




When do you need a geneticist and site selection

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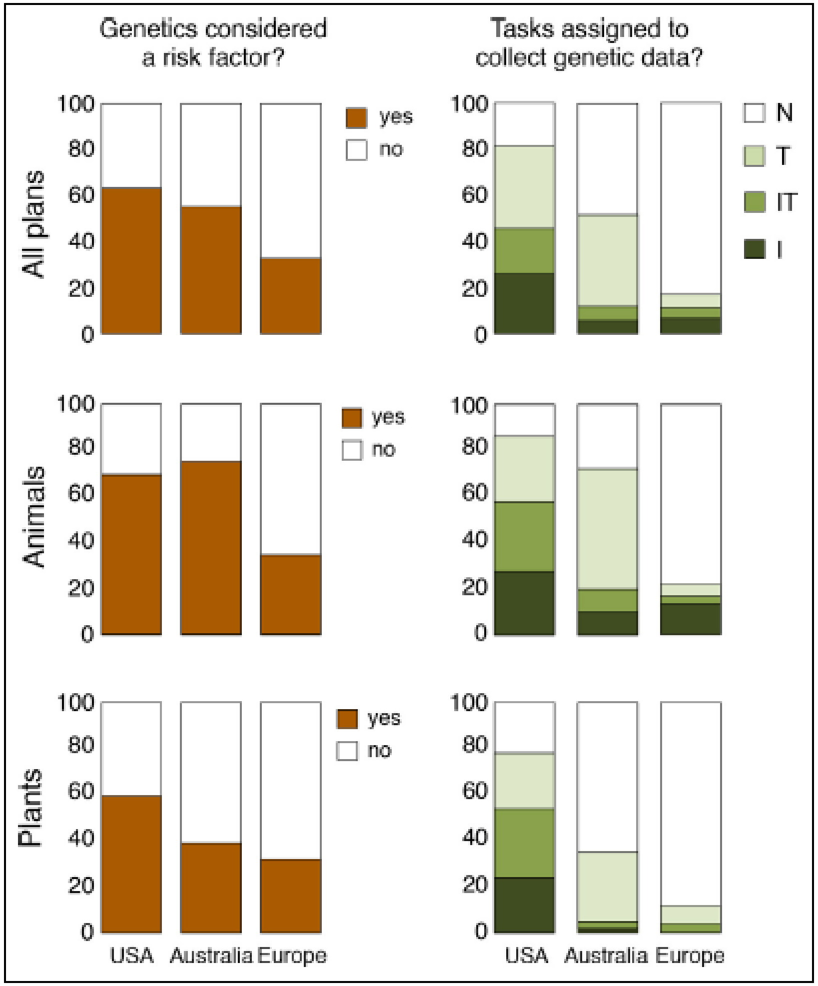
