Maintaining adaptation in revegetated landscapes

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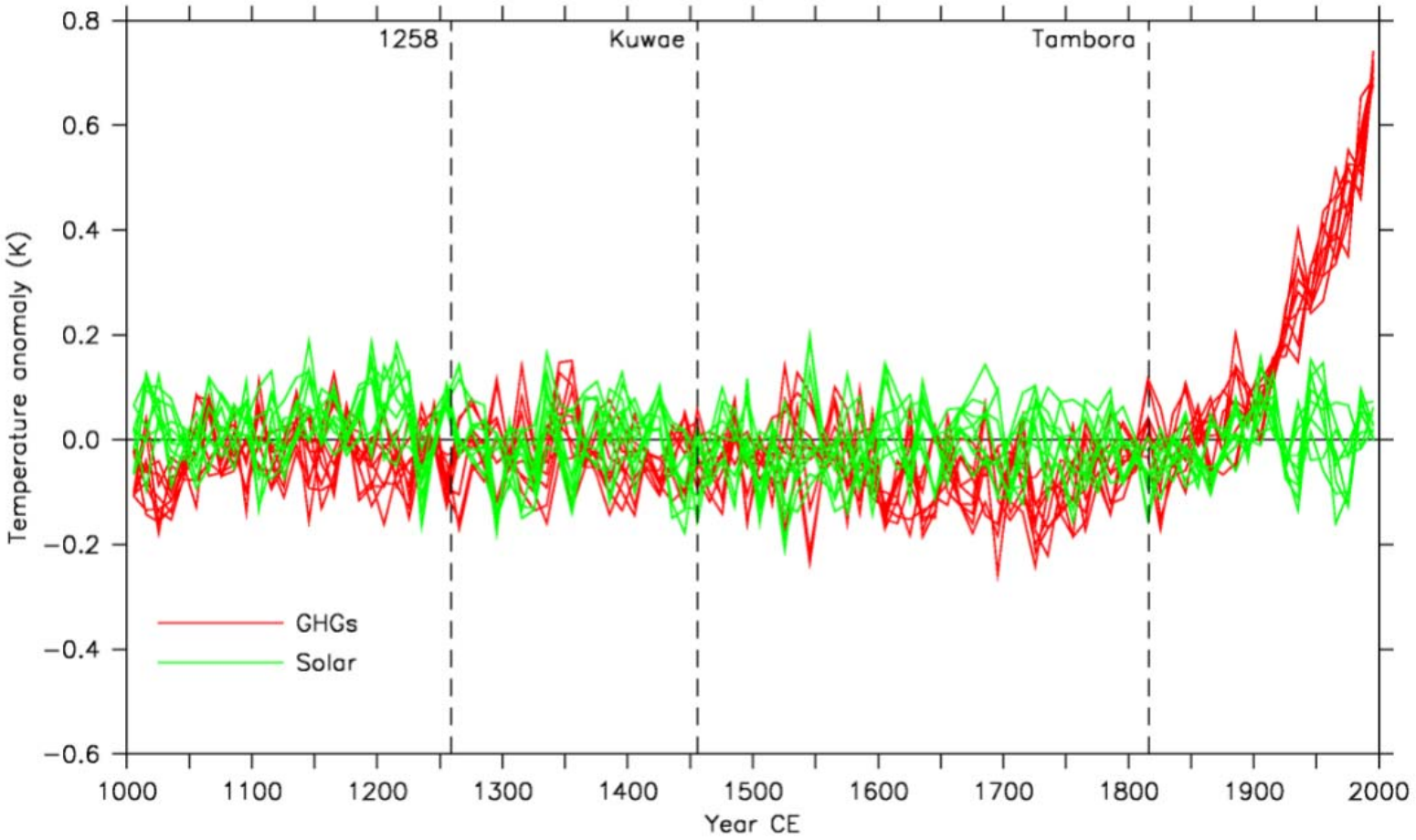
