Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

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THE UNIVERSITY OF WESTERN AUSTRALIA

Is Restoration Working?
An Ecological Genetic Assessment

ARCLP150100450

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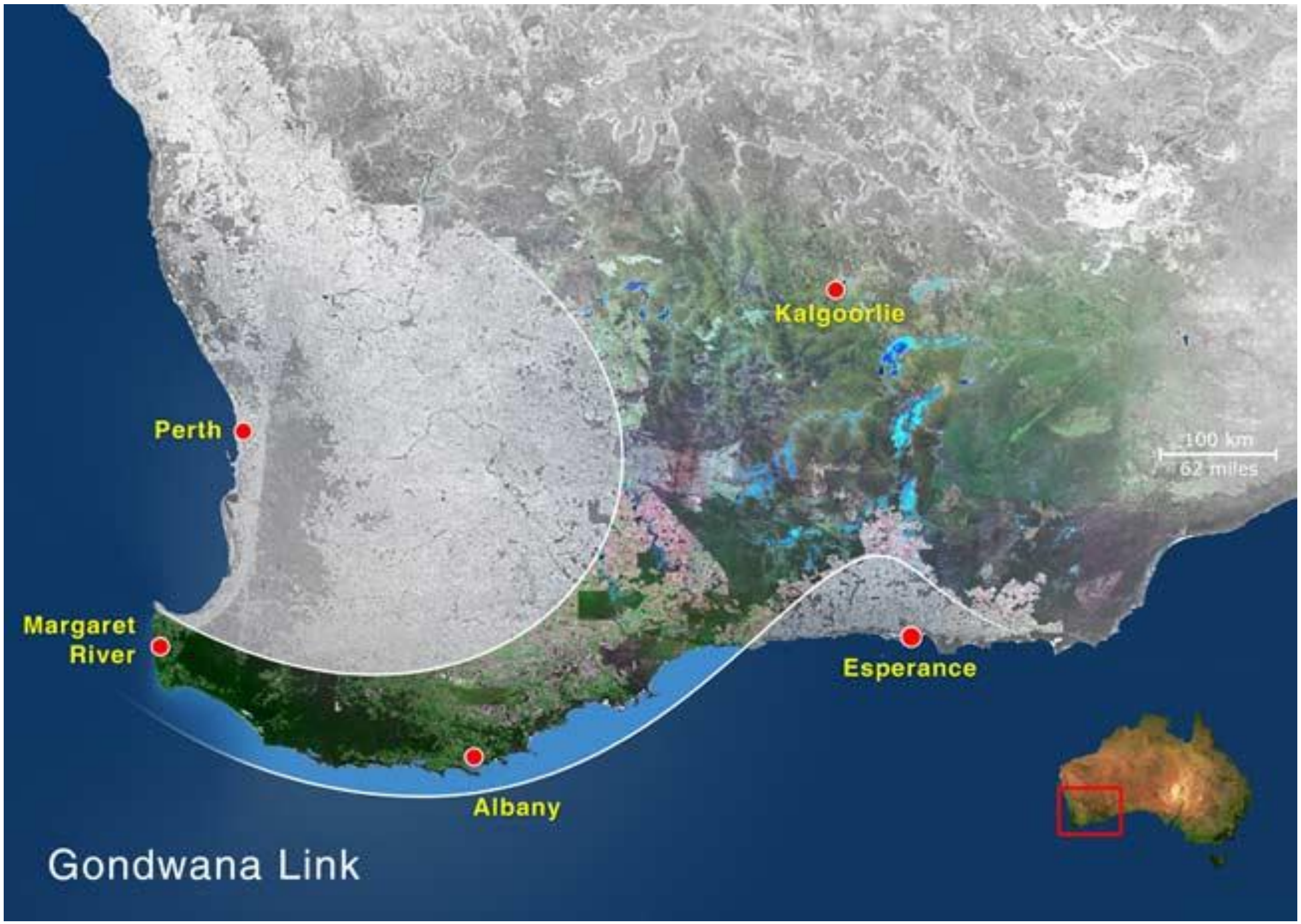
‘Gondwanalink is the most exciting thing that is happening in restoration in Australia, if not in the world.’