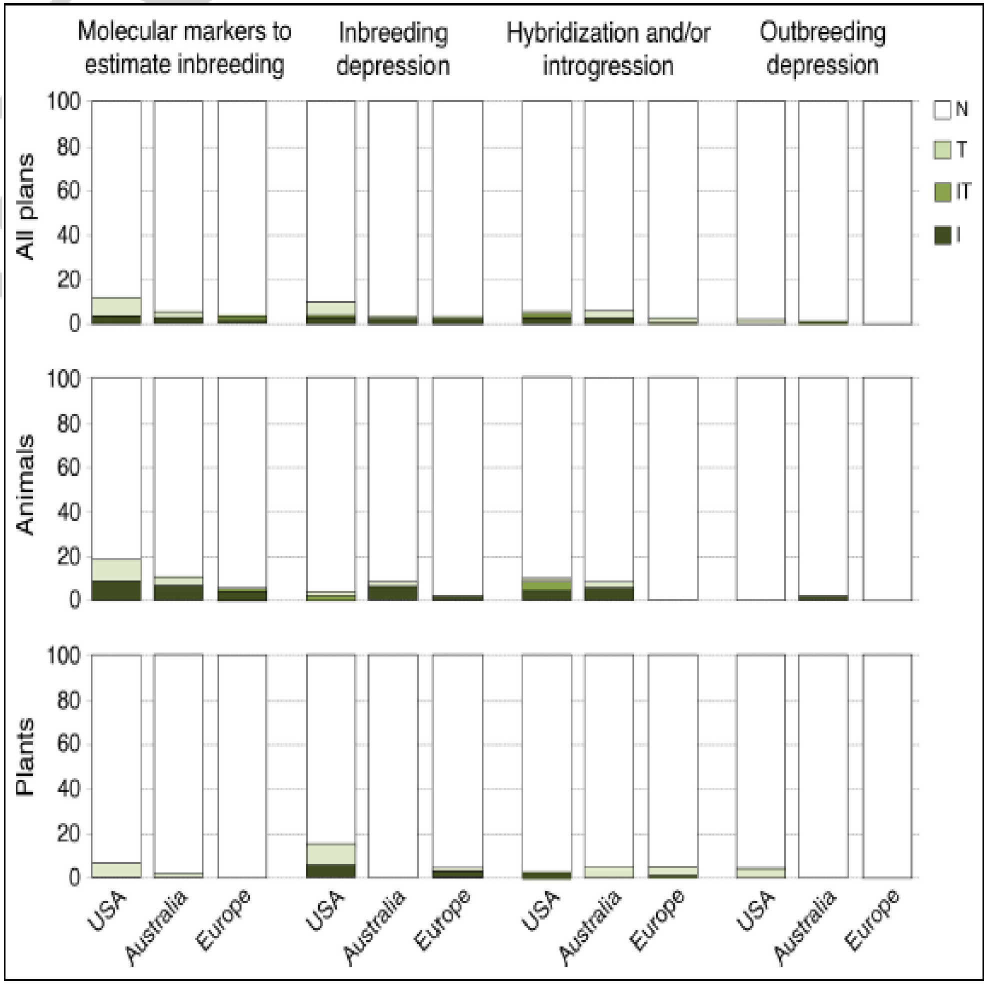
Key questions posed if our goal is to conserve genetic diversity and evolutionary processes for successful translocations

