Securing the seed supply chain

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9 July 2015

CSIRO NATIONAL RESEARCH COLLECTIONS AUSTRALIA/CANBR

Centre for Australian National Biodiversity Research

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Global context

- 10-15% global drylands degraded
- Forests lost 25 countries, 90% cover lost another 29
- ¼ terrestrial surface now occupied cultivated systems
- Inland wetlands in worse condition any other major ecosystem

- Ecosystem services, food & water security, health and well-being affected
- Restoration Imperative – Convention on Biological Diversity = restore 15% degraded systems by 2020 (i.e. next 5 years)

Scale of Restoration

- Kenya – 30M trees
- Macedonia – 6M trees
- Dubai - ~ 26km^2 indigenous trees, shrubs
- China – four forest belts 1,500 km
- Utah Dixie National Forest - 162km^2
- Australia – 20M trees, K2C, Gondwanan Link, GER, Habitat 141, mining industry, landcare groups, landholders, CMAs, LLSs
  - 1997 Natural Heritage Trust - $1.249B over 5 years – 10,900 projects
  - 2000 NAPS&WQ $1.4B, extended 1.032B

Restoration requires seed

- Direct seeding and/or tubestock
- Far fewer examples of cuttings (clones)

- Australian agency - 2,000 kg of seed 8 years restore an average of 3.5 km^2 per year
- Pilbara – 820,000 kg for 1,200 km^2
- Glacial Ridge Project Minnesota - >500,000 kg seed harvested 12 years, 90 km^2 northern tallgrass prairie
- US BLM Idaho regional seed warehouse - purchased an average of 998,000 kg of seed over 10 years

Restoration requires seed

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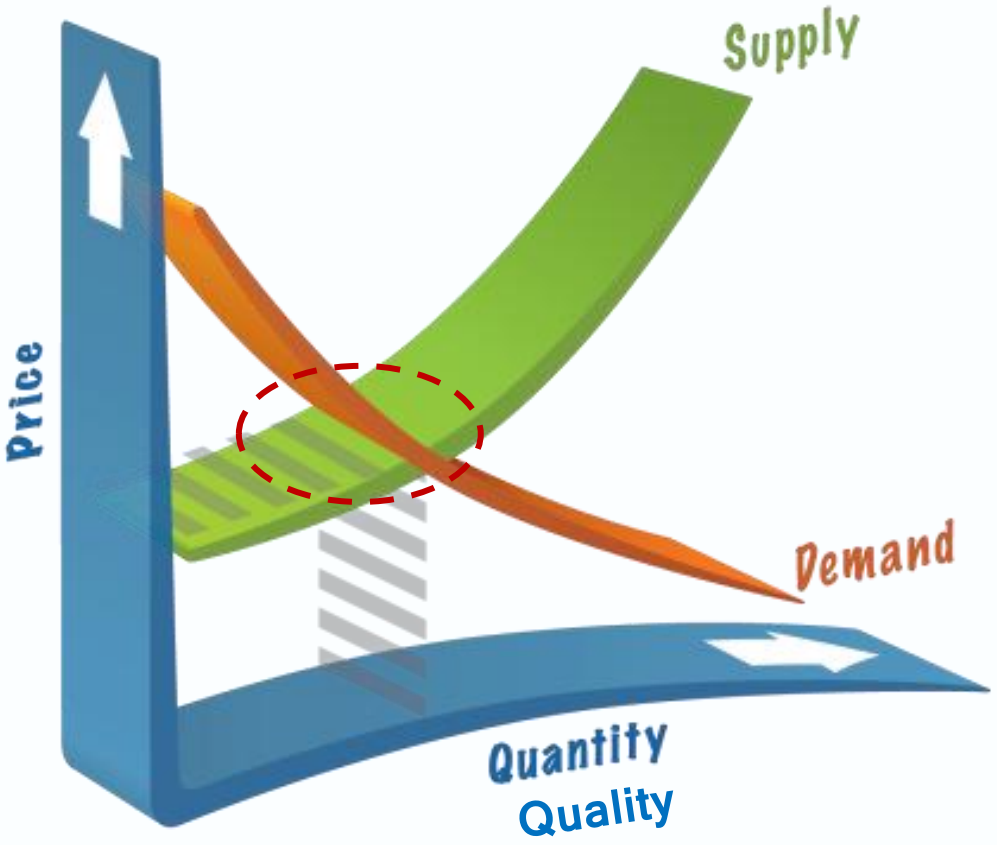
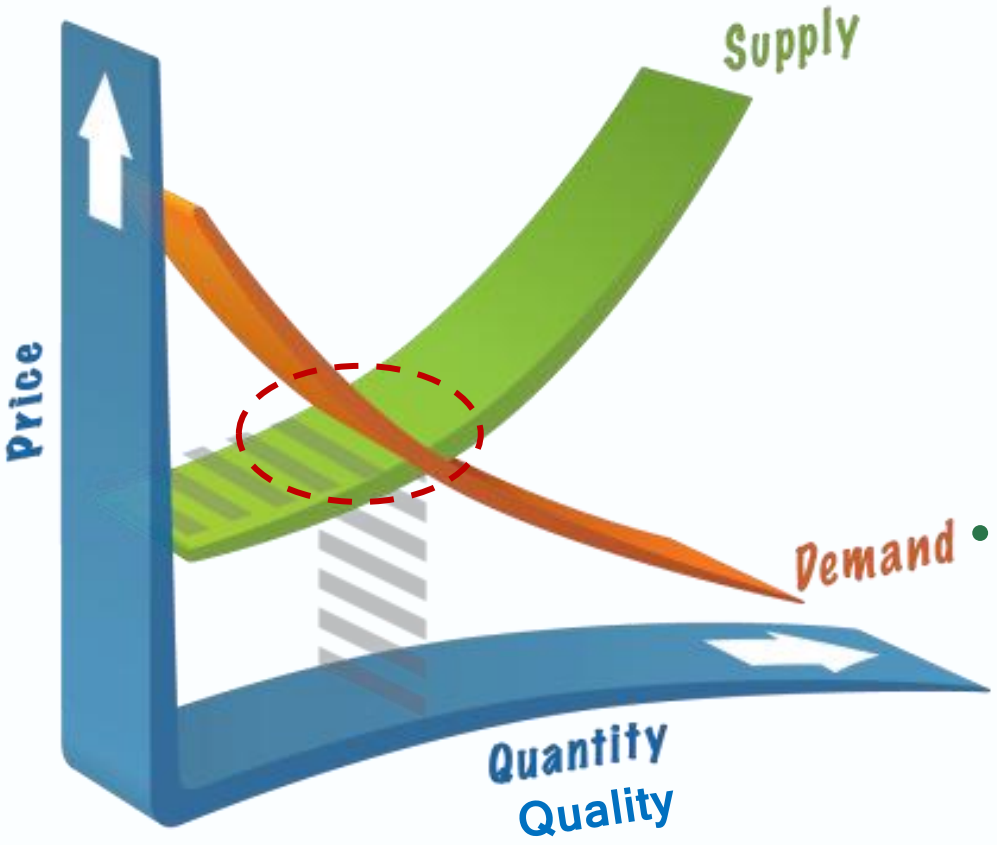
One seed = one plant back in the environment

