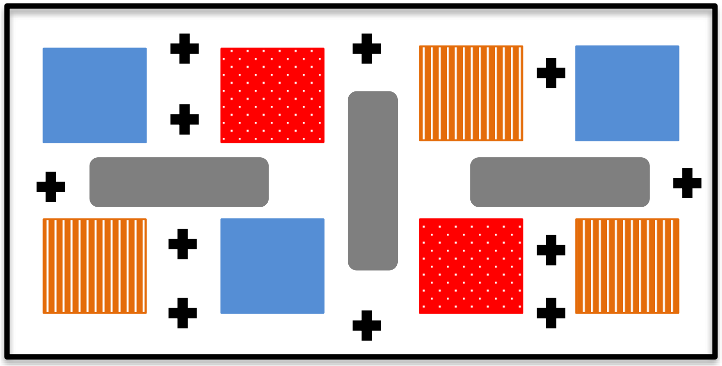
What to include

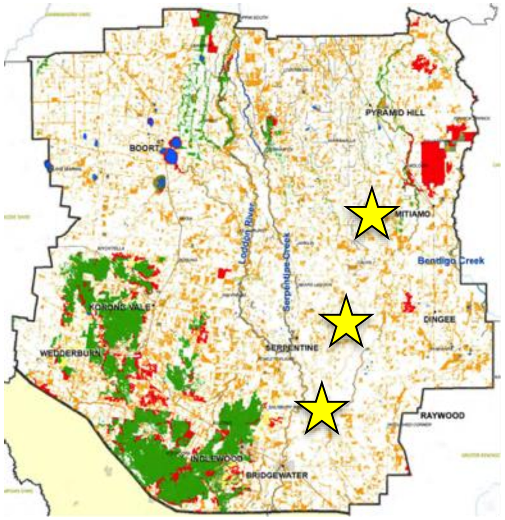
1. **Grey Box**
   - local (Bendigo)
   - +1 °C (Wagga Wagga)
   - +2 °C (Dubbo)

2. **Alternative species**
   - Yellow Box (*E. melliodora*)
   - Blakely's Red Gum (*E. blakelyi*)
   - Buloke (*Allocasuarina luehmannii*)

   - ✚ *Eucalyptus woollsiana*

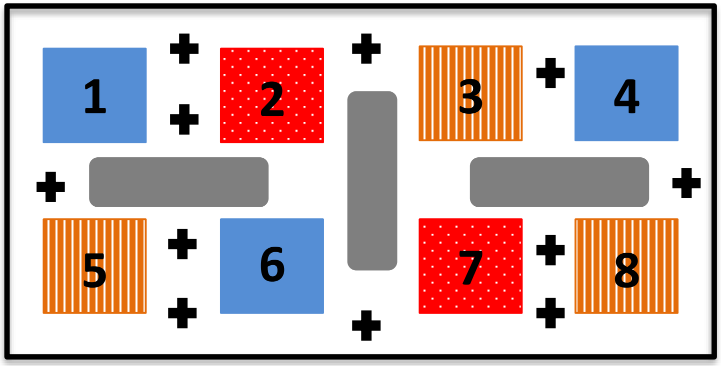
3. **Shrubs & other vegetation**
   - Gold-dust wattle (*Acacia acinacea*)
   - Drooping cassinia (*Cassinia arcuata*)

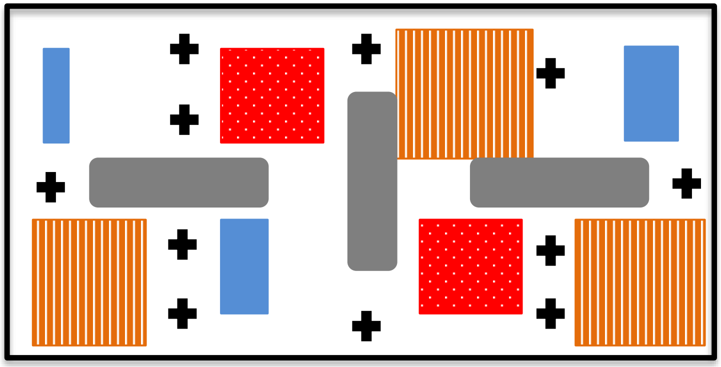




Documentation & Monitoring

- What & where





Making CF plots a reality

- Collaboration

Across conservation sector
- restoration practitioners
- land managers, public & private
- science
- government / policy

- Learn by doing!