The ‘Provenance Issue’: Challenges and Opportunities for Ecological Restoration

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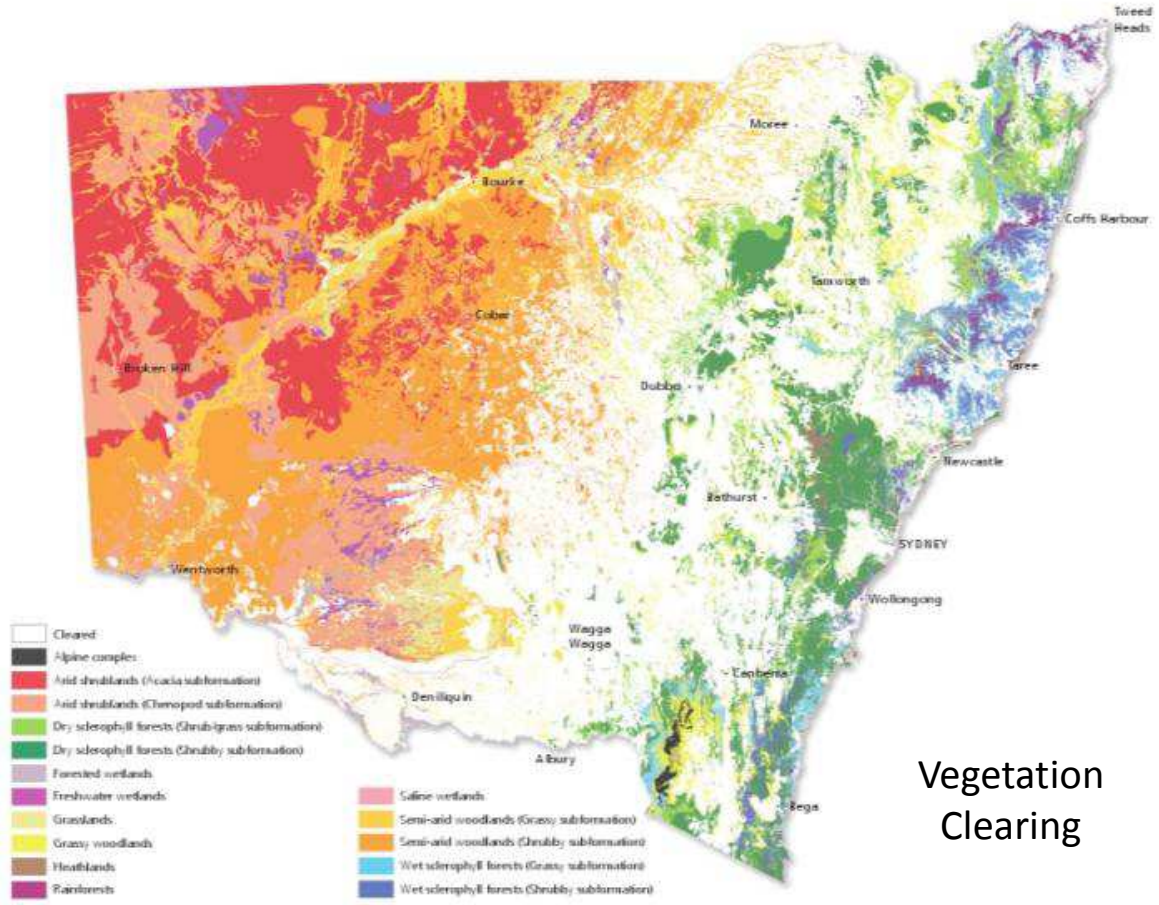
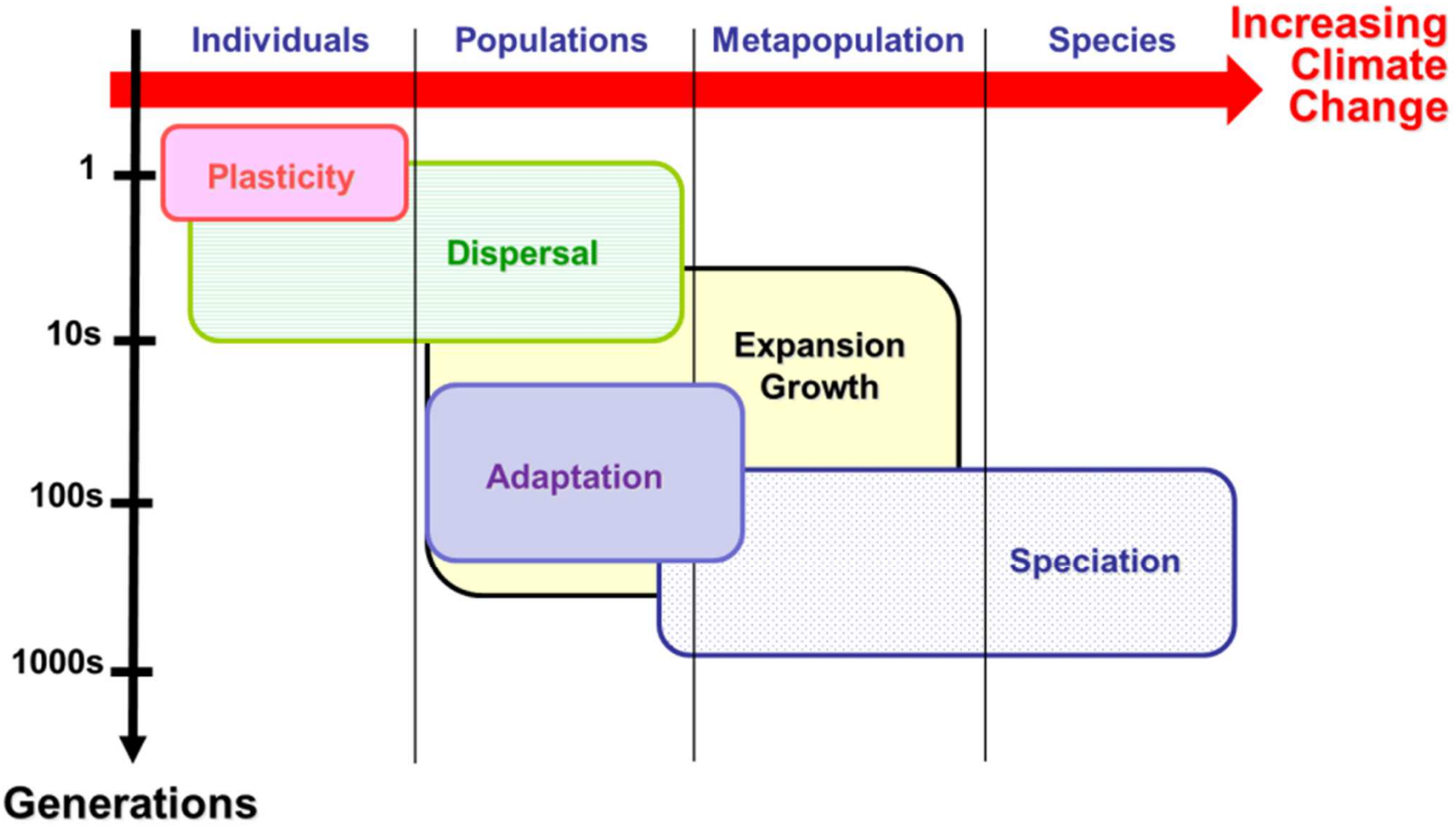
The Royal Botanic Gardens & Domain Trust

Threats: Habitat Degradation



Vegetation Clearing

Threats: Climate Change



Responses to Change

- ADAPT
  - Population size and the diversity within it sufficient for evolutionary response
  - Persist through plastic resilience
  - Multiple provenances with different adaptation
- MOVE
  - To newly available or remaining habitat
  - If capable and competitive
  - Can gene flow support adaptation
- LOCAL EXTINCTION

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Responses to Change

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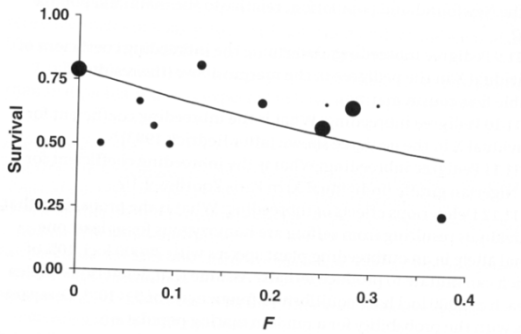
Why is the evolutionary context important?