- What are the policy and planning units for conserving genetic diversity? Species, subspecies, Evolutionarily Significant Units (ESUs)?
- Do we risk loss of significant cryptic variation if we ignore genetic diversity/structure in translocations?
- How do we deal with Climate Change and assisted migration?
- When do we consider admixture, augmentation, supplementing gene flow to increase genetic diversity and evolutionary potential in translocations and restoration?
- Is potential hybridisation and outbreeding depression an issue with translocations?
- What is the minimum viable population size for populations and translocations to minimise inbreeding effects? 50, 250, 500?
- How important is maintaining local adaptation and using local provenance material for translocation?

Summary of Threatened Species Recovery Plans that consider genetic factors a risk to population viability and then either present data (I=included), or assign tasks (T=tasks assigned) to collect genetic data. IT = plans both include and assign tasks to collect data; N = none specified.

Genetic factors ignored in less than half of all recovery plans (318) reviewed globally





Pierson et al. Frontiers in Ecology and Environment, 2016

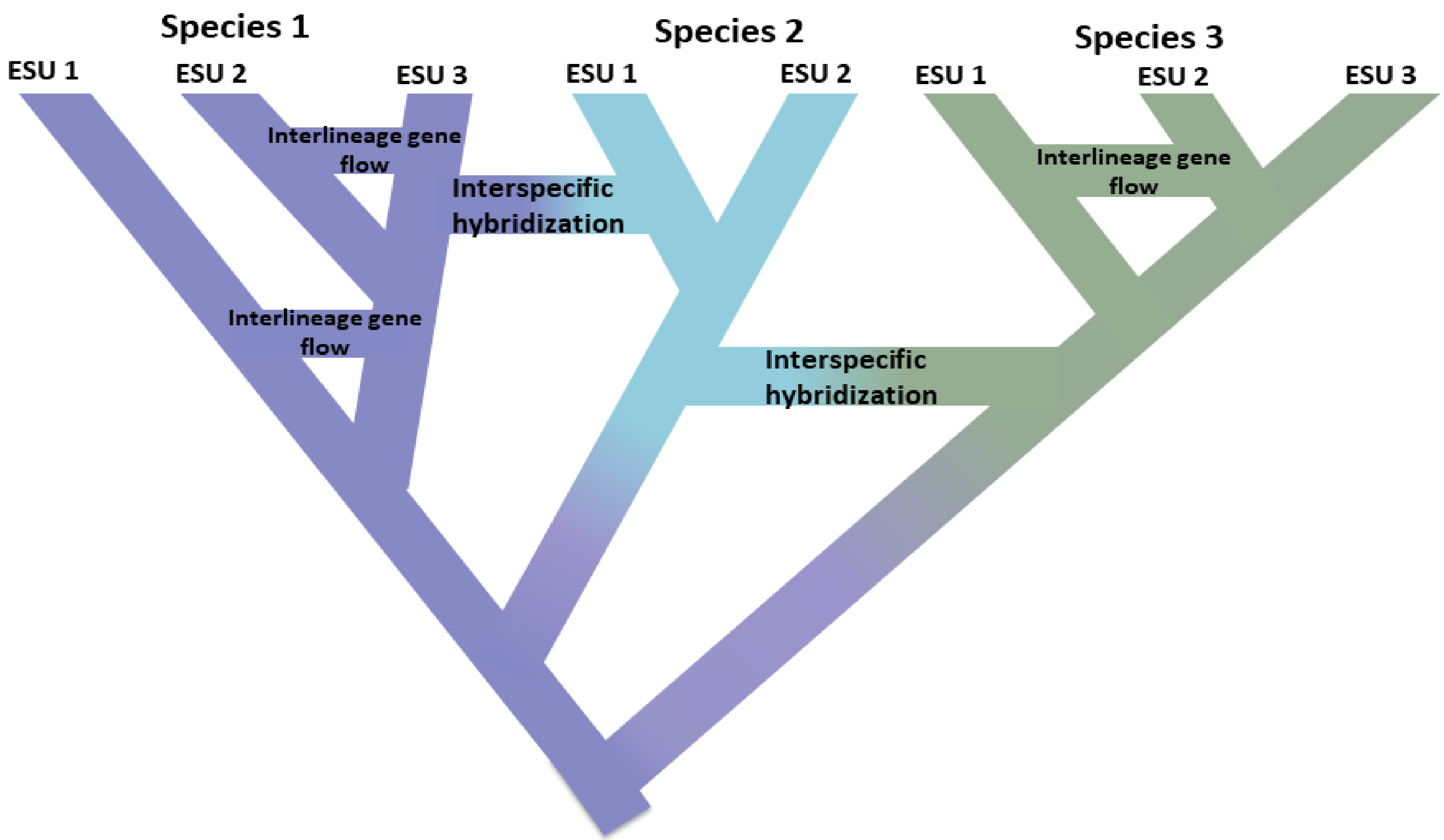




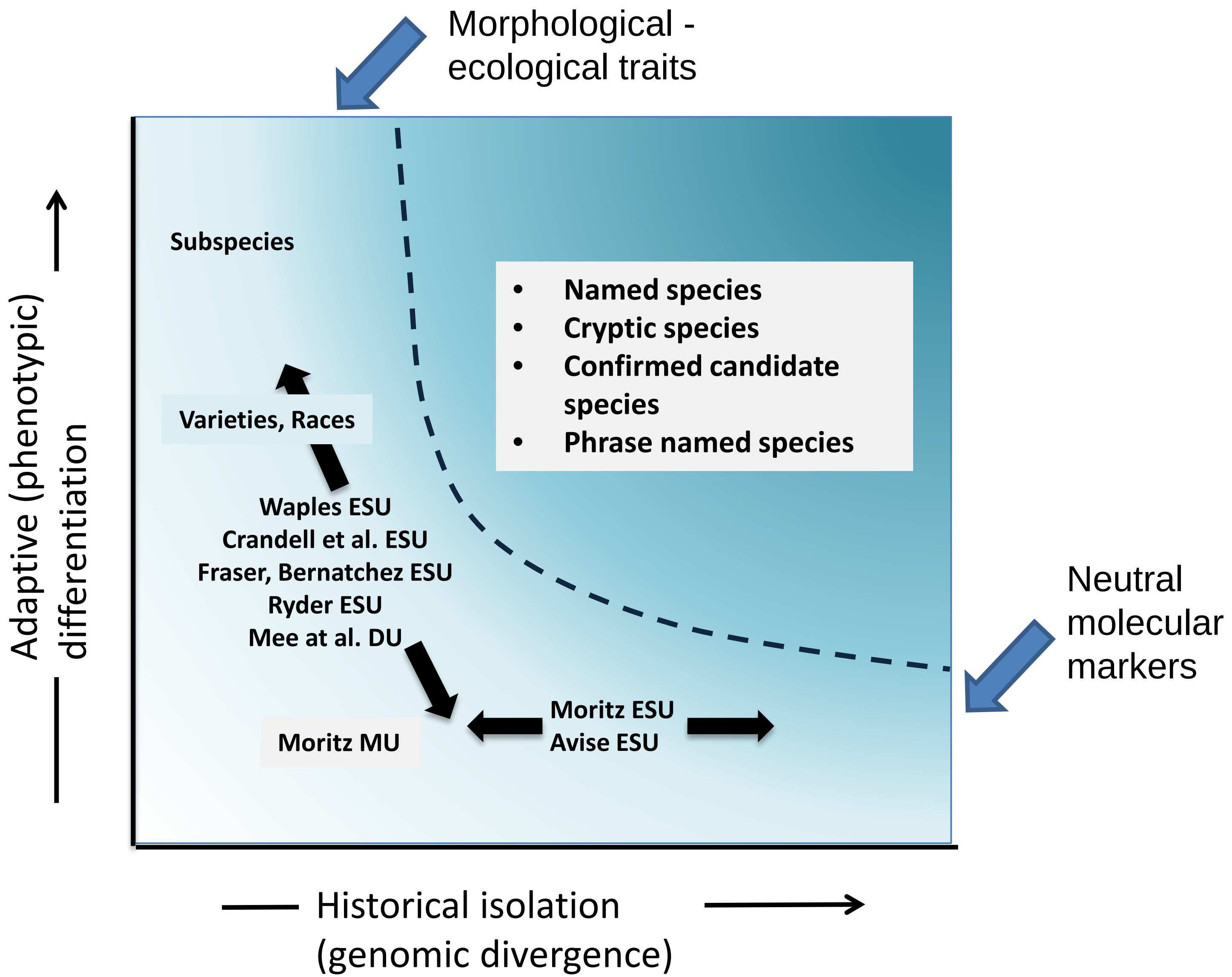

Species, taxa and conservation Units: conserving Genetic Diversity and Evolutionary Processes