Seed - food source, critical some organisms complete life cycle

Restoration assumptions

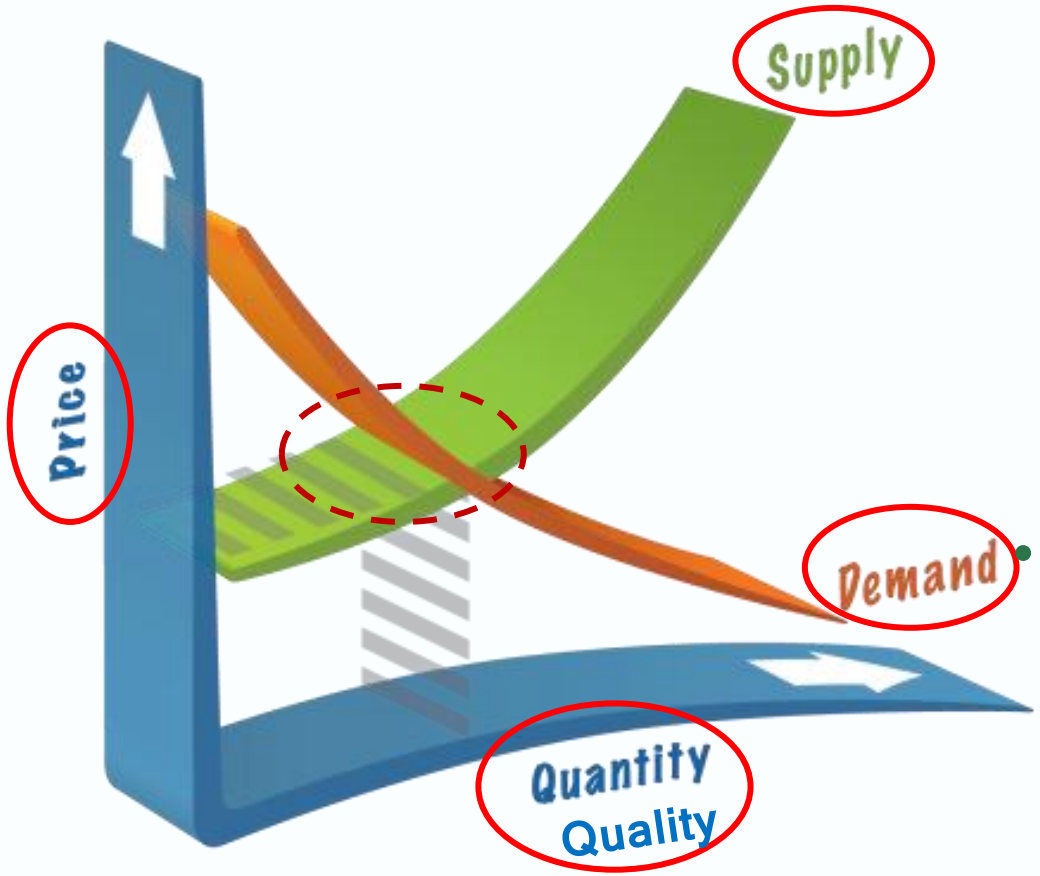


Restoration assumptions



- **Restoration is an 'industry'**
  - No standards (SERA developing guidelines)
  - No research investment by an 'industry' body e.g. RDCs
- **Seed supply and price can be 'market driven'**

Restoration assumptions



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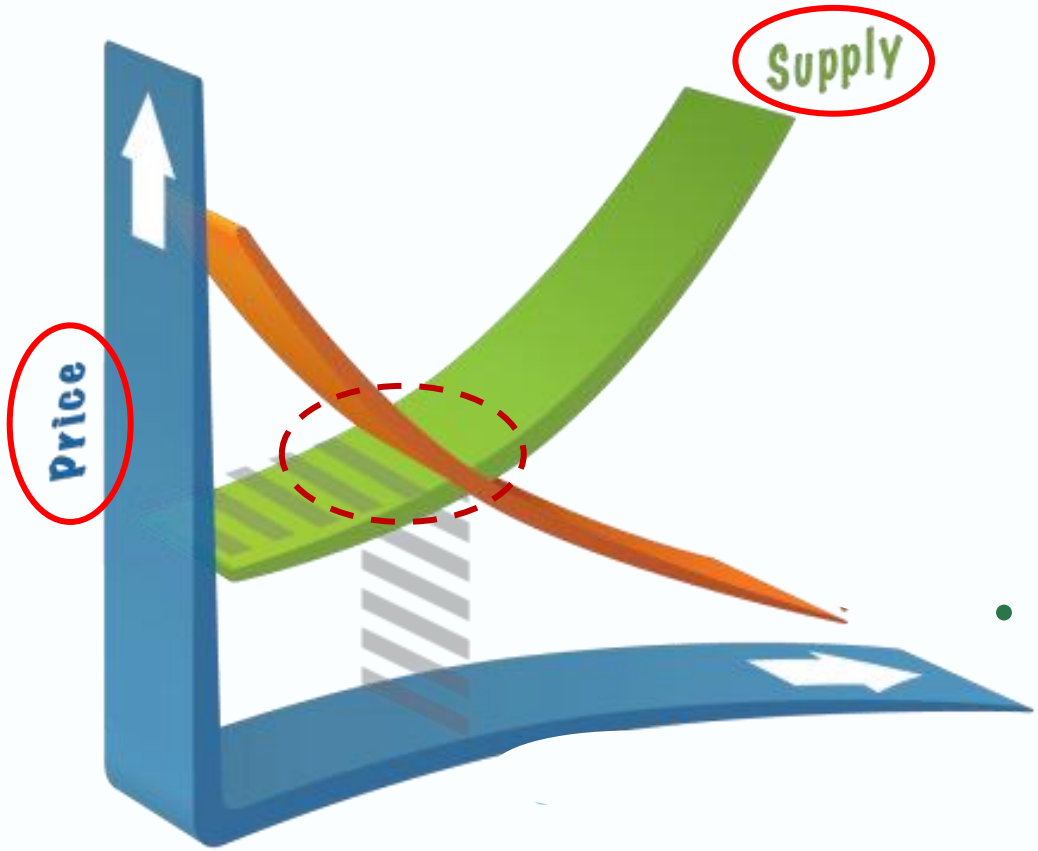
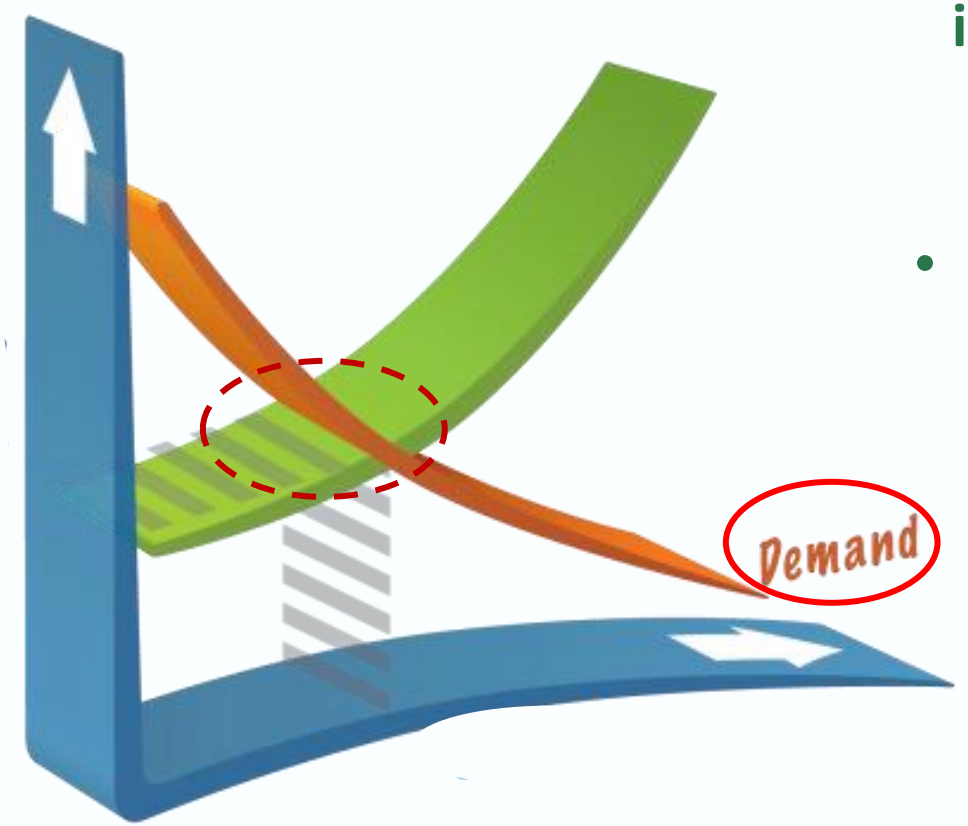