- Short-term: genomic diversity maximises fitness
  - loss of diversity / heterozygosity causes inbreeding
  - increased frequency of deleterious genes causes inbreeding depression

Pigmy hippopotamus



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Why is the evolutionary context important?

- Long-term: genomic diversity maximises adaptation potential
  - reduces vulnerability to environmental changes
  - increases potential for evolutionary differentiation (i.e. speciation)
  - outbreeding depression: loss of fitness resulting from mixing individuals from different provenances

Rutidosis leptorrhyncoides

Telopea speciosissima

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Ecological Restoration

Aims to recover the structure, dynamics and evolutionary potential of an ecosystem

MORE THAN GARDENING!

Ecological Restoration: Limitations

- **Sustainability**: unsuitable plantings are costly and demand high maintenance
- **Research**: limited evidence-based studies
- **Information Resources**: no central source

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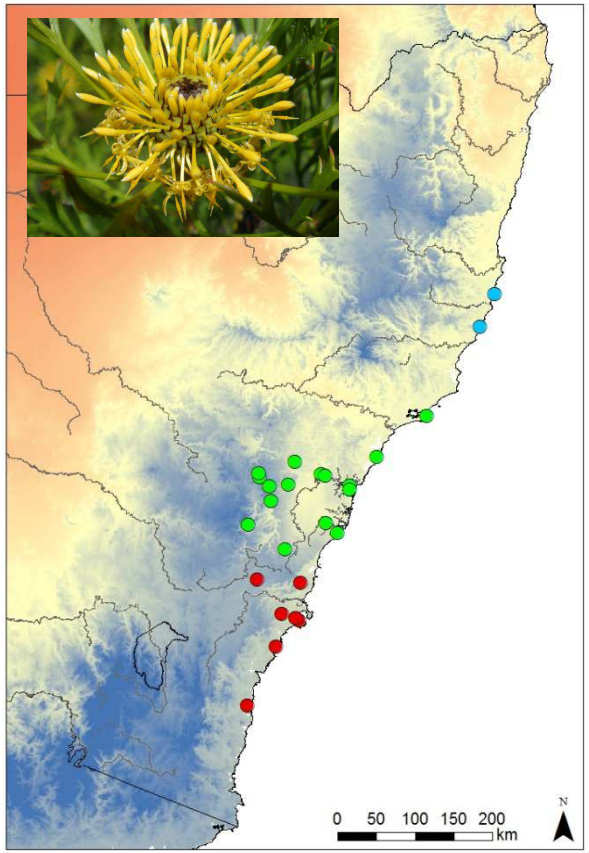
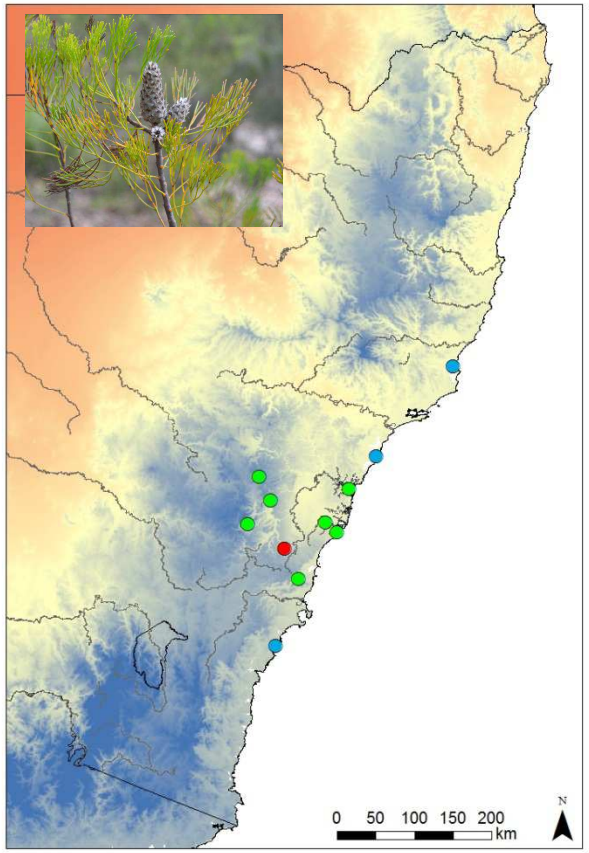
Can we Generalise? Assemblage