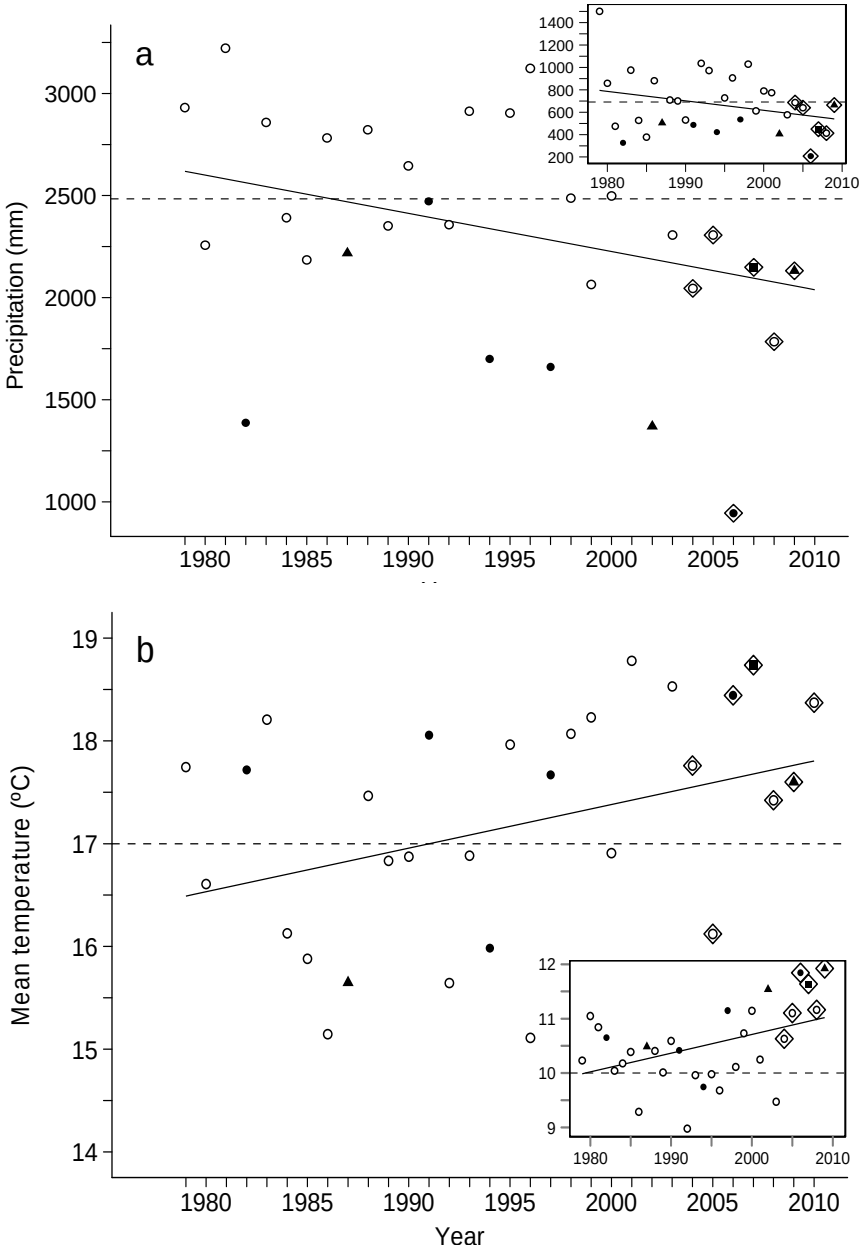
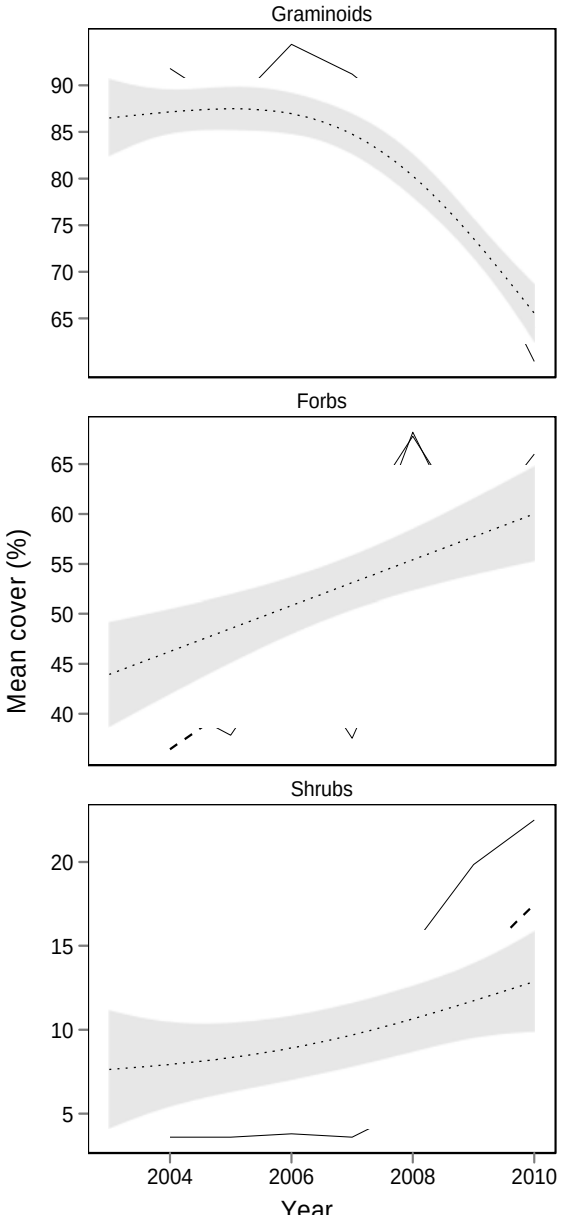
Simulated "fingerprints" of external forcings