Richard Hobbs, UWA

Landscape Repair at a Mega-Scale



Protect what remains

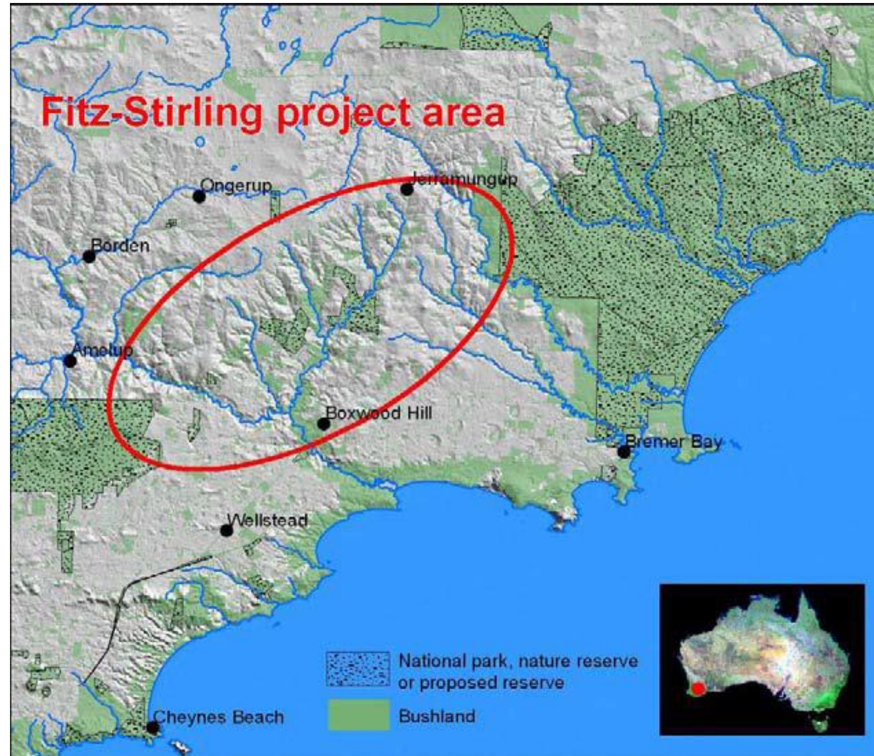
Restore the critical gaps

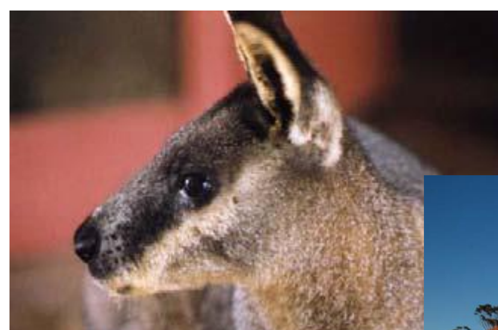
Maintain the extraordinary nature of southwestern Australia

And do it at a scale readily visible from space!

The Fitz-Stirlings

- 74km wide
- 2/3 cleared
- Clearing commenced only in the 1950's
- Some areas can regrow
- Large reserves with species diversity
- Significant creek systems
- Proteaceous communities
- Tammar, black-gloved wallabies, echidnas and western whipbirds
- Few weeds
- Unprofitable farming provides land for restoration
- Cultural importance for indigenous owners





Is restoration working?

- The achievements over ten years of groups working in the Fitz-Stirling section provides an outstanding opportunity to evaluate the ecological and genetic importance of seed sourcing methods, and the implications of planting design and species establishment.
- A need for improved restoration design standards with built in ecological genetic data.
- Restoration sites established with
  - differing seed and seedling establishment regimes
  - for differing lengths of time (15-6 yr).
  - Proteaceous species in ‘nodes’ or ‘grids’.

Chereninup Creek Reserve (BHA) 2003

Peniup Creek Reserve (BHA, GA) 2008

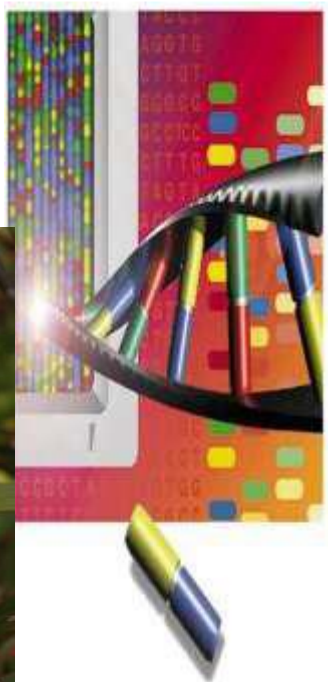
Chingarup Sanctuary 2005

Monjebup North Nature Reserve (BHA) 2012

Is restoration working?

- Is appropriate genetic diversity being captured? (is seed sourced from local provenance?)
- Is sufficient genetic diversity being captured? (is seed sourced from enough individuals?)
- Are mating systems functional? (is pollination resulting in appropriate outcrossing rates?)
  - Compare genetic and mating system parameters in restored populations to nearby, reference, remnant populations.
- Is gene flow via pollen dispersal effective within restored populations? (are pollinators present and effective?)
  - Direct paternity analysis in restored populations.