Sydney Sandstone Flora

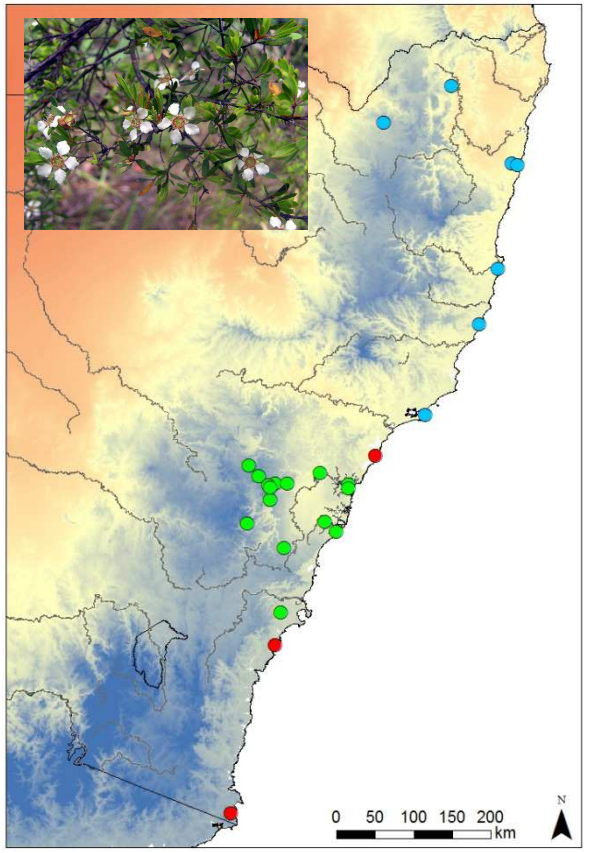
Isopogon anemonifolius



Petrophile pulchella

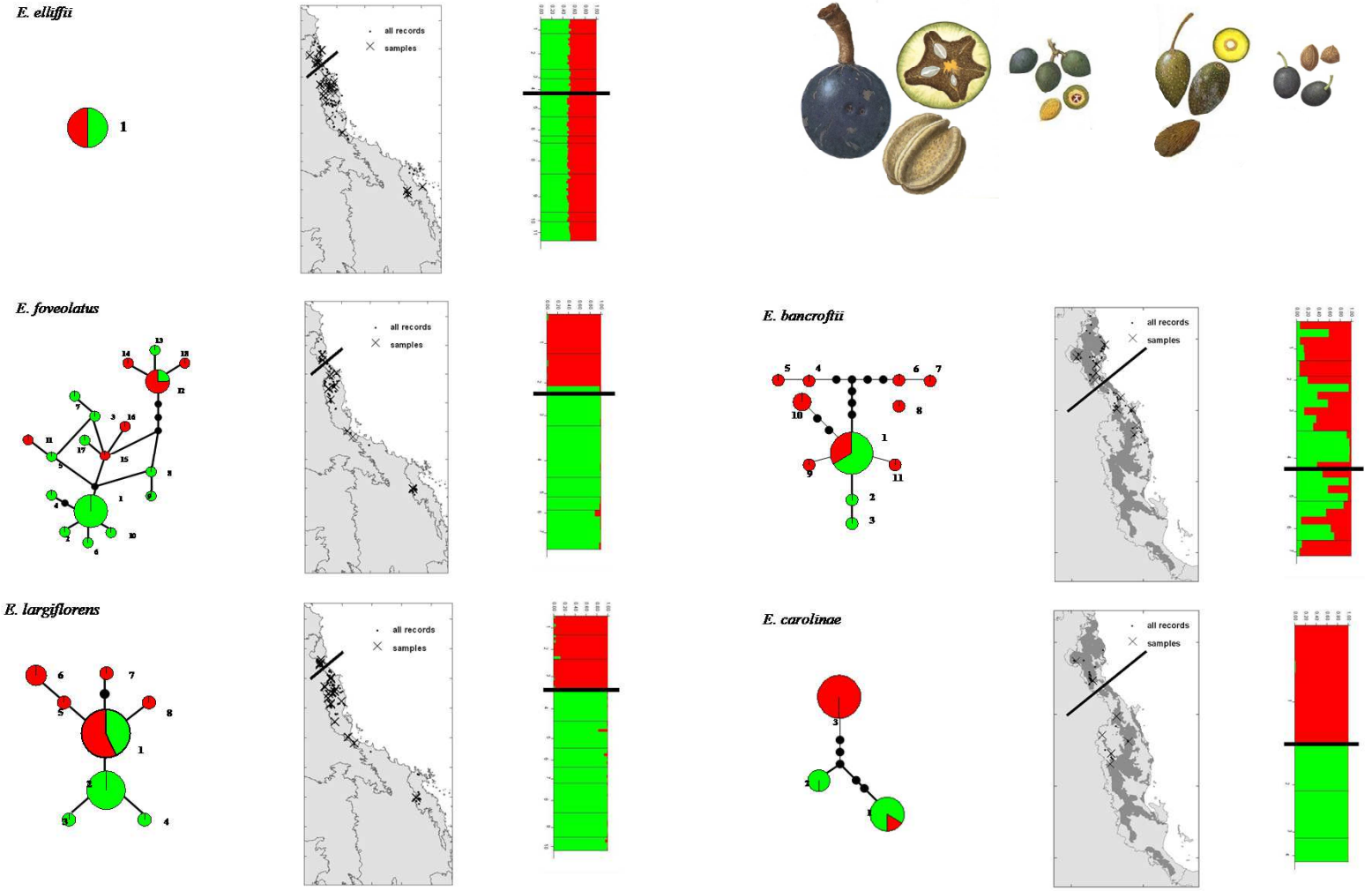


Leptospermum trinervium



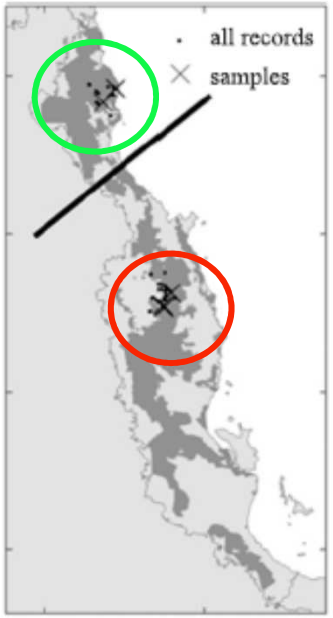
Can we Generalise? Taxonomy

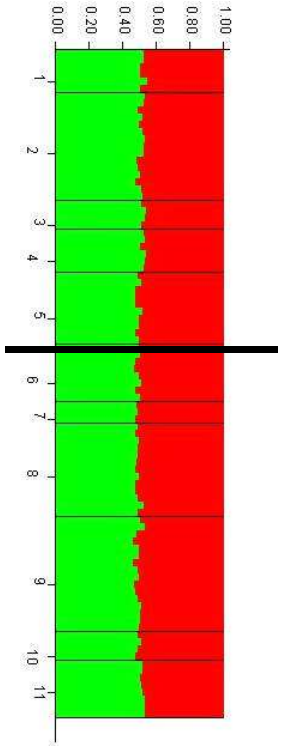
11 species of *Elaeocarpus* in AWT



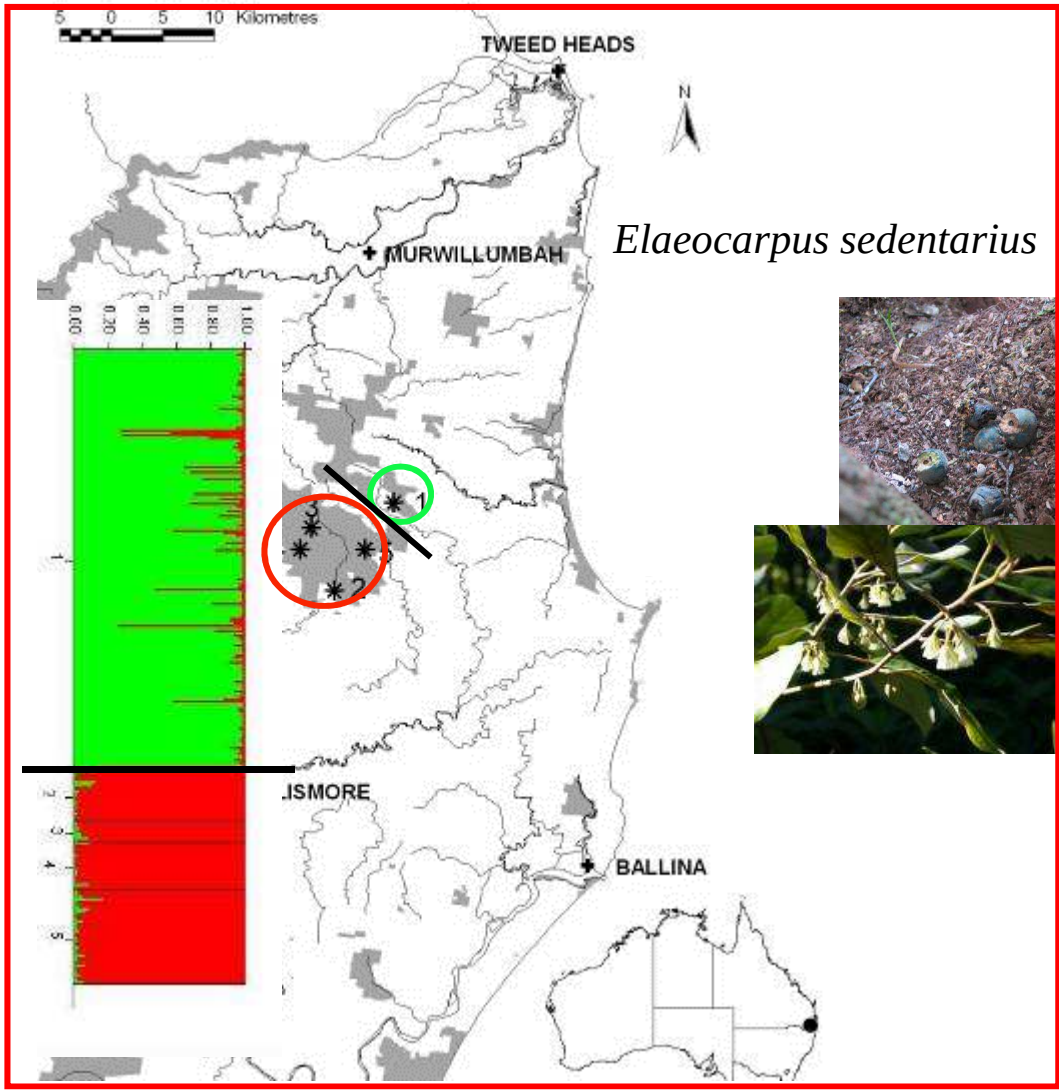
Can we Generalise? Taxonomy

Elaeocarpus johnsonii