- **Seed is plentiful**
  - Erratic, environmentally driven in many species
  - Largely unavailable for key species/groups
    - Species substitution
    - Low species diversity (low resilience)
- **Price**
  - Driven by availability rather than supply/demand
  - Rapidly rolled out initiatives

Restoration assumptions



- **Primarily Government initiatives**
  - e.g. NHT1 & 2, CfOC, Bio Fund
- Demand and funding are driven by same ‘organisation’
  - Not a ‘market’

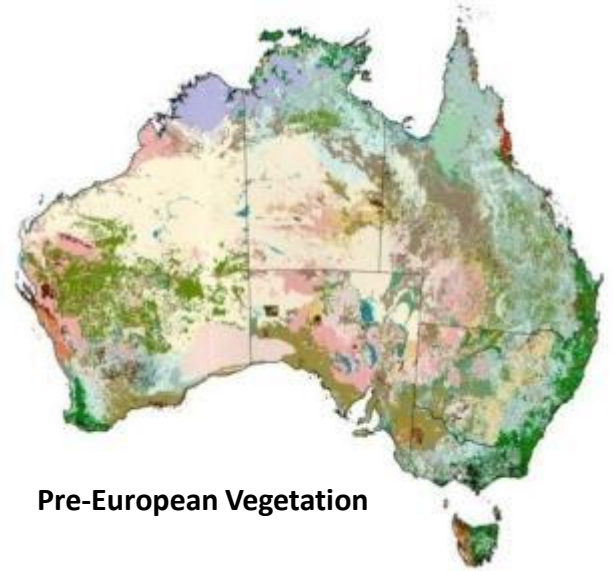
Restoration assumptions

- **Seed is of equal quality**
  - Environmentally driven, pollinator limitation
- **Seed is genetically diverse**
  - Inbreeding of concern in fragmented landscapes
  - Low diversity – limited ability cope with change
  - Impacts ability restored populations to produce next generation

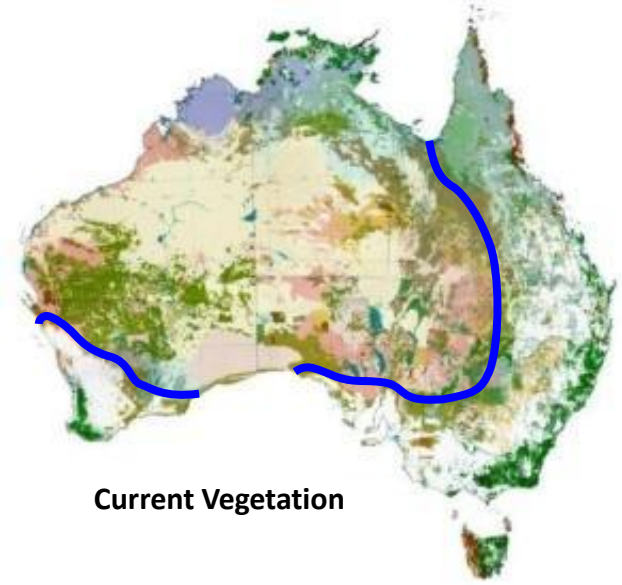
Background

Substantial changes to vegetation abundance and distribution

- Irreversible loss of genetic diversity
- Smaller, more isolated populations



Pre-European Vegetation



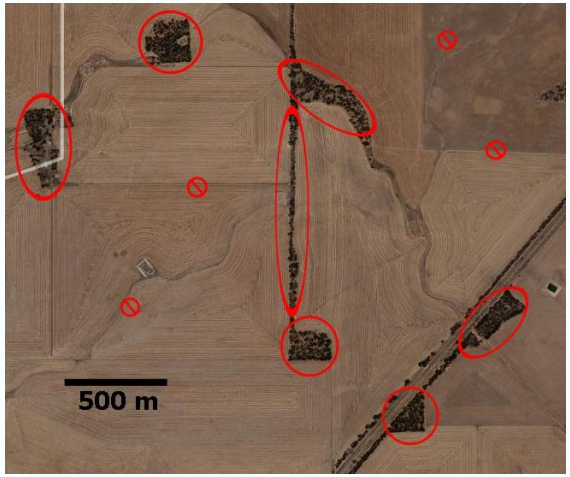
Current Vegetation

Background

Complex challenges for plants (static)