Is restoration working?

Five species representing different genera.
Insect/bird/mammal pollinated.

Acacia cyclops

Hakea laurina

Hakea nitida

Banksia media

Melaleuca acuminata

Is restoration working?

- Sample leaf and seed material from individuals at a restored population and a nearby reference population (seed source or nearby remnant) for each restoration site.
- Genotype individuals with 10-12 microsatellite markers.
- Assess genetic diversity and divergence.
- Assess mating systems using progeny arrays.
- Assess pollen dispersal via direct paternity analysis for *Banksia media* and *Hakea nitida*.
- Assess population 'viability' via seed size/weight.
- Assess insect visitors.

Is restoration working?

Is appropriate genetic diversity being captured?

Little divergence among restored populations and known seed sources or nearby remnants.

Melaleuca acuminata

D_{ST}	Chingrem	Chingrest	Cherrem	Cherrest	Penrem	Penrest	MonjNrem	MonjNrest
Chingrem	0.000							
Chingrest	**0.016**	0.000						
Cherrem	*0.064*	0.036	0.000					
Cherrest	0.079	0.070	**0.000**	0.000				
Penrem	*0.027*	0.031	*0.066*	0.059	0.000			
Penrest	0.043	0.044	0.041	0.061	**0.023**	0.000		
MonjNrem	0.029	0.034	0.059	0.085	0.047	0.083	0.000	
MonjNrest	0.034	0.25	0.058	0.067	0.027	-0.006	0.055	0.000

Acacia cyclops

D_{ST}	Chingrem	Chingrest	Cherrem	Cherrest	Penrem	Penrest
Chingrem	0.000					
Chingrest	**0.009**	0.000				
Cherrem	*0.035*	0.023	0.000			
Cherrest	0.088	0.067	**0.040**	0.000		
Penrem	*0.031*	0.031	*0.024*	0.053	0.000	
Penrest	0.042	0.018	0.027	0.021	**0.030**	0.000

Seed collections for restoration appear to be of local provenance.

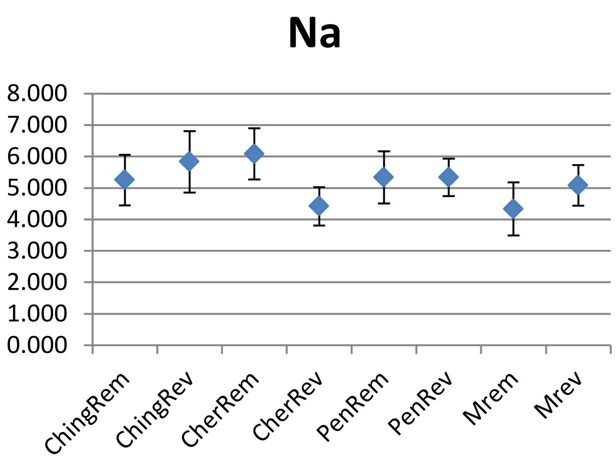
Is restoration working?

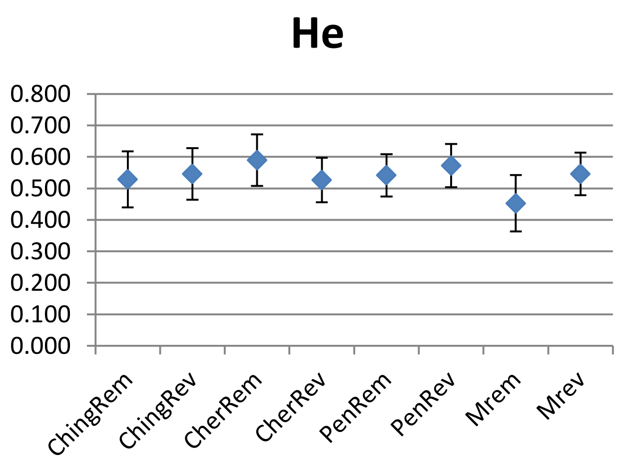
Is sufficient genetic diversity being captured?