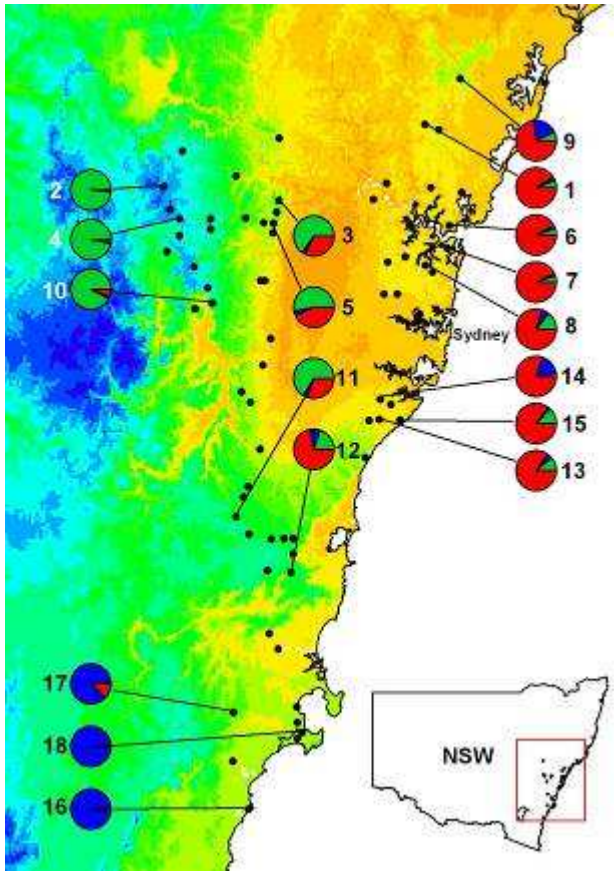


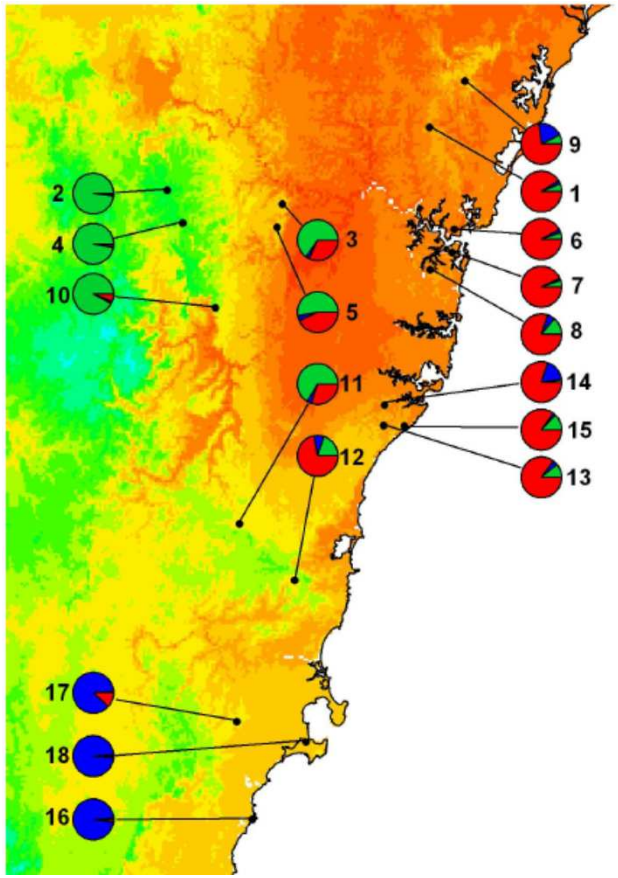
Elaeocarpus sedentarius

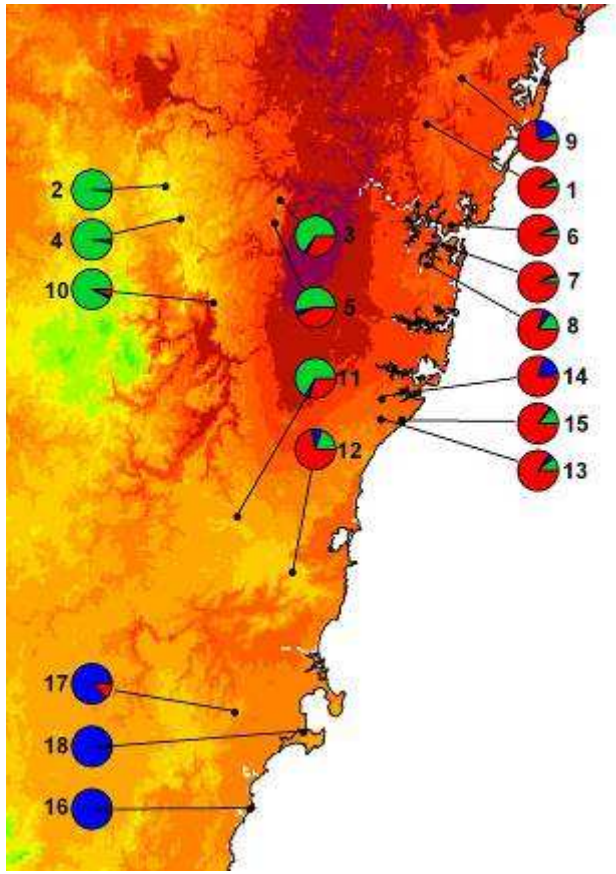


Can we Generalise? Biogeographic Barriers

What about Temporal Variation?





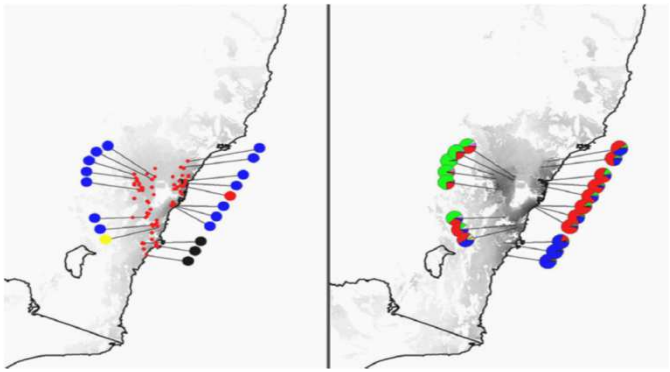


September October November

Short flowering season needs ~10 days of 20^{o}C

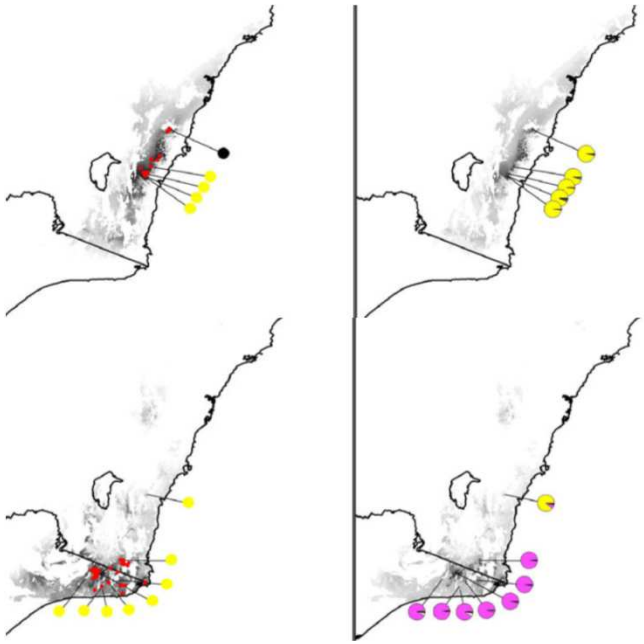
What about Temporal Variation?