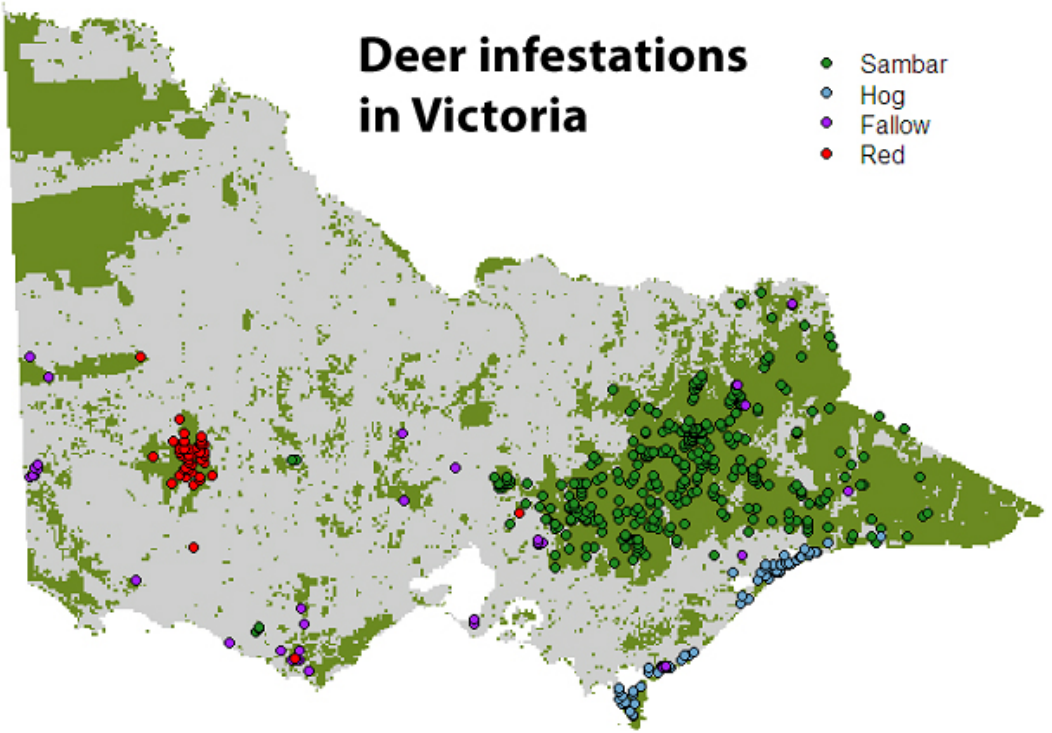
Phipps, Gergis, Karoly et al

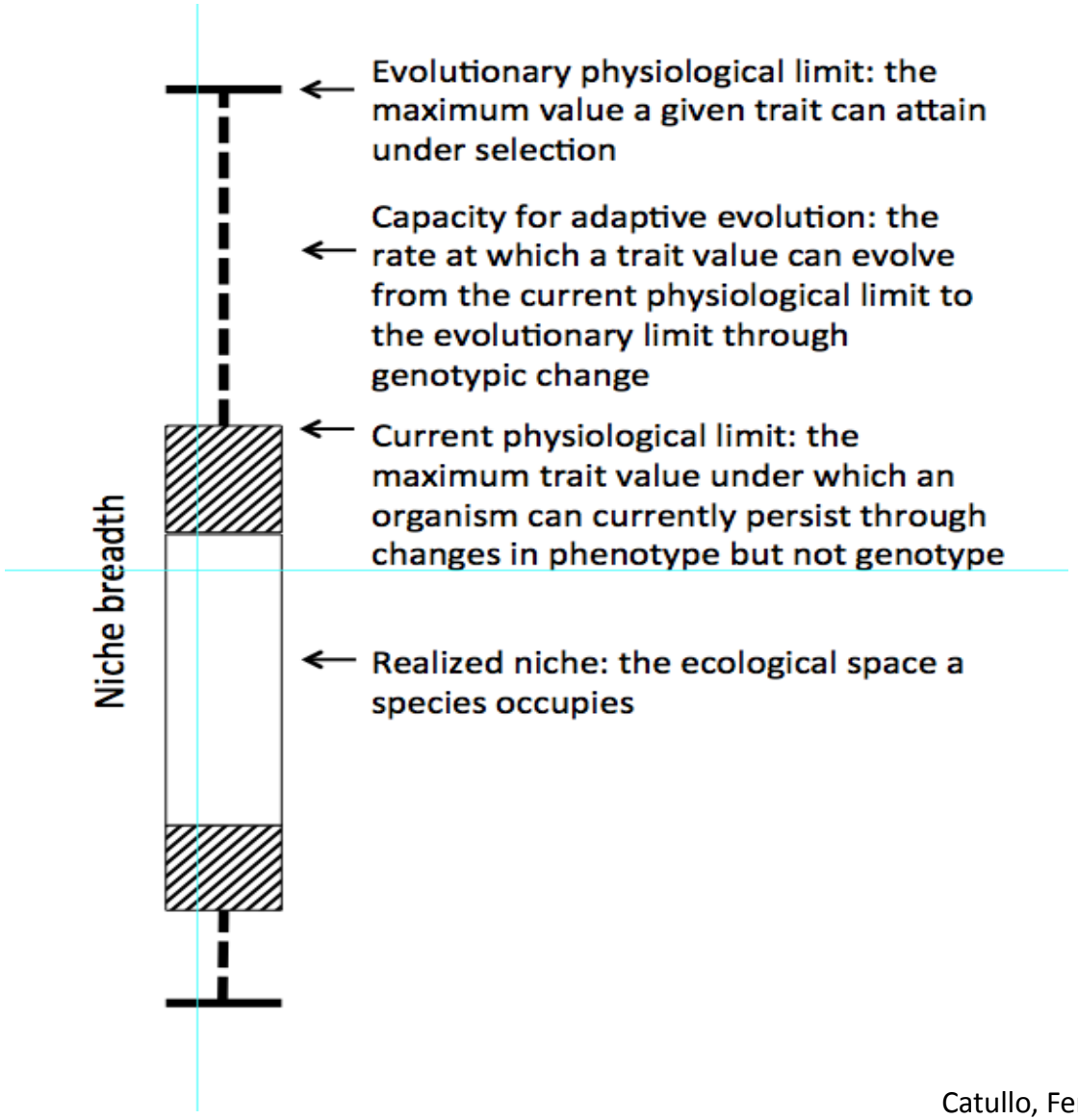

a
Precipitation (mm)
3000
2500
2000
1500
1000
1980
1985
1990
1995
2000
2005
2010
1400
1200
1000
800
600
400
200
b
Mean temperature (°C)
19
18
17
16
15
14
12
11
10
9
Year



Wahren et al Australian J Botany 2013


Damage at New Country Spur





Catullo, Ferrier, Hoffmann Global Biogeography and Ecology 2015

Evolutionary adaptation as an important component for dealing with environmental change

- Individuals have the potential to adapt by plasticity (=non-genetic adjustments)
- 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)
- Introduction of new genes into populations is a key component of adaptation