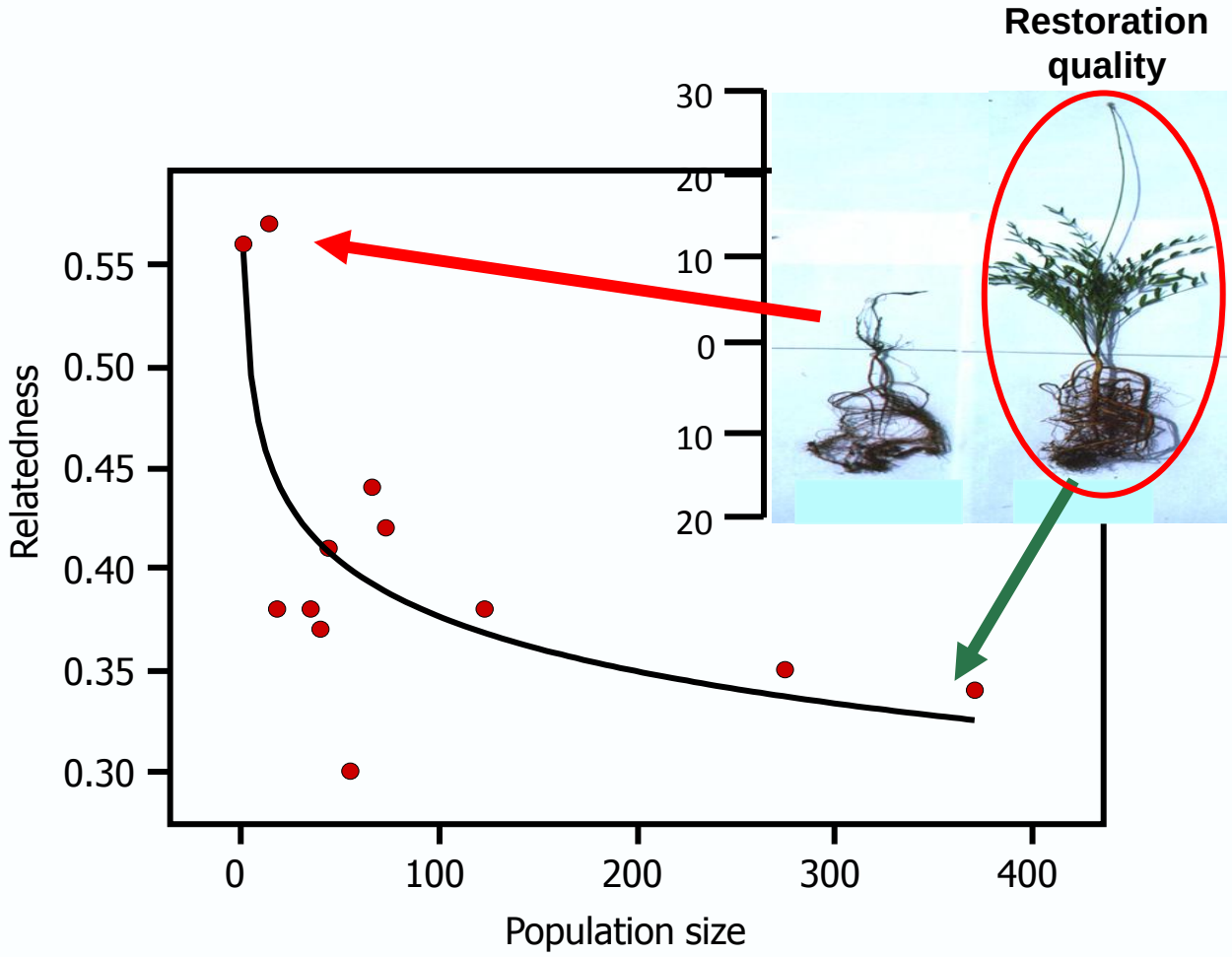
- Reliant biotic/abiotic vectors pollen and seed dispersal

- Influence genetic and demographic processes
  - Elevated inbreeding
  - Impacts seed production and quality



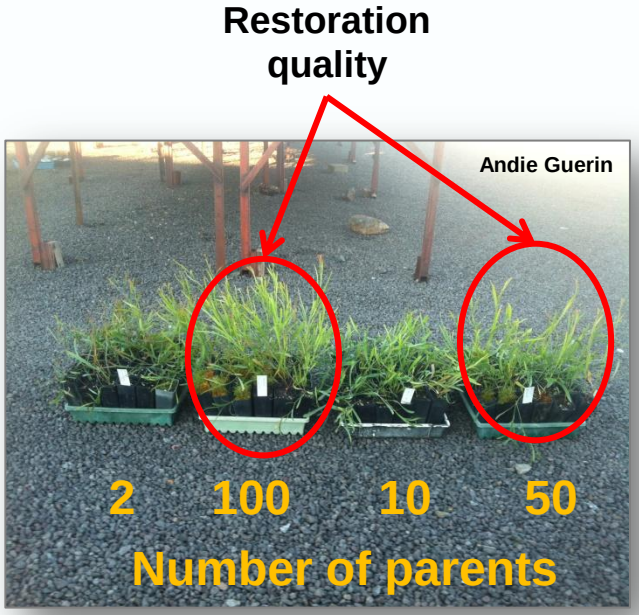
Elevated inbreeding

- **Self compatible species**
  - Poor *quality* seed crops



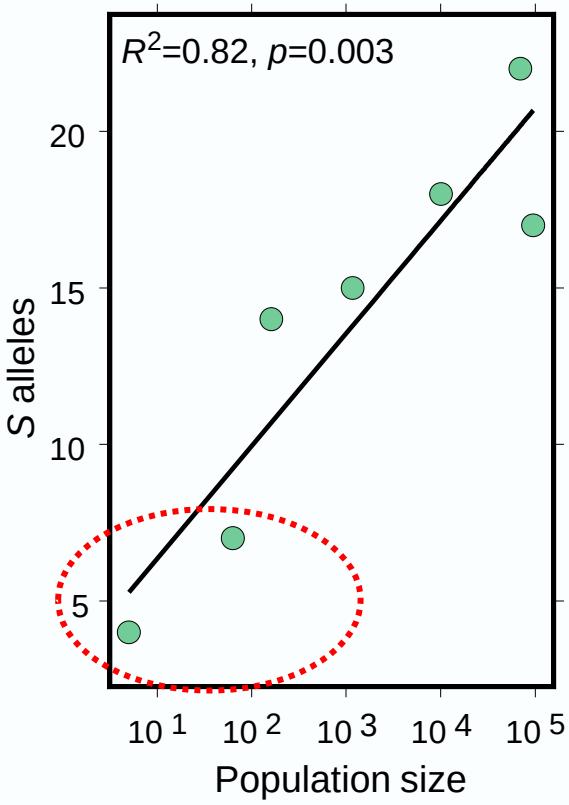
Elevated inbreeding

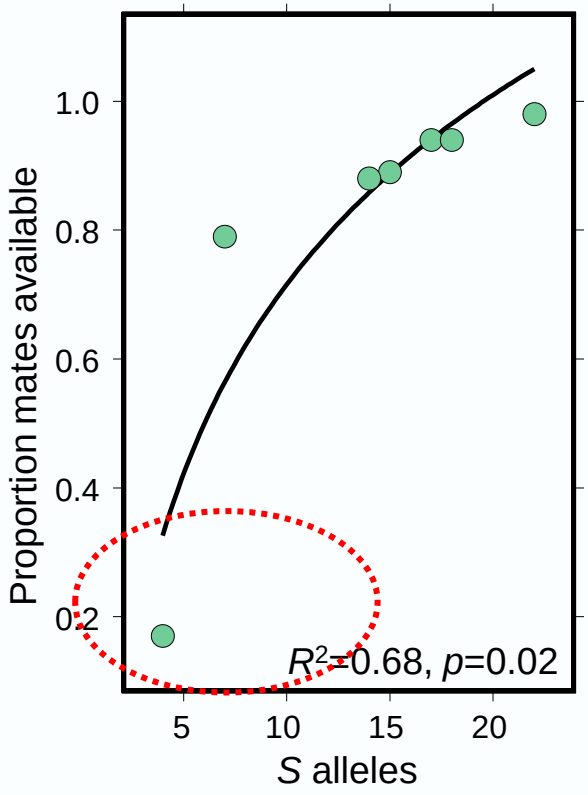
- **Self compatible species**
  - Poor *quality* seed crops
  - Recognition by some practitioners