Glacial cycles and *Telopea*



Telopea speciosissima

Telopea mongaensis



Telopea oreades

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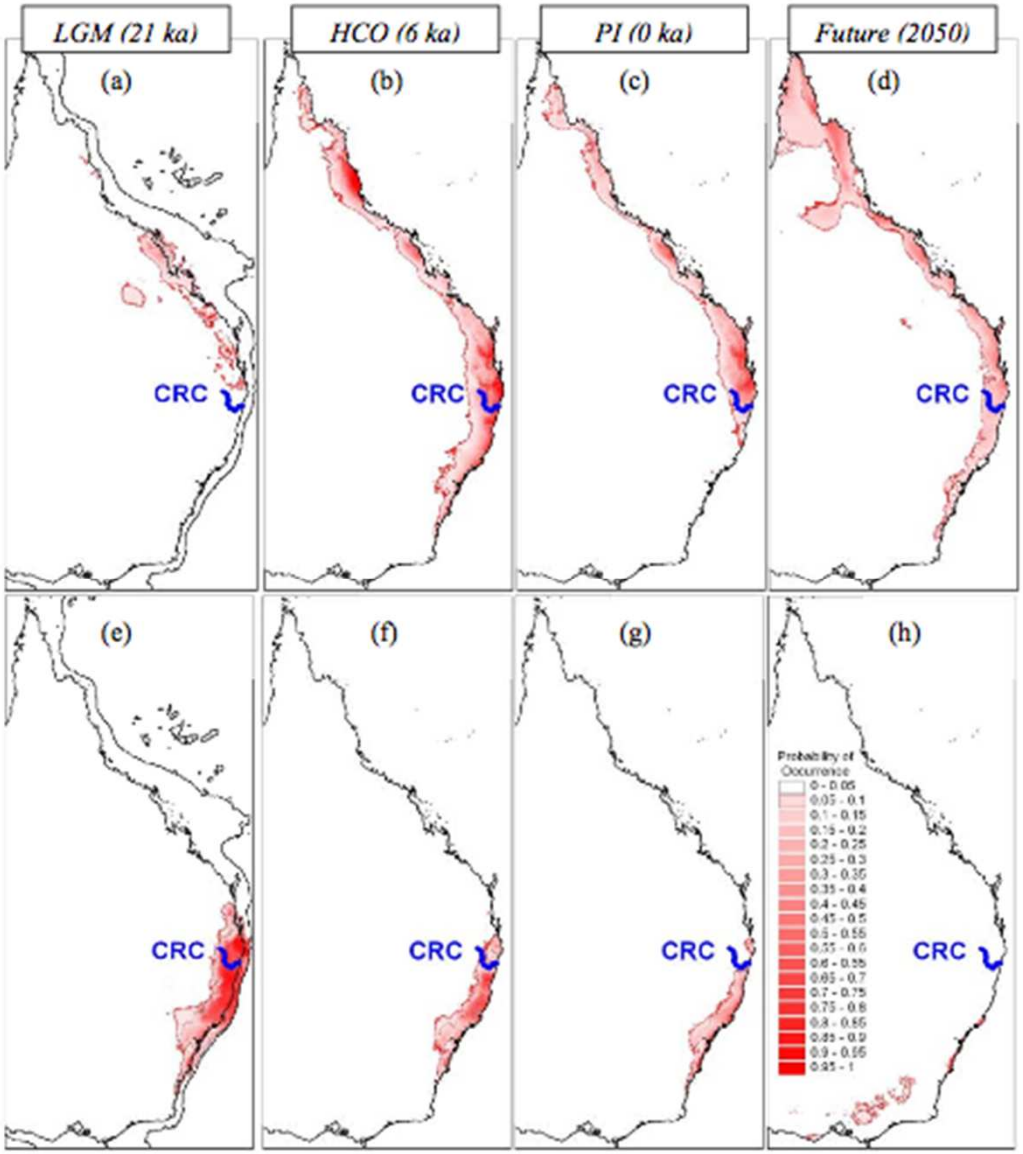
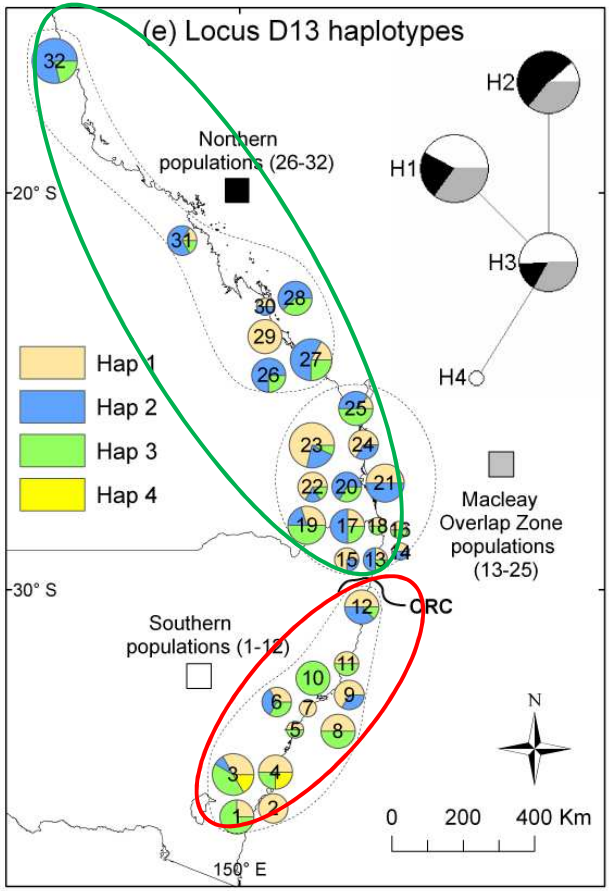


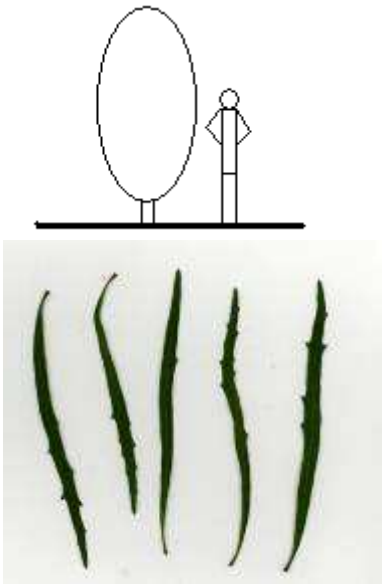
Podocarpus elatus



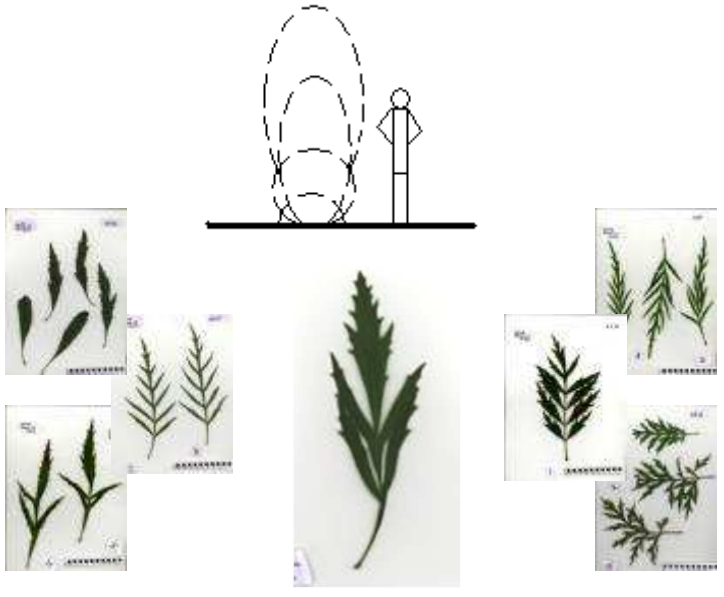
What about Natural Admixture?

Permeable species boundaries in *Lomatia*

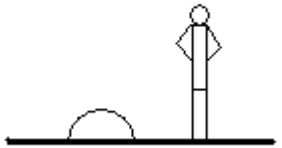
Lomatia myricoides



Hybrid



Lomatia silaifolia



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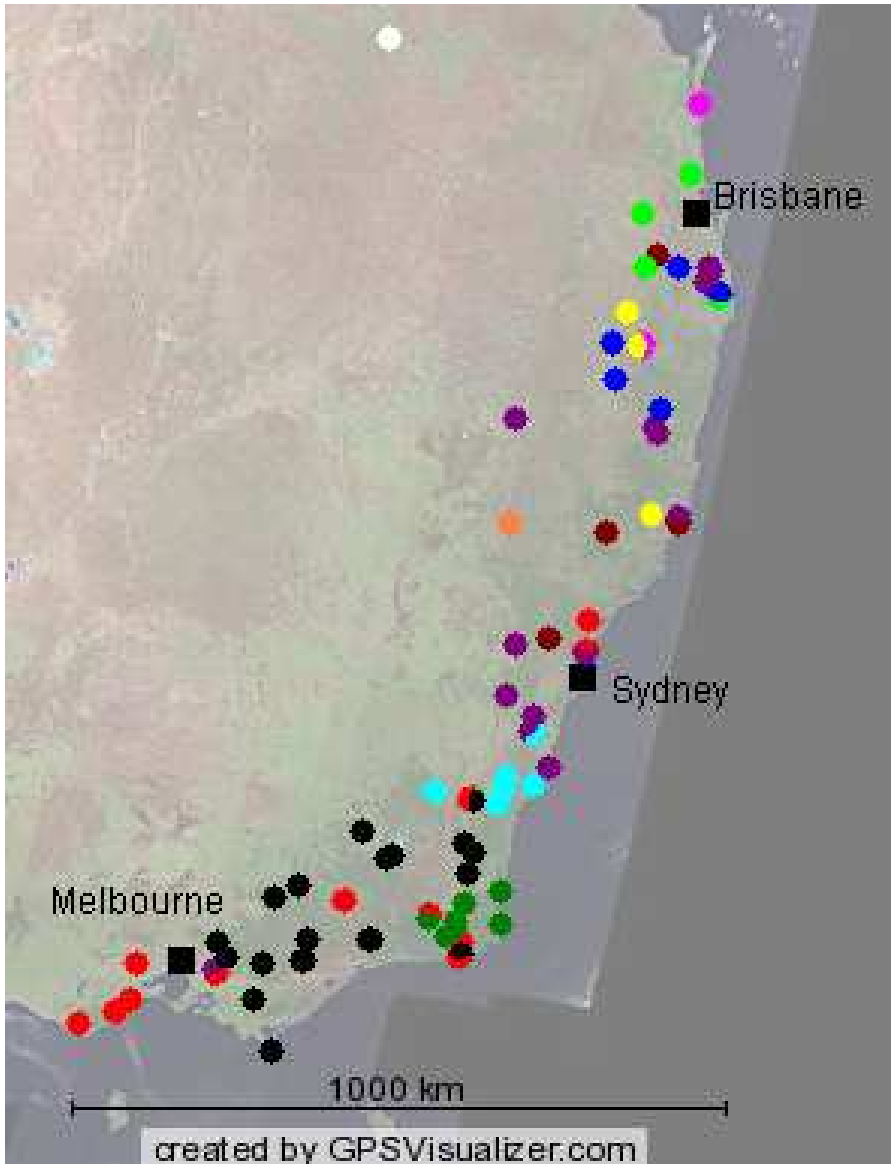