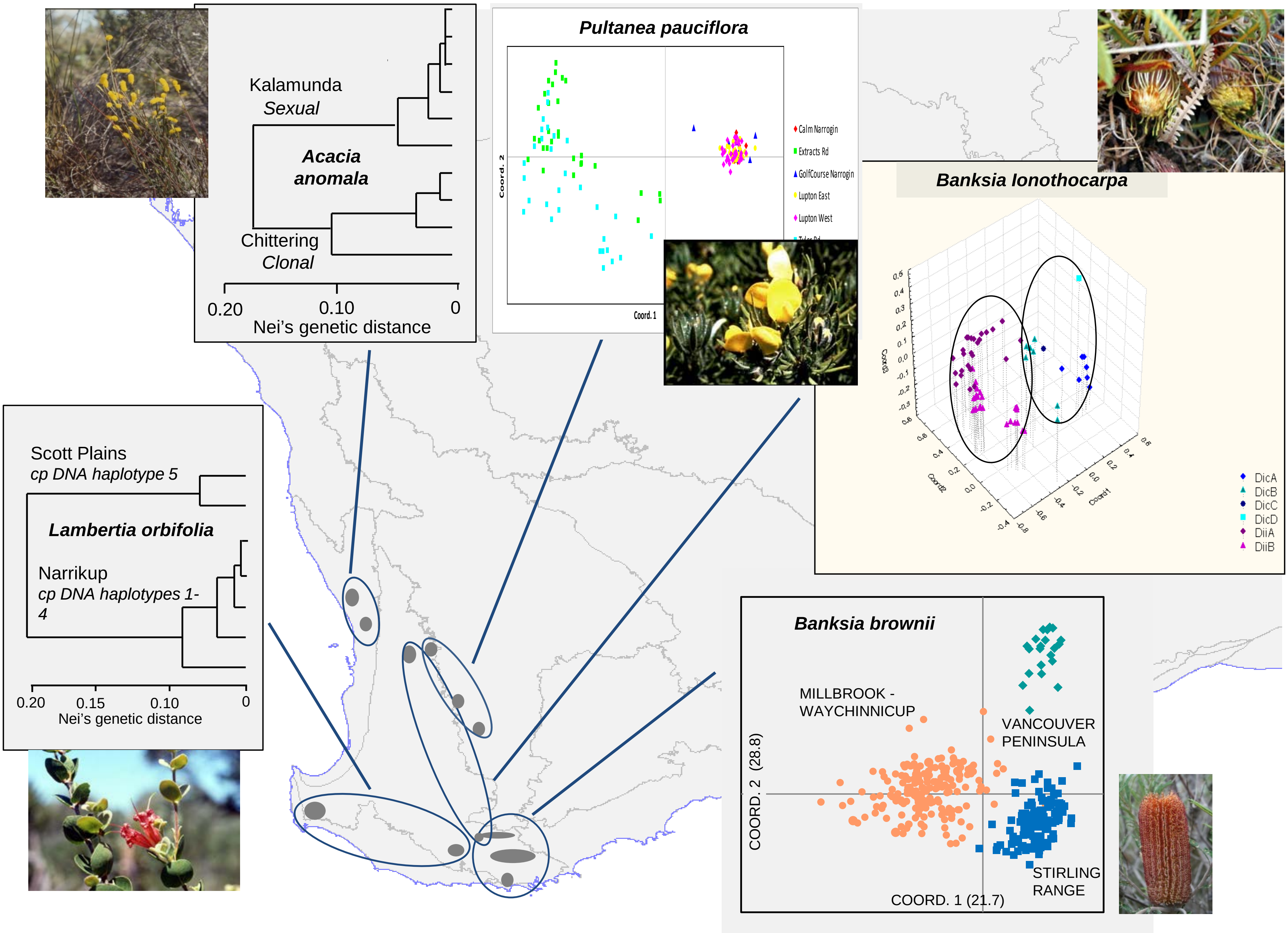
- A review of conservation legislation for threatened species reveals that legal definitions of “species” are quite flexible and can accommodate species as well as a range of infra-specific taxa and divergent populations:
  - **Species.**
  - **Subspecies,**
  - **Varieties (plants)**
  - **Geographically and/or genetically distinct populations (conservation units).**
- Conservation Units are population units identified within species that are used to help guide management and conservation efforts
  - **Evolutionary Significant Units (ESUs)** - a population or group of populations that warrant separate management or priority for conservation because of high genetic and ecological distinctiveness
  - **Management Units (MUs)** - demographically independent populations with restricted gene flow among them – sub set of ESU’s.