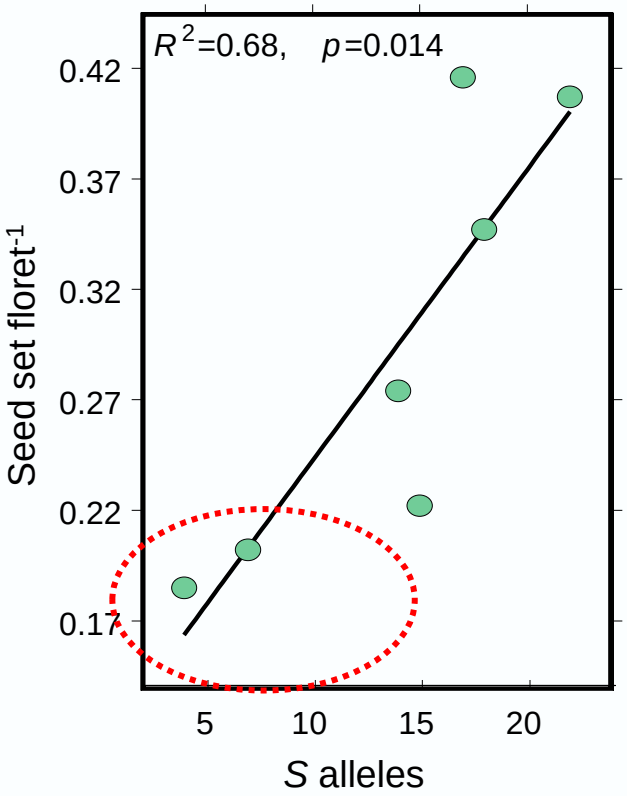


Slender bitter pea

Self-incompatibility and seed production







Low S allele diversity → Fewer plants to mate with → Poor seed set

Past restoration – Yellow Box (*E. melliodora*)

Iconic, valuable – shade, shelter, honey, habitat connectivity

Broadly distributed but can be highly fragmented

- EEC (Commonwealth, NSW, ACT)

Important revegetation species many years

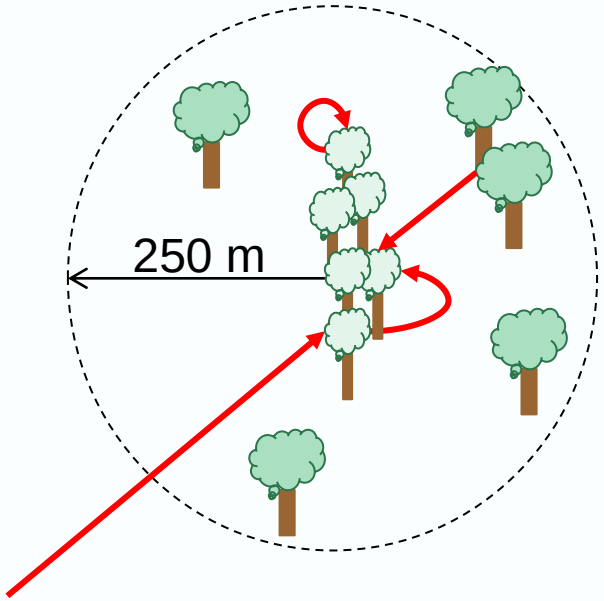
- Does presence = persistence?

Poorly known life-history

- Long-lived
- Flowers ~every 2 years (Sept – Feb)
- Isolated trees produce significantly less seed with poorer germination than woodland trees

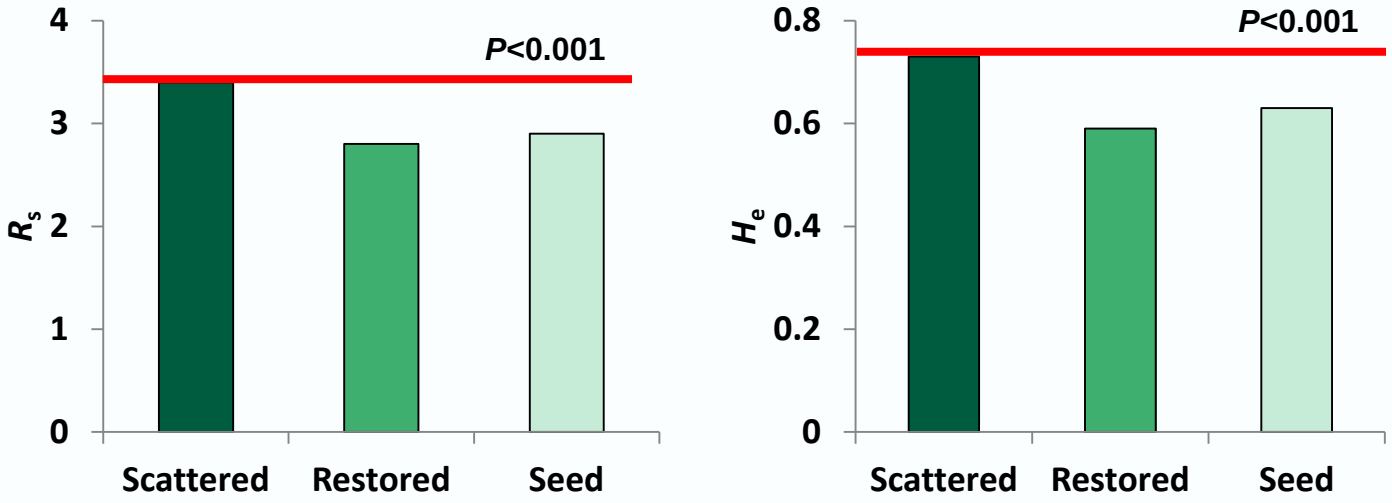
Study design

- Genetic diversity
  - Scattered (within 250 m) and restored trees
  - Seed (next generation)
- Mating system
  - Confirmed mixed mating
- Pollen movement
  - Selfing
  - From scattered trees
  - From restored trees
  - Long distance pollination (>250 m)



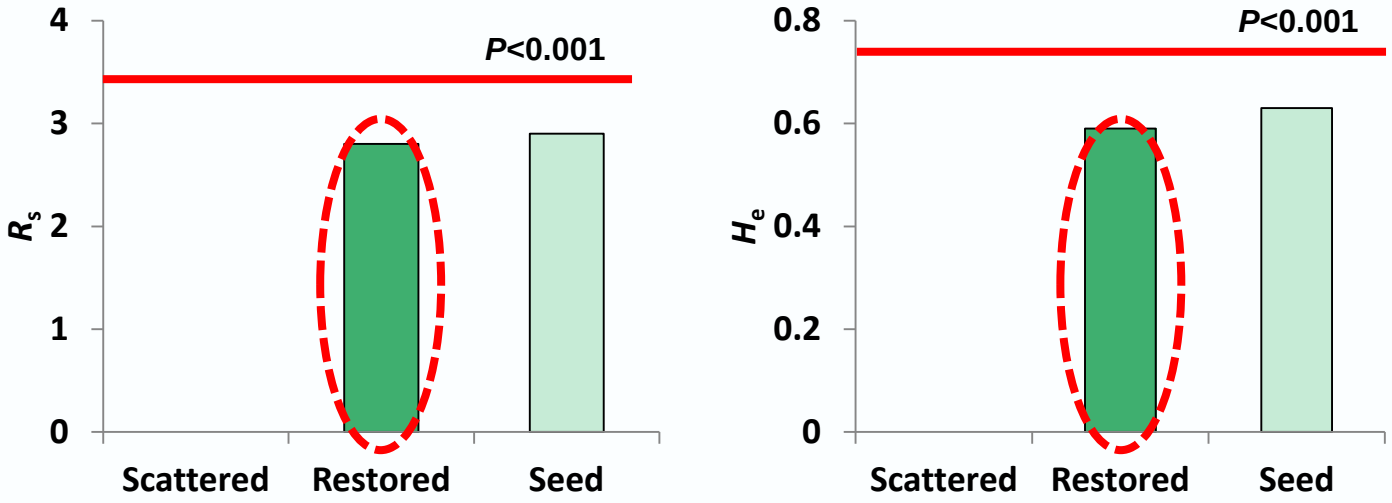
Yellow Box – genetic diversity

Significantly higher genetic diversity in scattered trees



Yellow Box – genetic diversity

- Scattered trees lost over next 150-180 years
  - Landscapes genetically ‘poorer’, reduced mating pools, inbreeding