- 5 species of *Lomatia*: genetic diversity is distributed geographically rather than taxonomically

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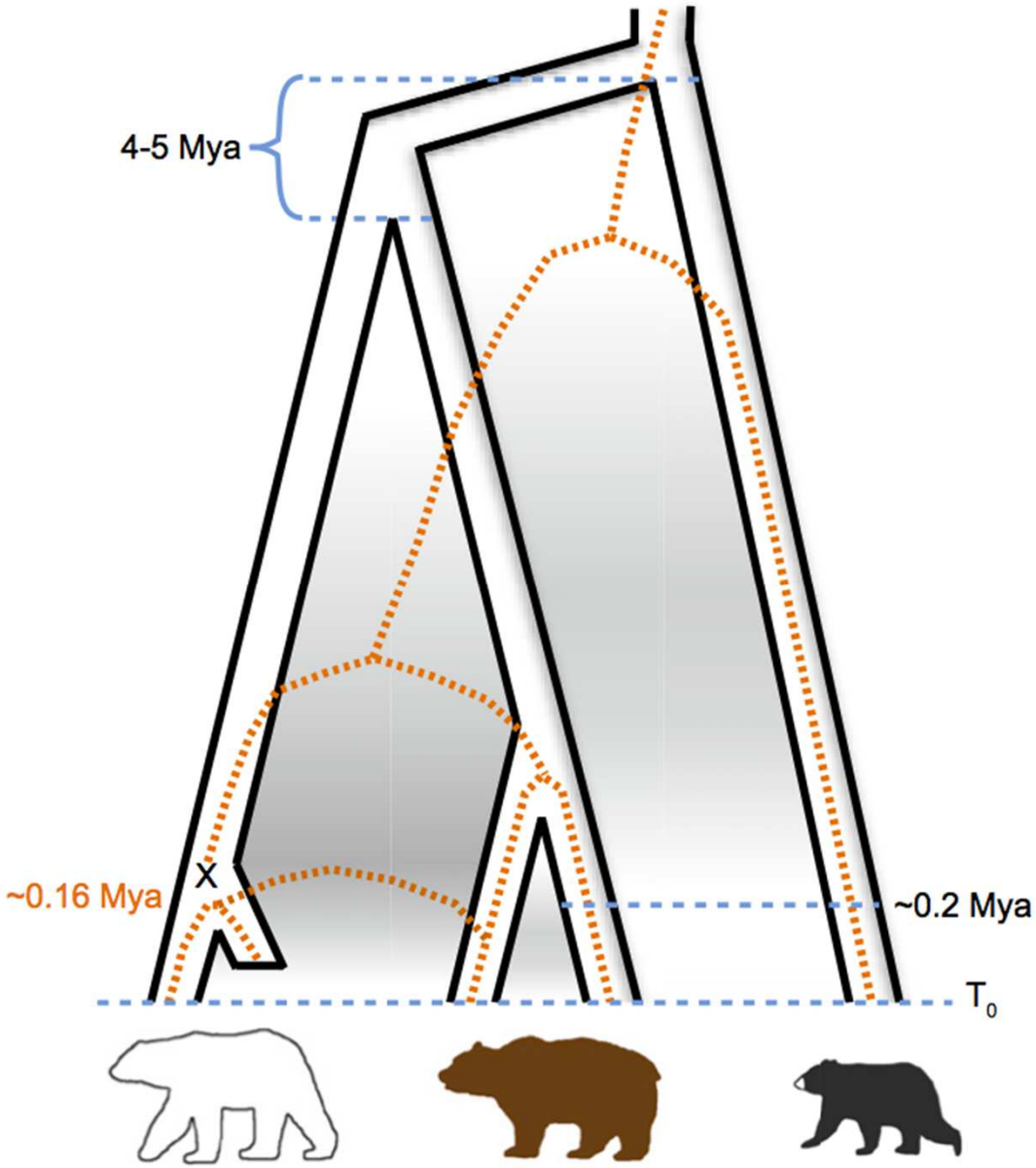
What about Natural Admixture?