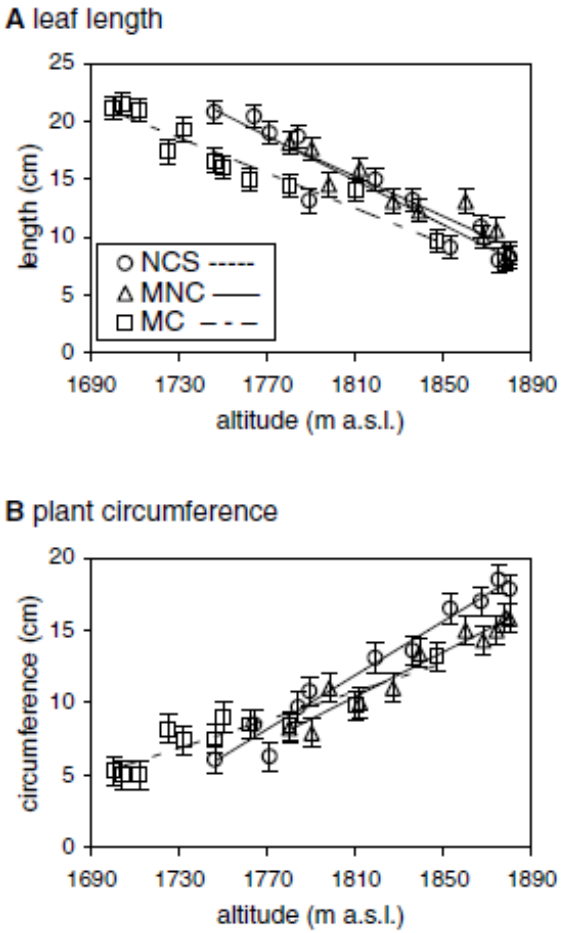
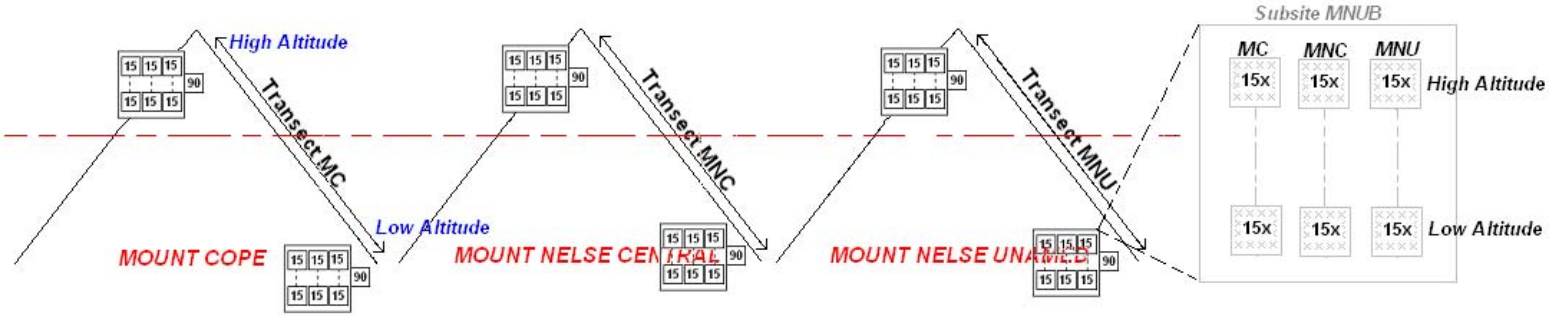
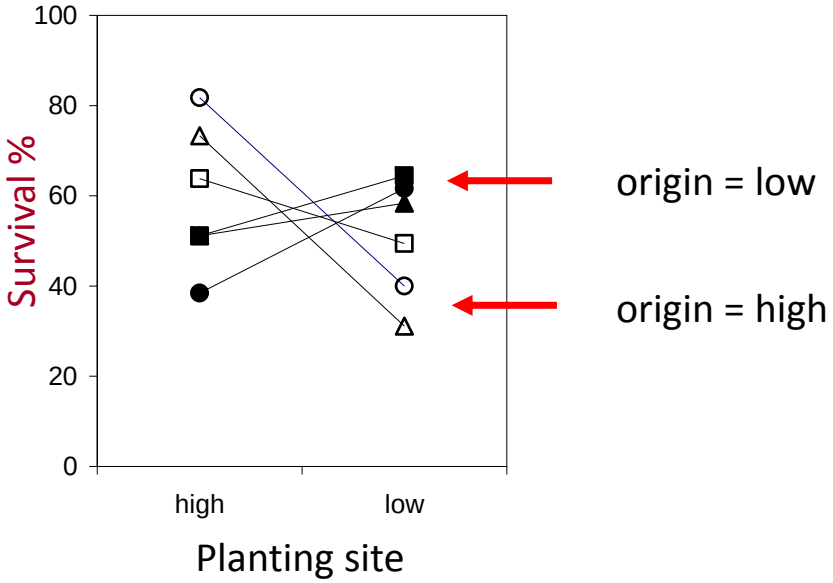
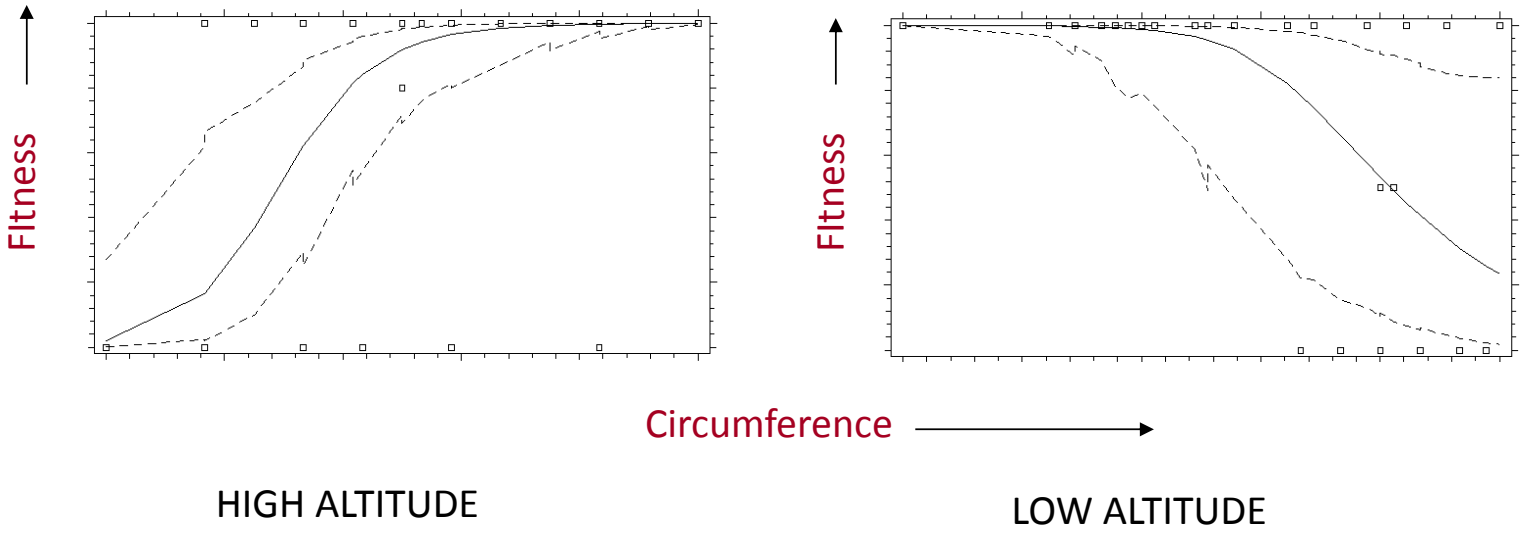


Figure 2. Linear regression of leaf length (A) and plant circumference (B) against altitude (m a.s.l.) for *Poa hiemata*. Values are mean (± SE mean) at each of the three sites. Key: NCS (New Country Spur), MNC (Mount Nelse Central), and MC (Mount Cope).