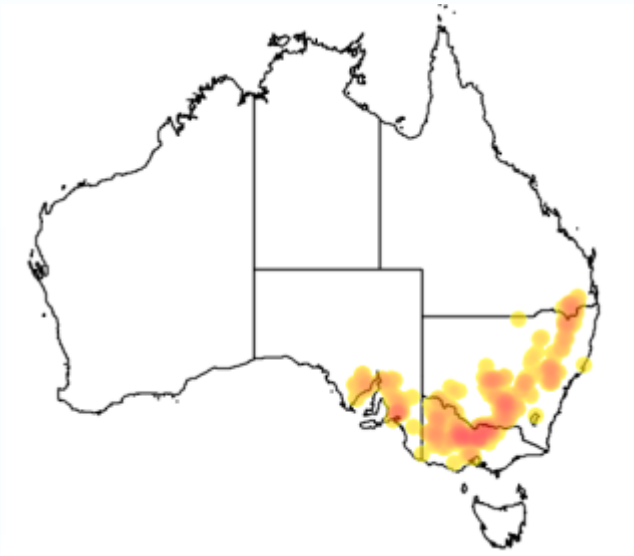
Securing seed supply and quality

- **Develop Seed Production Areas (SPAs) for suitable species (esp. rare species)**
  - Regular, QA supply of high quality seed

- **Some NRMs already establishing SPAs to meet their seed demands**
  - Little guidance
    - Species choice
    - Provenance choice
    - Layout of plants
    - Size
    - Location and siting for reproductive success

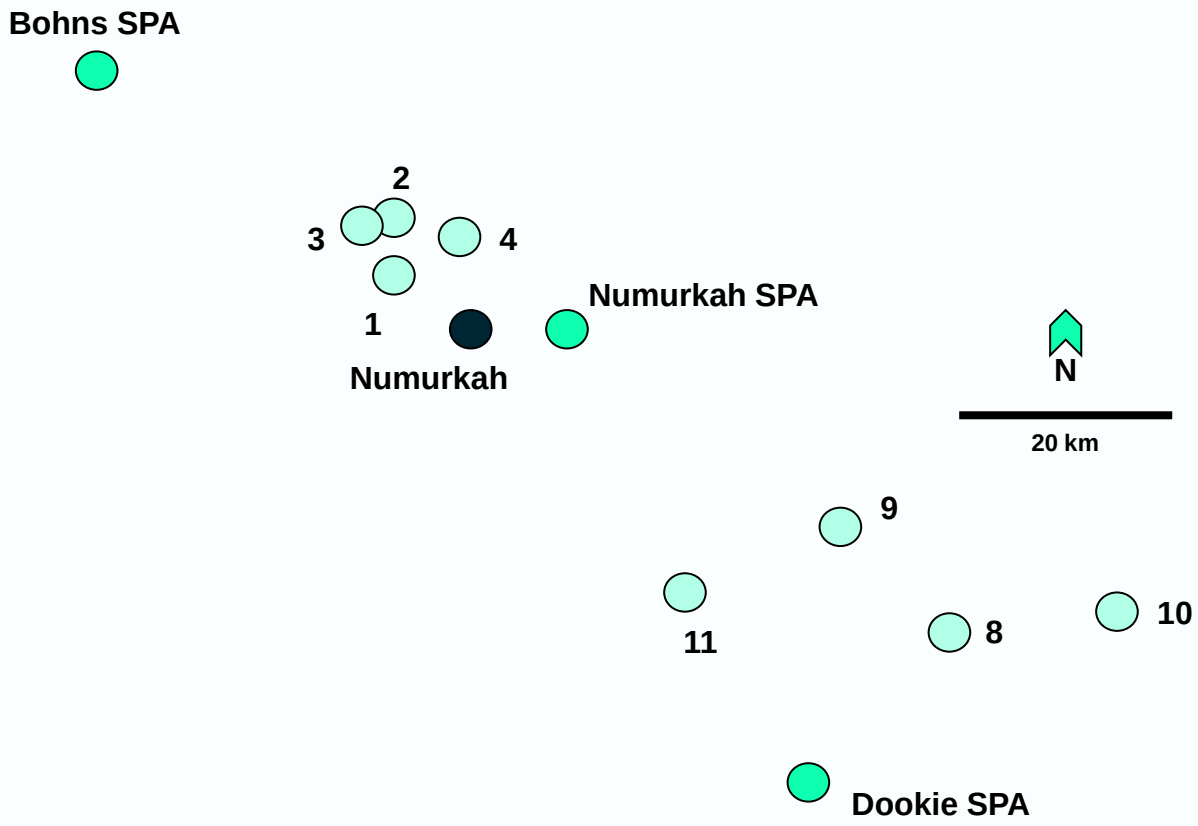
Acacia montana (Mallee Wattle)

- Rounded shrub to 4 m
- Distributed SA, Vic, NSW and Qld
- Frost hardy (frosts to -7 C)
- Hybrids (*A. aspera*) in Bendigo region