- Polar bears



Local Adaptation vs. Drift: the Green Ashes

E. dendromorpha
Fitzroy Falls

E. dendromorpha
Blue Mountains
Redhills Road

E. stricta

E. laophila

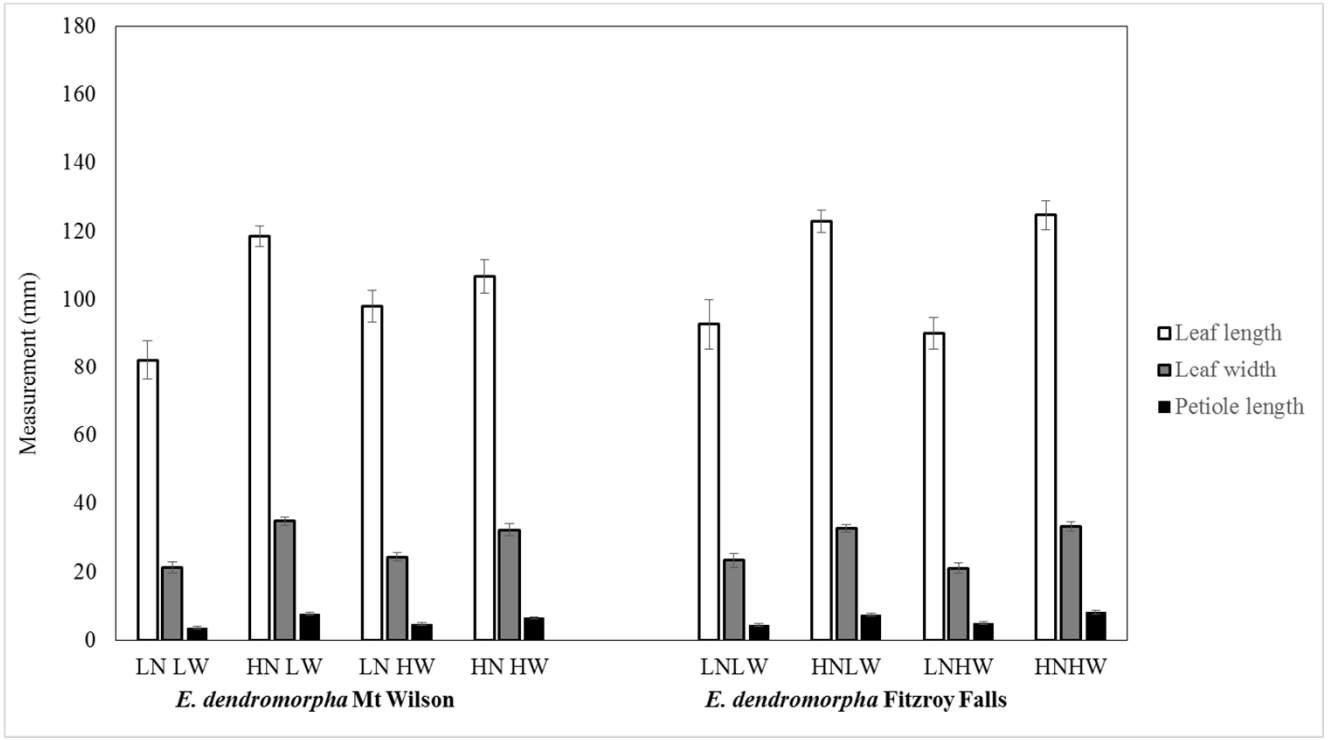
E. obstans

E. langleyi

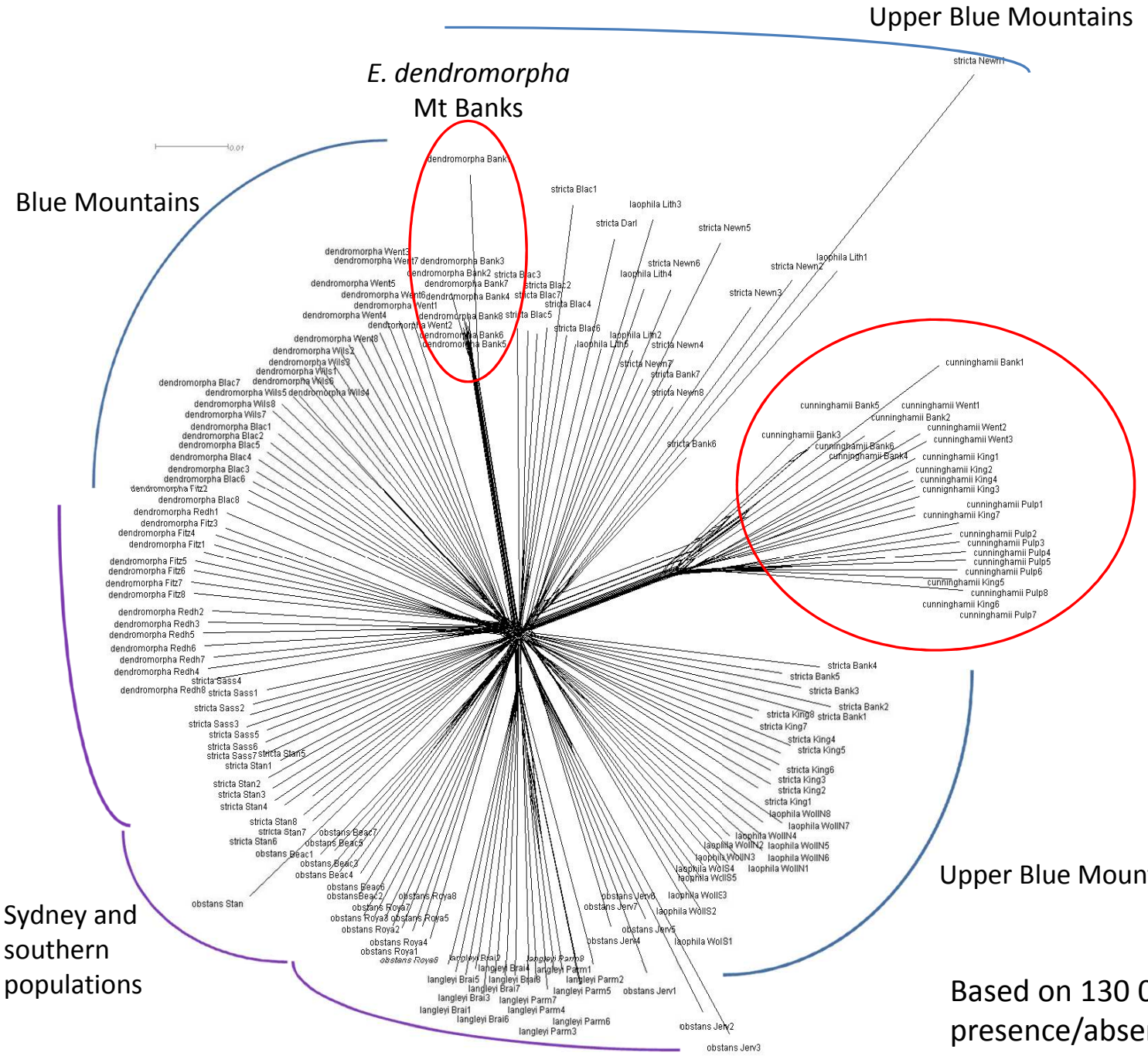
Axis 2

Axis 1

Local Adaptation vs. Drift: the Green Ashes



Differences between treatments significant $P<0.05$



E. cunninghamii
Upper Blue Mountains

Based on 130 000 DArTseq
presence/absence markers

Provenance: Challenges and Opportunities

- Defining provenances is a mechanism for quantifying biodiversity
- They are a complex mix of drift and adaptation, often resulting in temporal flux of non-equilibrium lineages and assemblages
- Preserving them within changing climate needs understanding of the driving processes

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Provenance: Challenges and Opportunities

- Biodiversity preservation is about managing mostly unknown change
- Restoring ‘past composition’ is difficult and often ecologically unrealistic
- Ecological restoration should focus on re-establishing ‘evolutionary resilient landscapes’

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Provenance: Challenges and Opportunities

Conclusion

Provenances should not be used to define hard boundaries but to develop decision-making frameworks that are evolutionary relevant

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Provenance: Challenges and Opportunities

Evolutionary-relevant decision frameworks can lead to:

- Preservation of unique local adaptations
- Assisted re-colonisation of suitable habitats
- Genetic rescue and / or targeted admixture

Florida Panther

Restore & Renew

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Restore & Renew: introduction

- **Community website**: definitive and readily accessible tool
- **Location-specific & generalisations**: operational support and future proofing
- **Globally pioneering**: world-first initiative approach, scale and scope

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How does it work?

Species selection

200+ widely used species through extensive community consultation

Environmental modelling and sampling

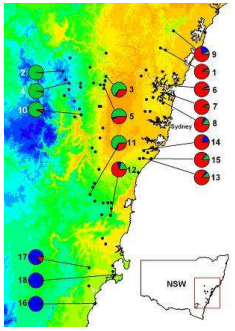
Trained citizen science teams to support collection from 5,000+ sites

Evolutionary and ecological analyses

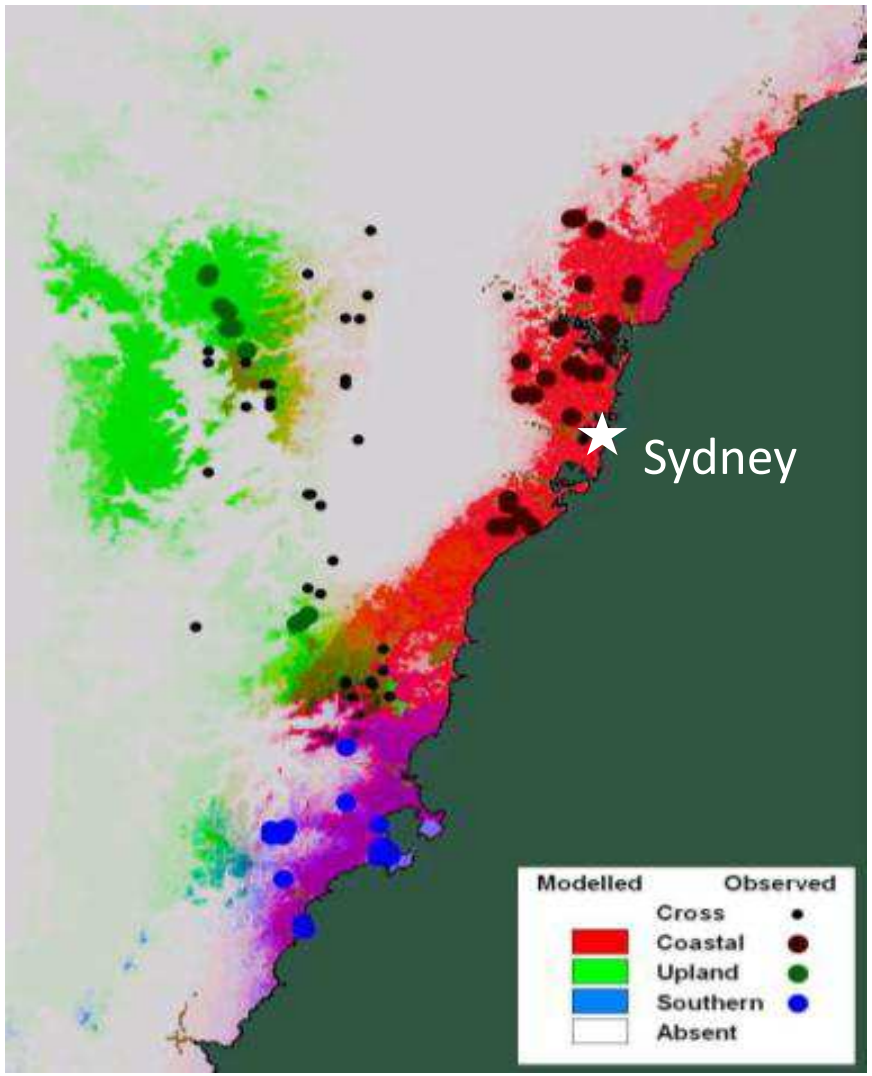
Next Generation DNA Sequencing will reveal unparalleled information on provenance, diversity and dynamics

Easy access: website

User-friendly guidelines empowering communities to deliver successful and self-sustainable restoration