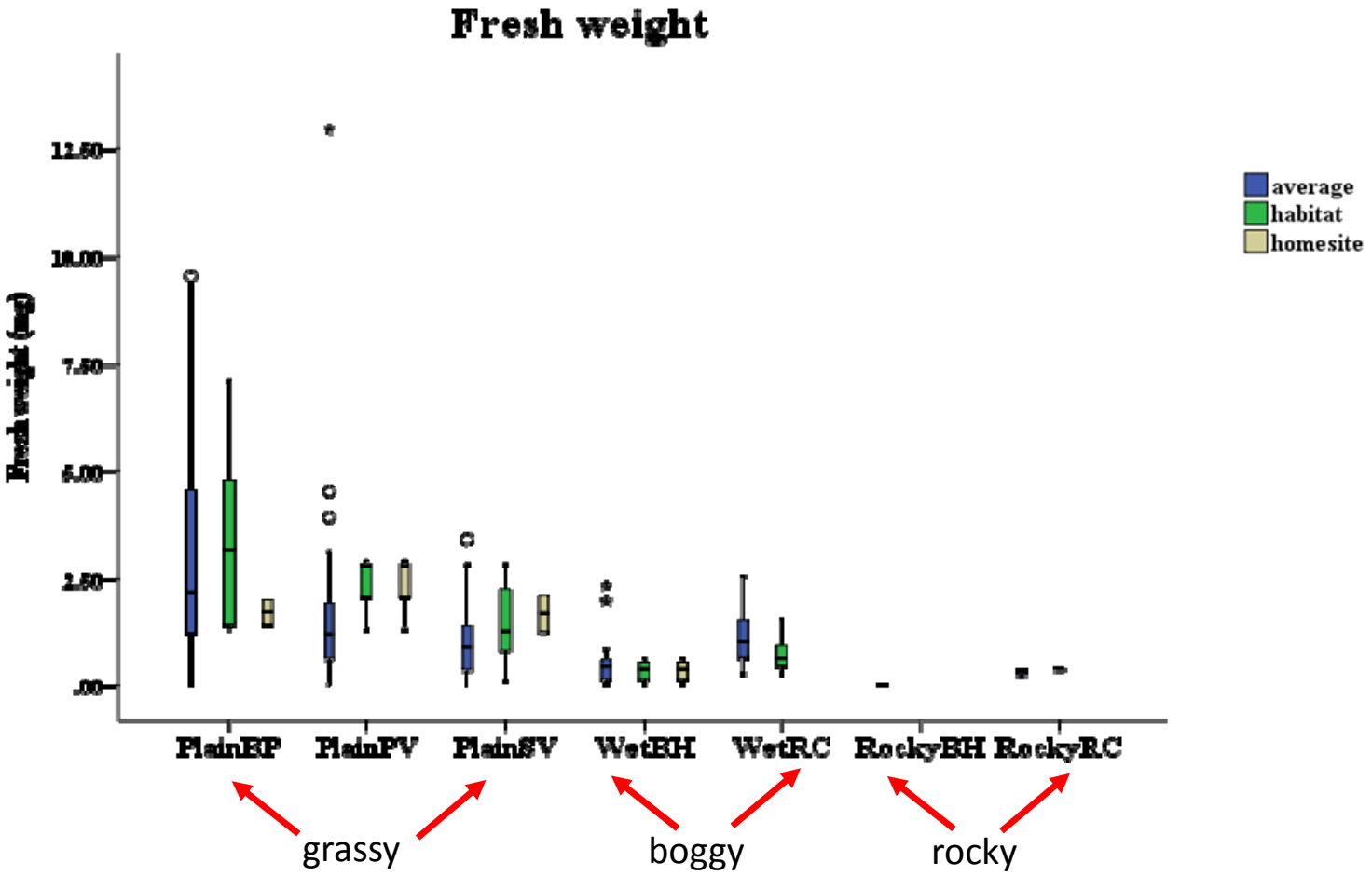
Byars, Papst, Hoffmann Evolution 2007


High Altitude
Transect MC
Low Altitude
MOUNT COPE
Transect MNC
MOUNT NELSE CENTRAL
Transect MNU
MOUNT NELSE UNAMED
Subsite MNUB
MC
MNC
MNU
15x
High Altitude
Low Altitude


100
80
60
40
20
0
Survival %
high
low
Planting site
origin = low
origin = high


Fitness
Fitness
Circumference
HIGH ALTITUDE
LOW ALTITUDE

Brachyscome decipiens: alpine daisy (occurs across rocky, boggy and grassy sites)

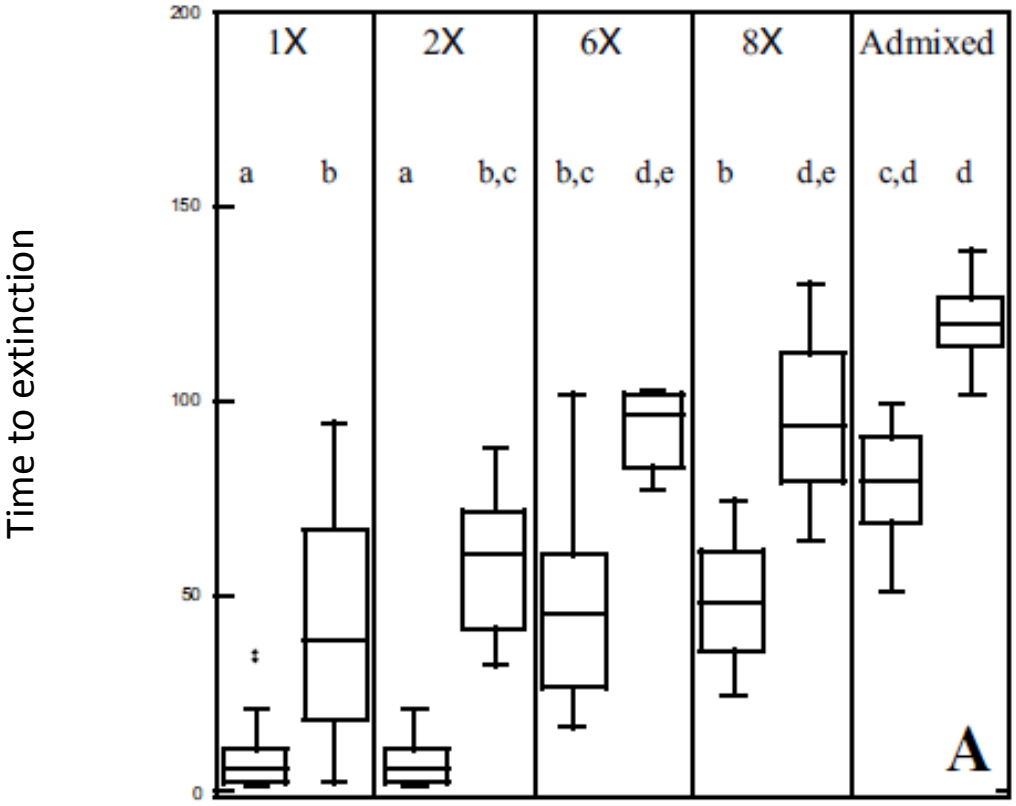


Megan Hirst

Evolutionary rates depend on:

- Population size (big = faster, further)
- Movement of genes between populations
- Movement of genes between species

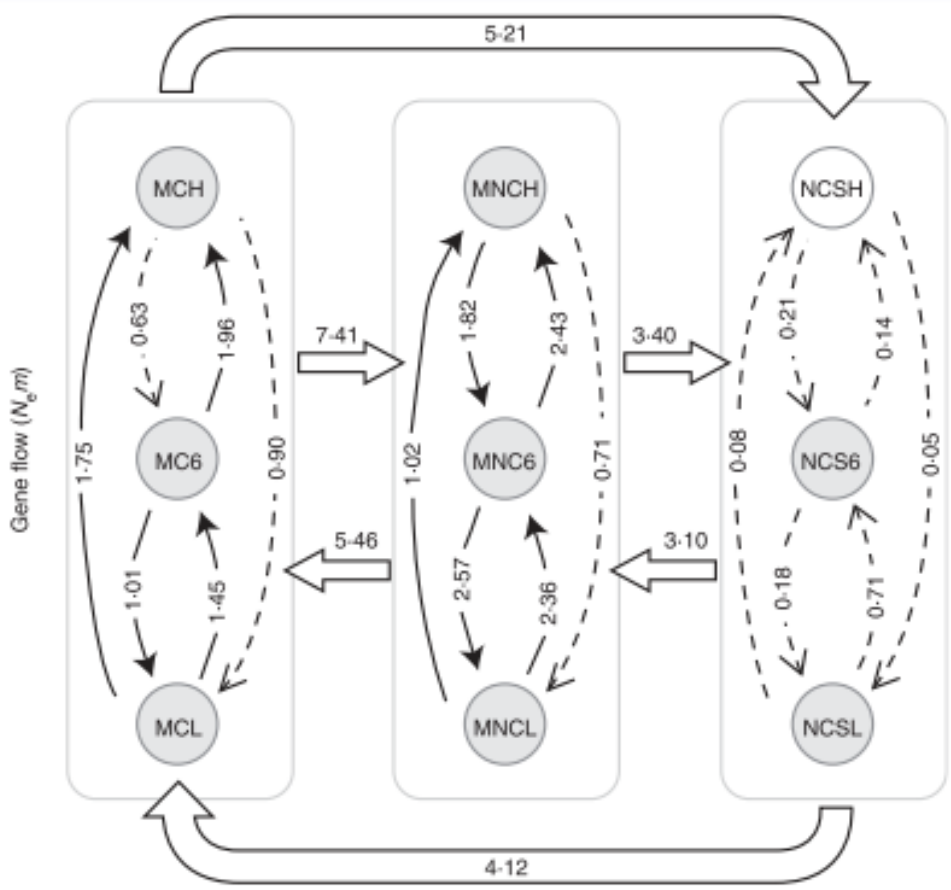
Markert *et al. BMC Evolutionary Biology* 2010, **10**:205
http://www.biomedcentral.com/1471-2148/10/205



Genetic variation = population size

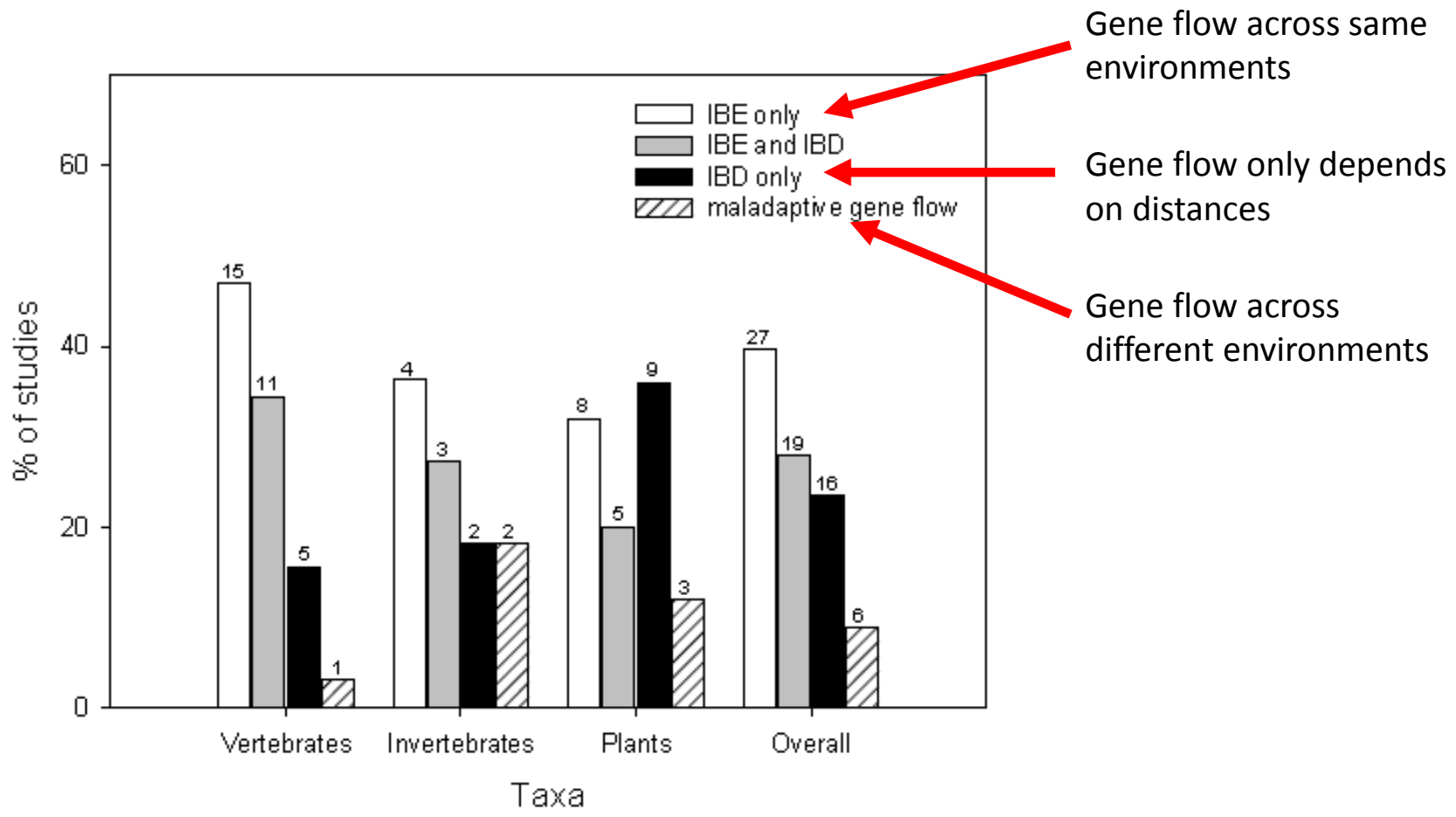
Poa hiemata – gene flow helping adaptation