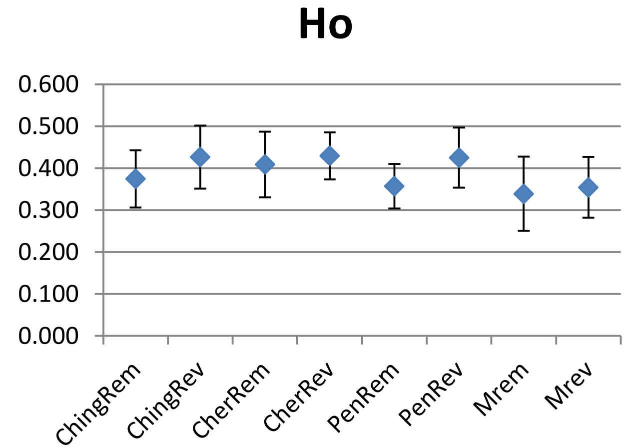
Little difference in levels of allelic diversity among restored populations and known seed sources or nearby remnants.

Seed collections appear to have sampled enough individuals to capture appropriate levels of genetic diversity.

Melaleuca acuminata







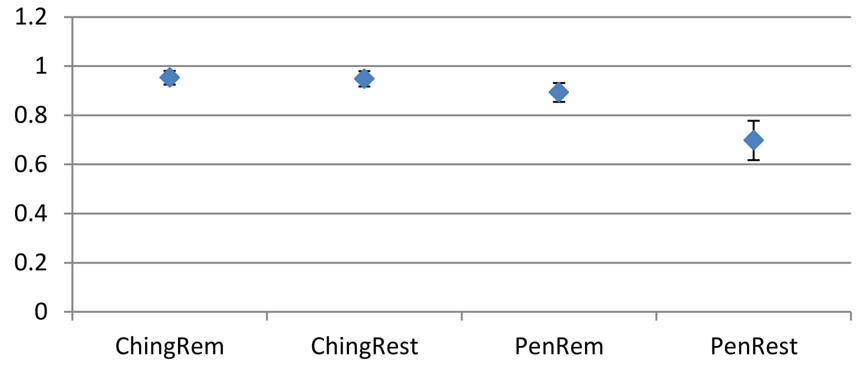
Is restoration working?

Are mating systems functional?

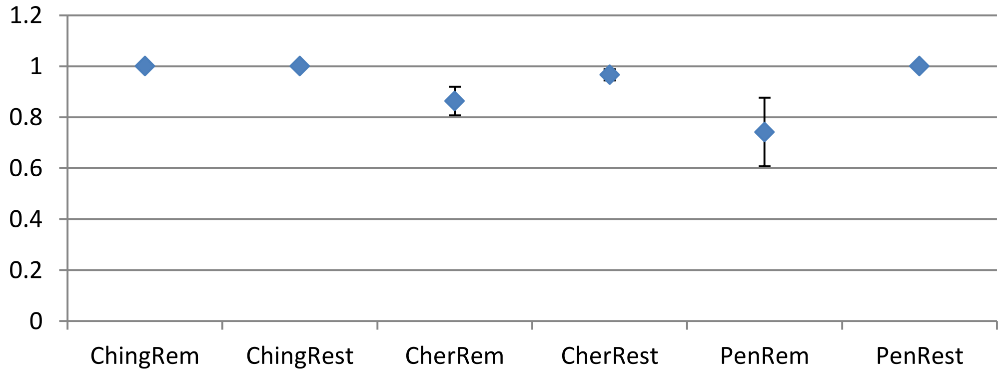
Some differences among sites but,

Pollinator services for insect/bird pollinated species appear to be effective in maintaining mating systems in restored populations.