Example: NSW Waratah

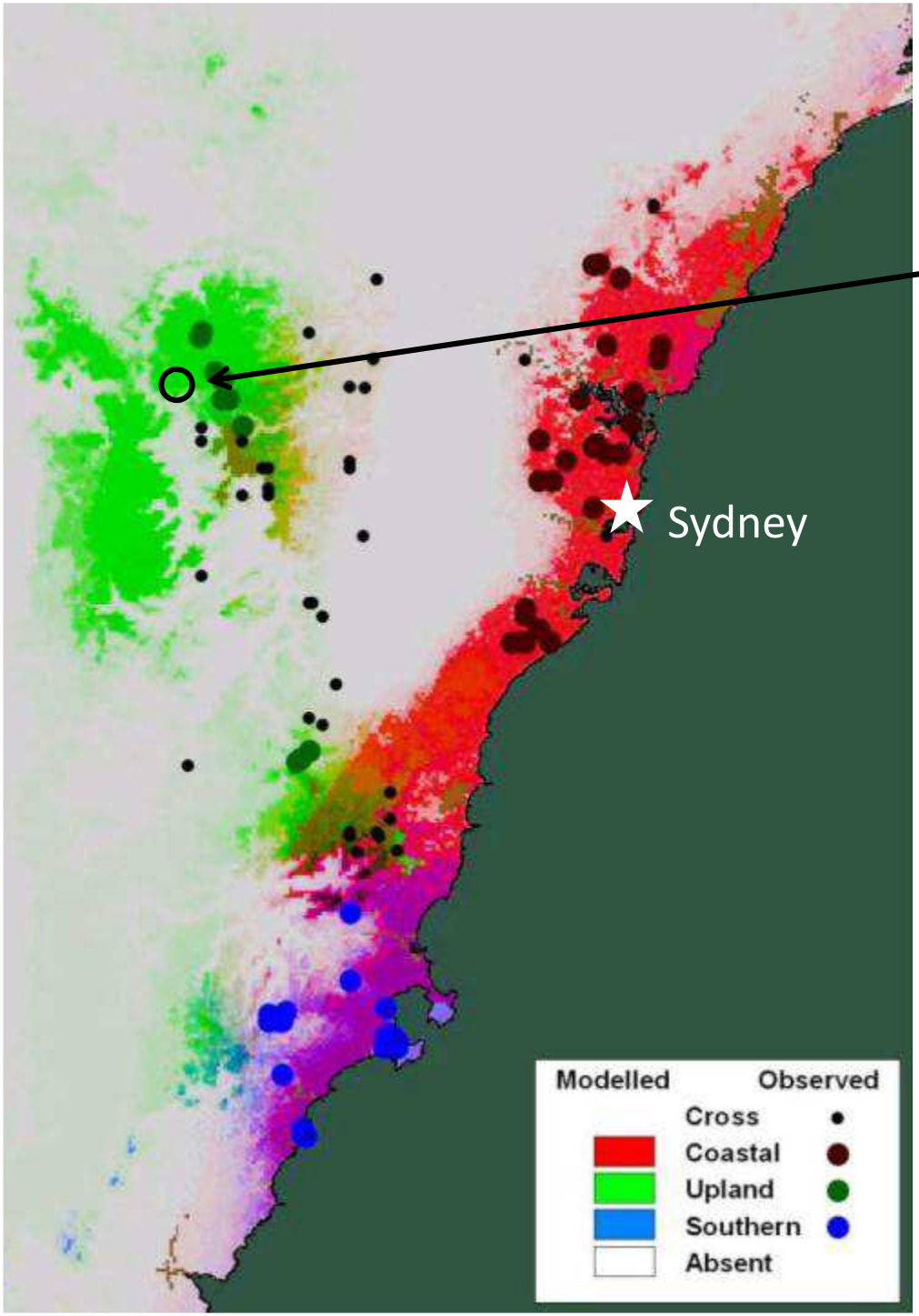


Waratah *(Telopea speciosissima)*

Three distinct provenances:

- Upland
- Coastal
- Southern

(plus areas of admixture)

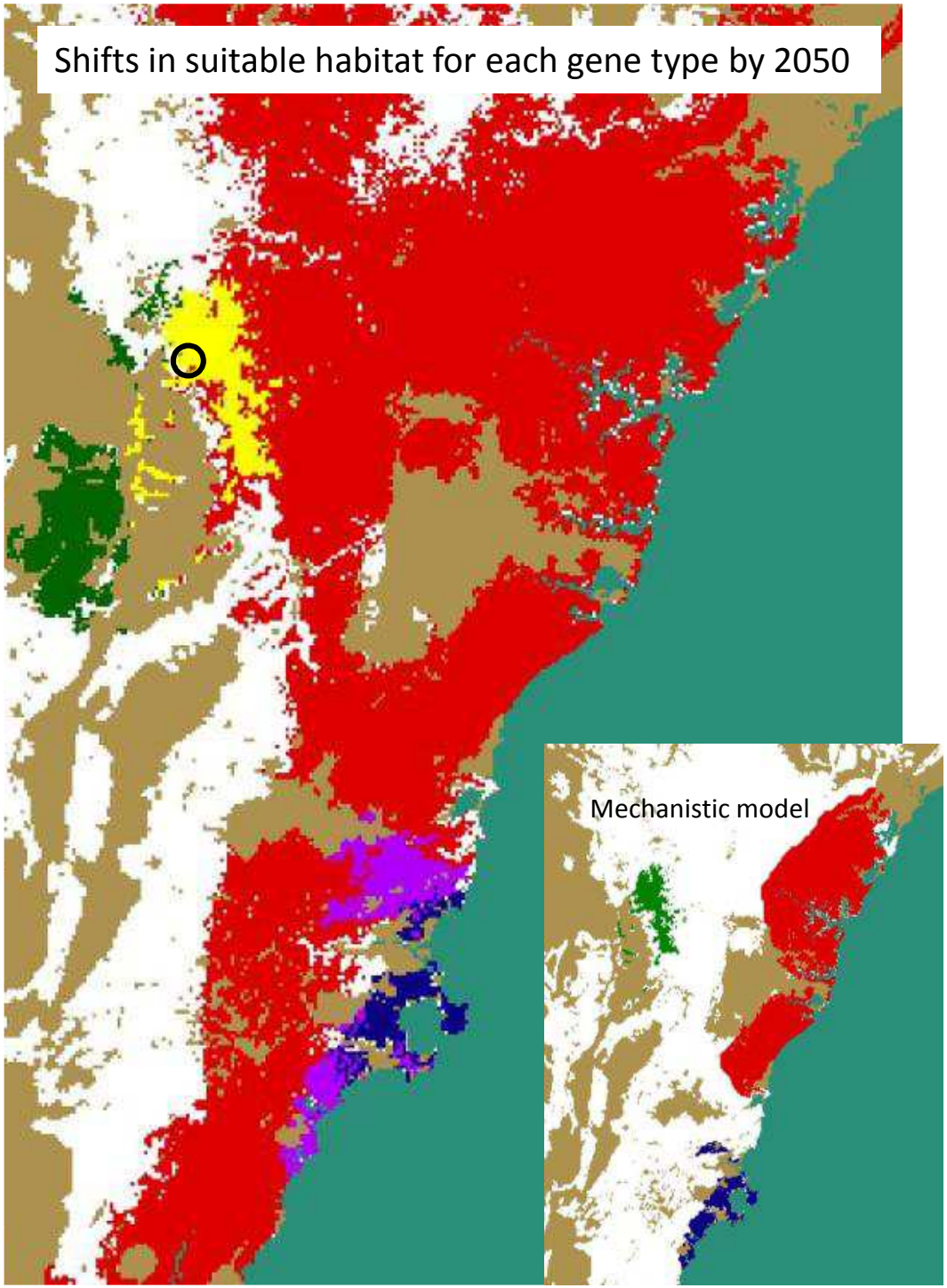


Species selection:
NSW Waratah (*T. speciosissima*)

Site selection (*Lat-Long*):
-33.42S; 150.19E

Supporting information:

- Upland (green) provenance (more).
- Preferential outcrosser, so must maintain heterozygosity (more).
- To achieve this ideally sample from multiple sites within the provenance and multiple individuals within each site (more).
- For ‘future proofing’ click here.



Species selection:
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Supporting information:

- Suitable habitat will shift with coastal gaining (more).
- Predicted natural movement is limited (more).
- At selected site upland and coastal provenances could be mixed (more).
- To maintain upland provenance need conservation introduction in new area (more).

Get Involved!

- Become a project partner/sponsor
- Host a collection group
- restore.renew@rbgsyd.nsw.gov.au

Restore & Renew

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