High elevation sites



Low elevation sites

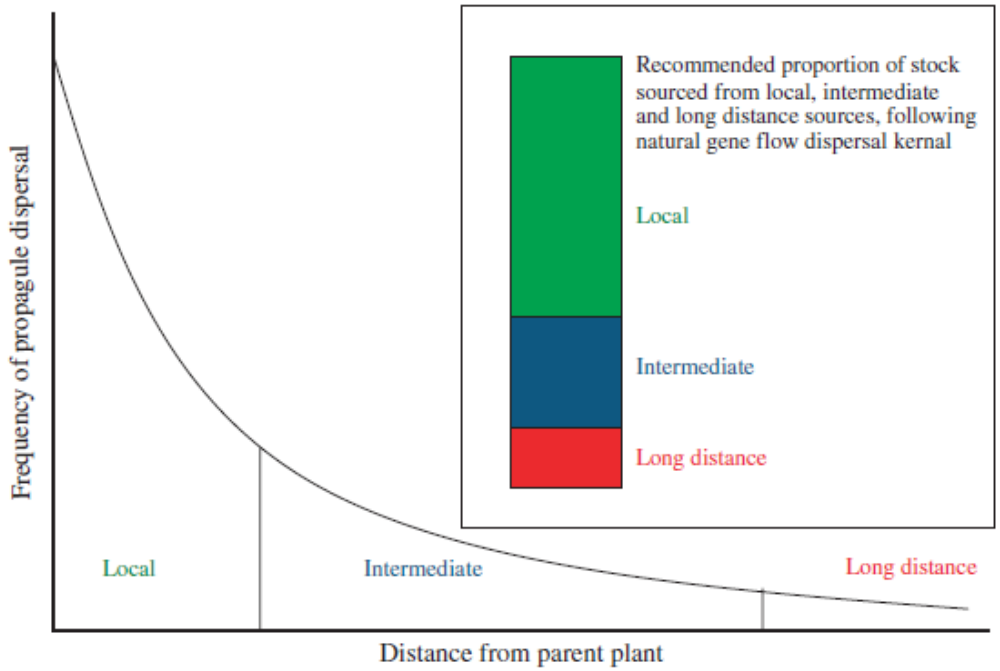
Byars, Parsons, Hoffmann 2009 Annals of Botany



Sexton, Hangartner and Hoffmann Evolution (2014)

FloraBank

Increasing Adaptive Capacity by Increasing Gene Flow



Sgro, Lowe, Hoffmann Evolutionary Applications 2011

Hybridization as a controversial approach

- Climate change and human activities are causing increasing movement of species across landscape
- This increases potential for species hybrization
- Evidence of hybridization events driving big adaptation events in the past is increasing as we dissect genomes

- Pollution or adaptation?

Genomic tools help to understand gene flow, population size, and local adaptation

Genomic tools provide a window on past and present revegetation programs

Natural stands: *E. microcarpa* (Grey Box)