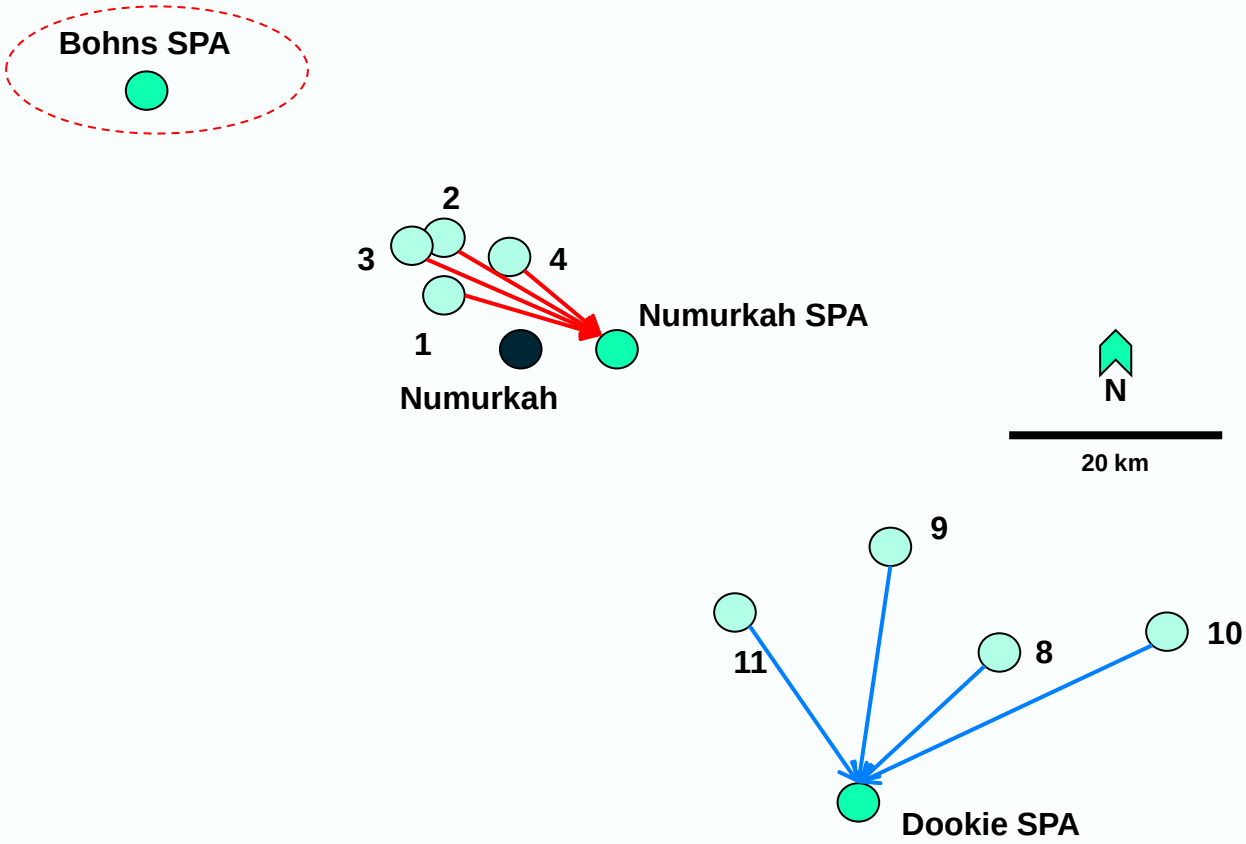


Populations sampled

Sampled shrubs (6-50) at 8 remnants populations and 3 SPAs
Species-specific molecular markers (SSRs)

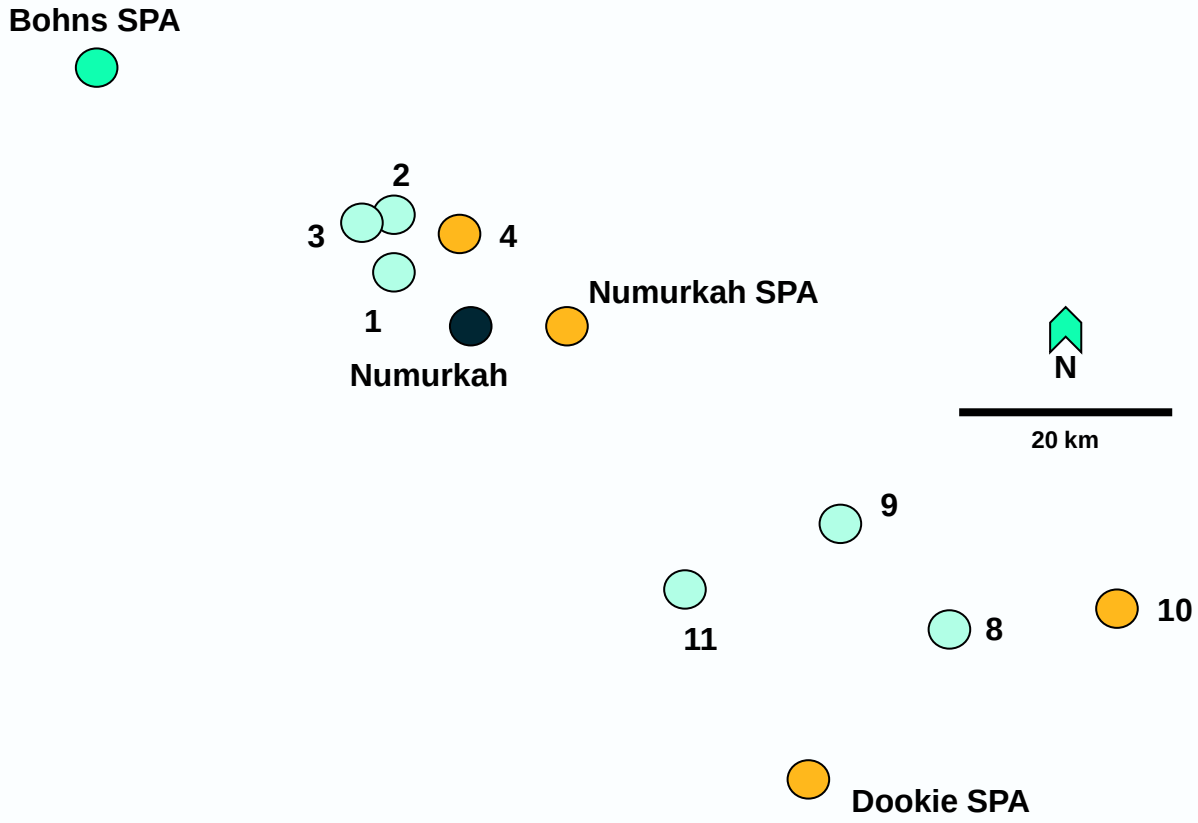


SPA source material

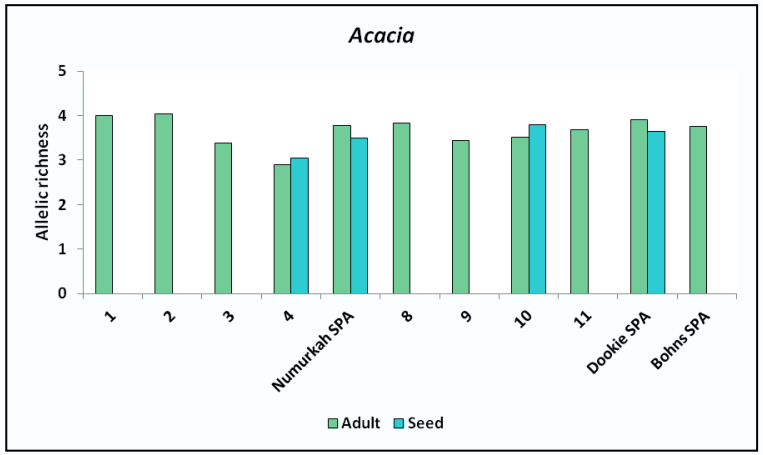


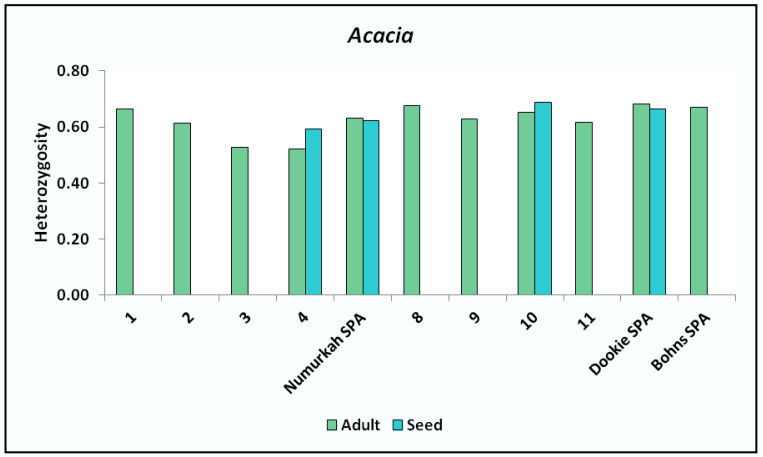
Populations sampled

Genetic diversity and inbreeding in seed (restoration)