Hakea laurina **tm**

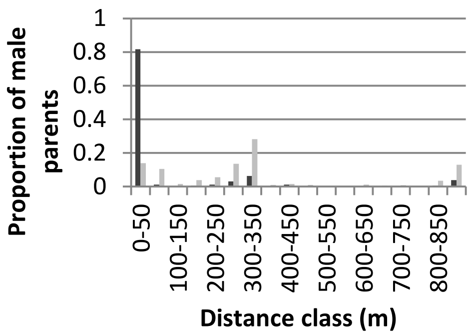


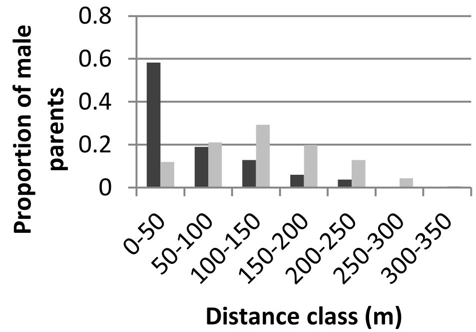
tm *Acacia cyclops*

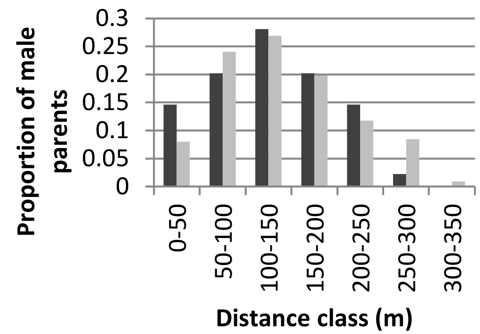


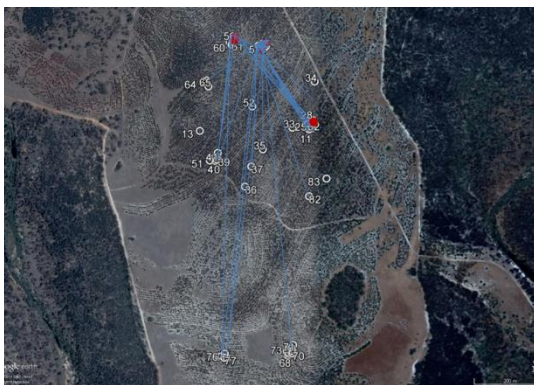
Is restoration working?

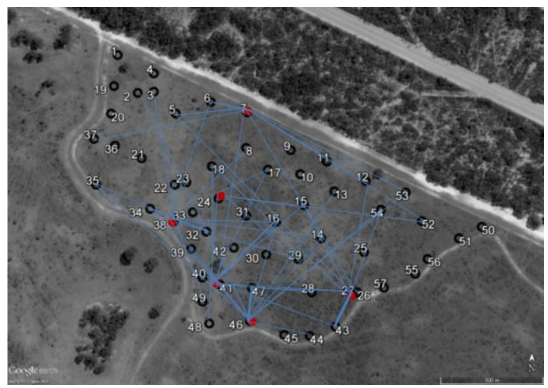
Is gene flow via pollen dispersal effective within restored populations?

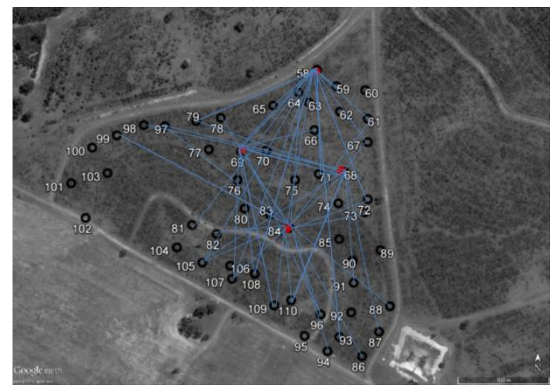












Yes, and patterns of dispersal vary with spatial aggregation of founders and proximity to large native remnants.

Is restoration working?

Not always.

High divergence among restored population and known seed source of a small nearby remnant population of *Hakea nitida*.

D_{ST}	Penrem	Penrest
Penrem	0.000	
Penrest	**0.239**	0.000

Evidence of genetic bottleneck in restoration population.

Inadequate sampling may be from limited number of plants in small populations.

Sample site or Region	P	N	Na	Nar	Ne	H_e	H_o	F_{IS}
Adults								
Peniup remnant	91.67	18.500 (0.544)	4.583 (0.679)	4.388 (0.598)	2.450 (0.374)	0.481 (0.076)	0.449 (0.092)	0.103 (0.103)
Peniup restoration	91.67	142.750 (8.389)	11.833 (1.906)	6.993 (0.977)	4.326 (0.794)	0.625 (0.089)	0.494 (0.081)	0.272 (0.100)
Mean	91.67	80.625 (13.591)	8.208 (1.245)	5.691	3.388 (0.155)	0.553 (0.059)	0.471 (0.060)	0.188 (0.072)
Progeny								
Peniup remnant	100	85.583 (8.124)	6.833 (0.851)	5.170 (0.628)	3.044 (0.496)	0.572 (0.063)	0.330 (0.071)	0.477 (0.077)
Peniup restoration	100	580.500 (27.877)	12.083 (1.510)	6.121 (0.655)	3.405 (0.566)	0.621 (0.052)	0.440 (0.066)	0.323 (0.076)
Mean	100	316.542 (56.841)	9.458 (1.009)	5.646	3.224 (0.370)	0.596 (0.040)	0.385 (0.049)	0.400 (0.055)

Is restoration working?

- Informs on ecological and genetic viability under different establishment regimes among restoration sites
- Provides improved guidelines for adaptive management
- Ensures future restoration is
    - Cost effective
    - Resilient and persistent in the long term
    - Functionally integrated into the landscape
    - Successful overall

Will move measures of restoration success beyond that of population establishment and survival to incorporate the evolutionary processes that provide long-term resilience, persistence and functional integration of restored populations into broader landscapes.

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VIRTUS IMPAVIDA