- Figures removed on request

Rebecca Jordan

Revegetated stands: *E. microcarpa*

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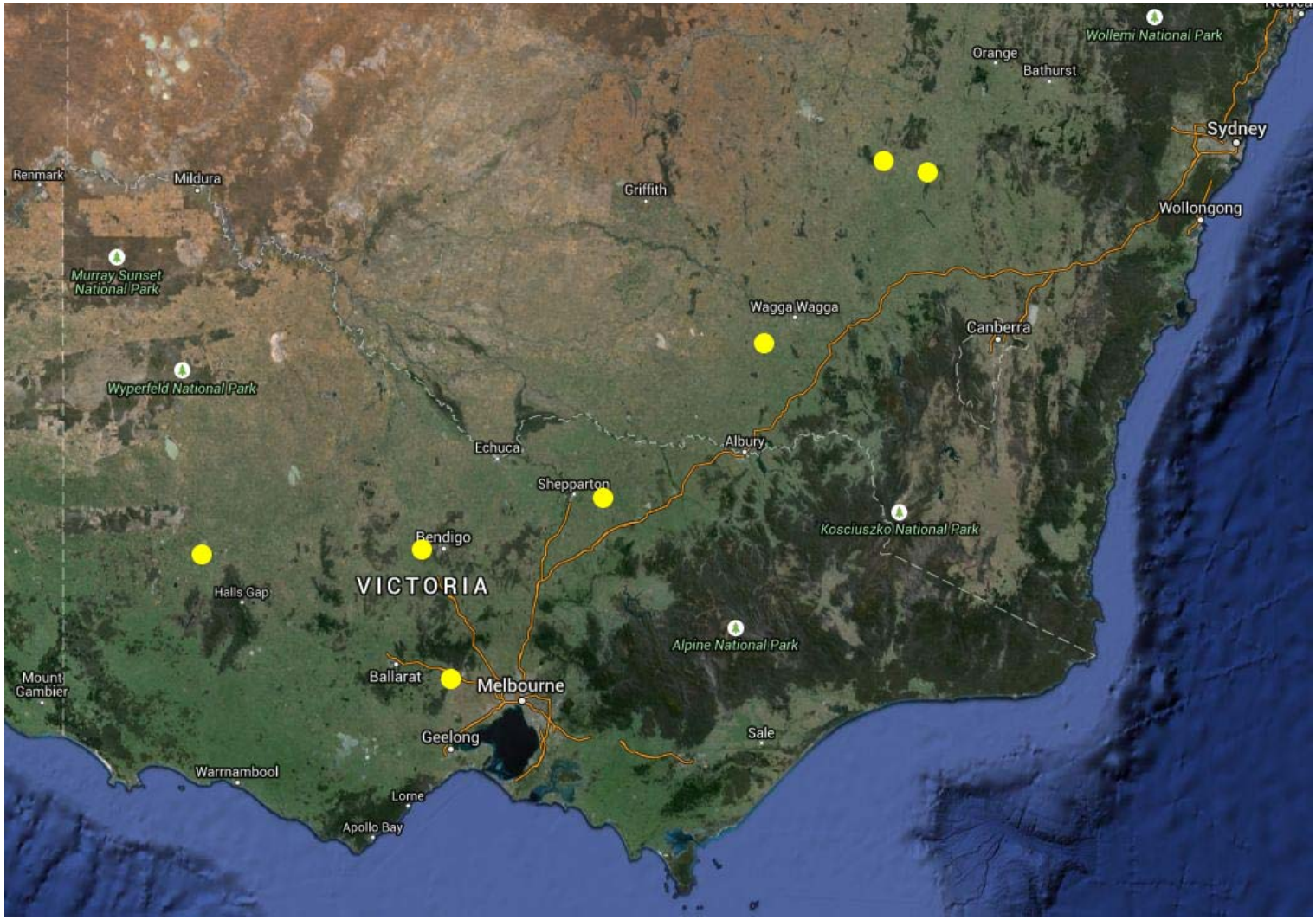
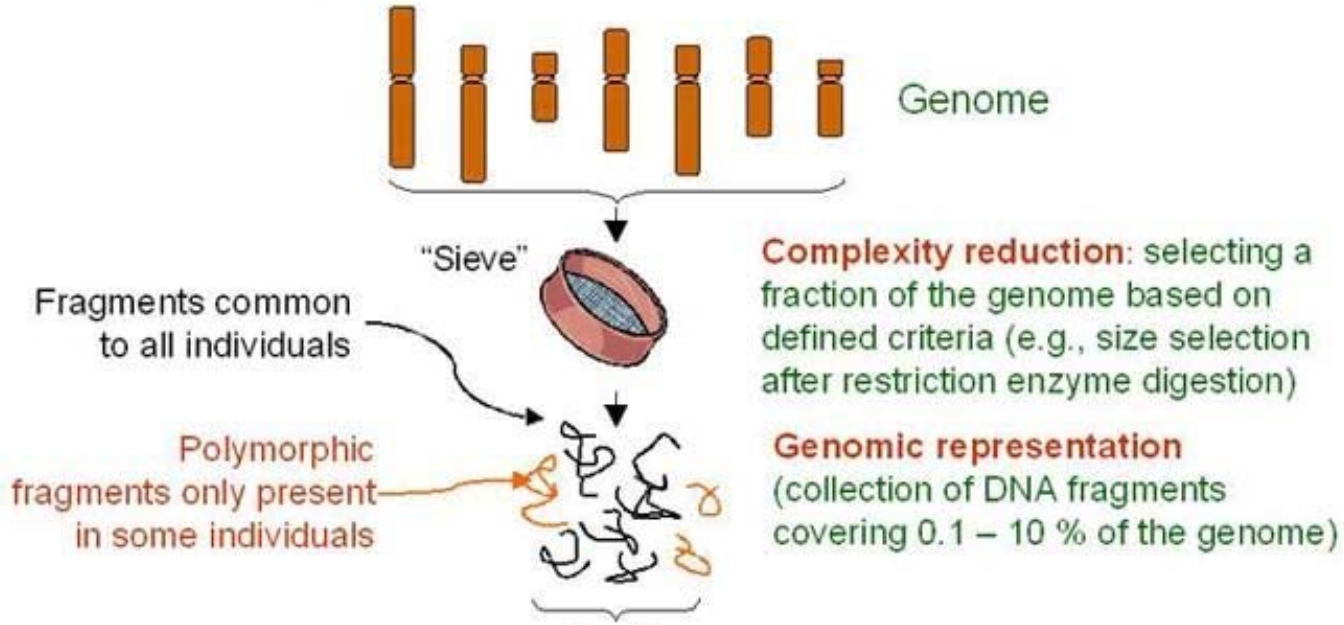

Wollemi National Park
Orange
Bathurst
Sydney
Renmark
Mildura
Griffith
Wollongong
Murray Sunset National Park
Wagga Wagga
Canberra
Wyperfeld National Park
Albury
Echuca
Shepparton
Kosciuszko National Park
Bendigo
VICTORIA
Halls Gap
Alpine National Park
Mount Gambier
Ballarat
Melbourne
Geelong
Sale
Warrnambool
Lorne
Apollo Bay

Principle of Diversity Arrays Technology



Complexity reduction: selecting a fraction of the genome based on defined criteria (e.g., size selection after restriction enzyme digestion)

Genomic representation (collection of DNA fragments covering 0.1 – 10 % of the genome)

DArT

Determine genotype by detecting the presence/ absence of the polymorphic fragments through hybridisation to microarrays containing polymorphic sequences (dominant marker)

DArTseq

Determine genotype by sequencing genomic representation on Next Generation Sequencing (NGS) platform (codominant markers)

Modified from CambiaLabs - Principles of DArT (www.cambia.org)

Genomic variation within individuals

- Figure removed on request

Genomic variation within populations

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Genomic differences across space

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Genomic uniqueness across distance

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Gene flow: isolation by distance

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In terms of *E. microcarpa*

- Past revegetation efforts have done a reasonable job of capturing local genetic variation (=if local adaptation occurs, this would be captured)
- In some cases the revegetation sites have lower levels of genetic variability (= lower adaptive potential to some extent)
- Revegetation areas carry some unique alleles, and these cause larger differences across short distances than seen in natural populations
- Gene flow based on distance
- (Evidence of natural hybridization)

Generally…

- Local adaptation (but also instances where it does not occur……plasticity might be really important)
- High genetic variation, certain patterns of gene flow promote local adaptation, others oppose it
- Worth preserving adaptive potential to allow species to counter environmental change
- There are ways of doing this, but the right approach will depend on the species being considered
- Genomic tools provide a unique way of getting a lot of information rapidly