Genetic diversity

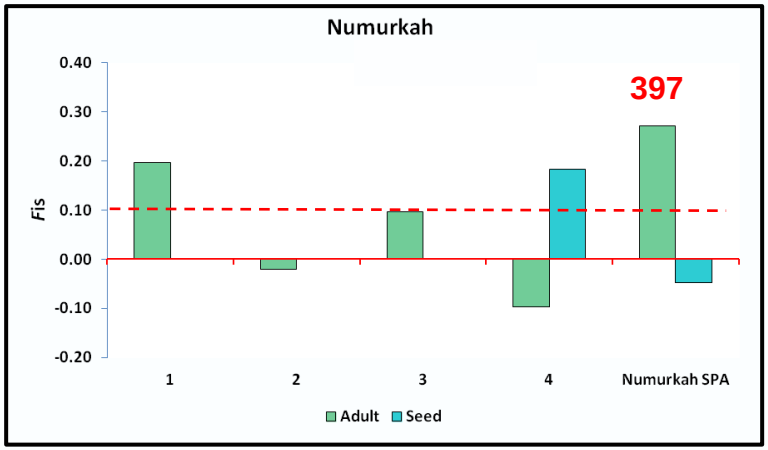


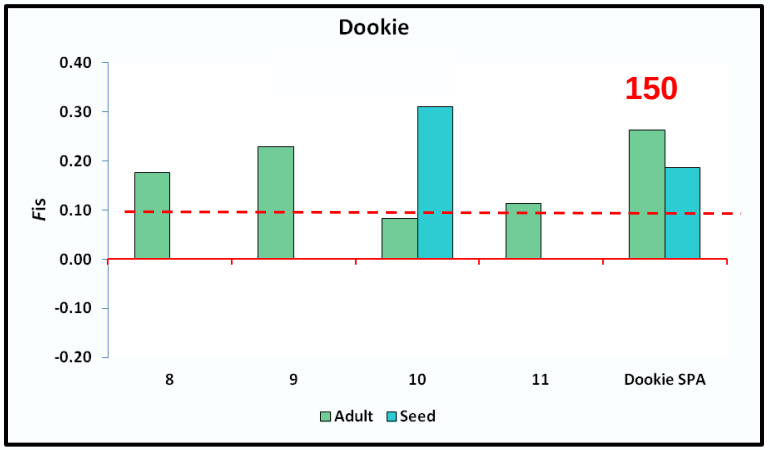


Allelic richness and heterozygosity are generally comparable

- among populations (green)
- between shrubs (green) and their seed (blue)

Inbreeding

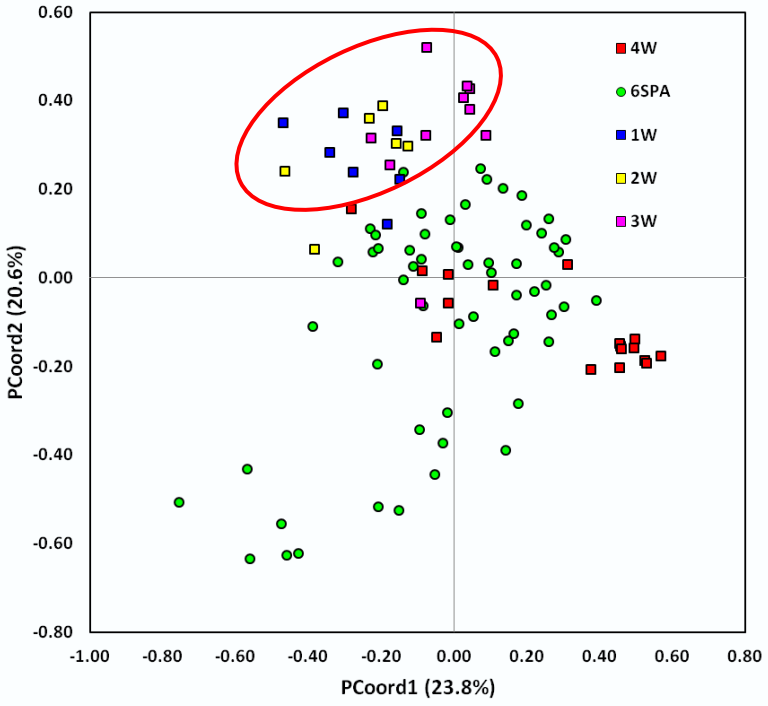




- Inbred seed of concern at Dookie SPA – illustrates importance of knowing genetic quality and inbreeding of stock plants used to set up SPAs
- Having large number plants doesn't help if start with inbred stock

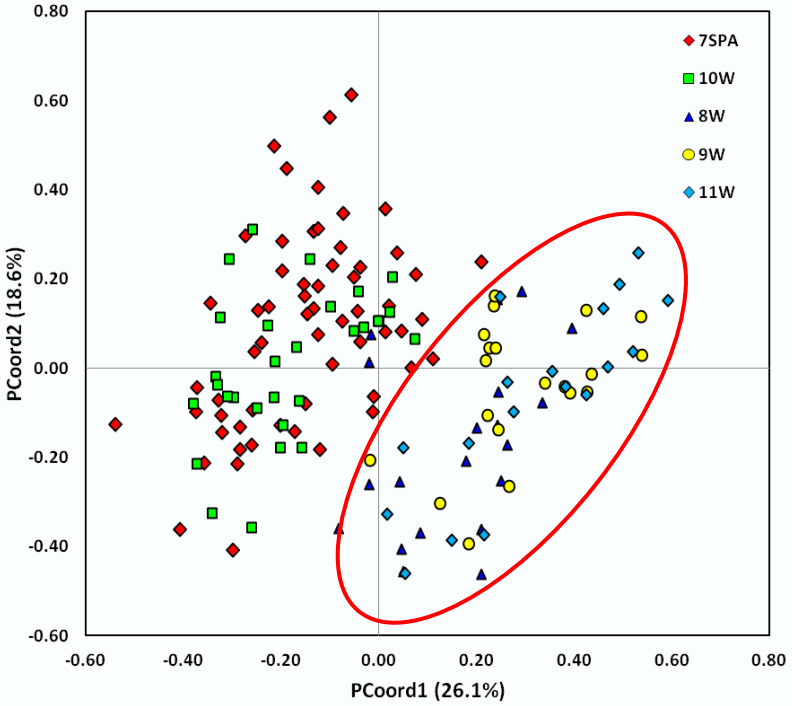
Genetic representation

Numurkah



Primarily Pop 4 samples

Dookie



Primarily Pop 7 samples

Goulburn Broken CMA SPA summary

Mallee Wattle	Genetic Diversity	Inbreeding	Representation
Numurkah	✓	✓	✗
Dookie	✓	✗	✗
Hop-bush			
Numurkah	✓	✓	✗
Dookie	✓	✗	✗
Silver Banksia			
Numurkah	✓	✓	✓ ✗
Dookie	✓	✓	✓ ✗

Conclusions

1. Need to ***secure seed supply chain*** – especially longer-lived species (e.g. eucalypts)
   - Expensive – currently developing rationale/decision-making tool to determine which species, where, how to design etc
2. Need to place restoration within ***funding framework that is realistic*** with biological time frames
   - 3 year cycles – little opportunity M&E
   - Not learning from past to improve practices
3. Plants in the ground or area restored are ***not a measure of success***, simply a reflection that money has been spent
   - Real success will be measured by re-establishing critical plant processes such as production of the next and subsequent generations
   - Many of these successes will be realised beyond our own personal timelines

Thank you

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