Speciation as a continuum progressing from isolated populations to unambiguous species shown by the shift in colour with the colours representing different species



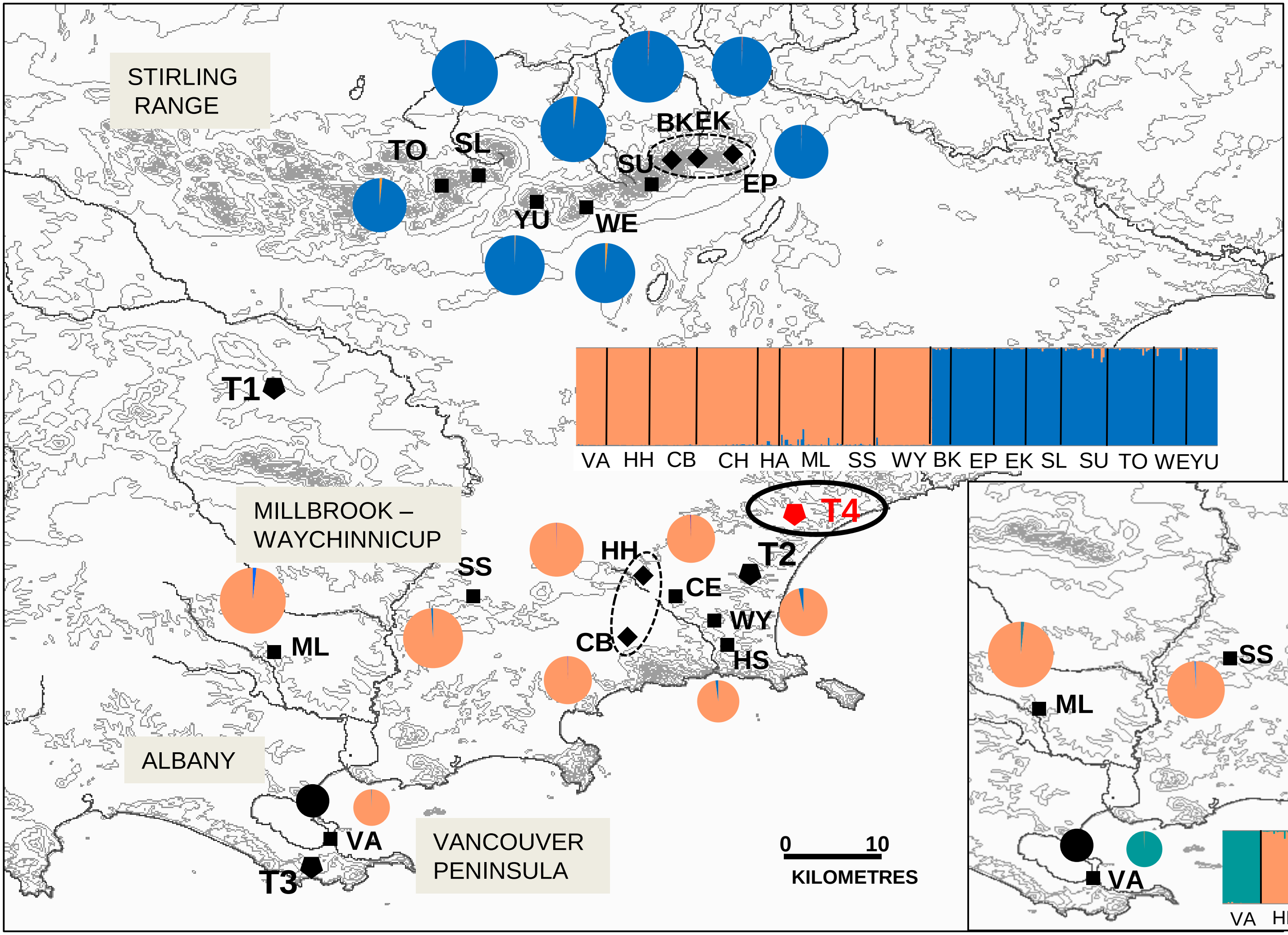
Two Axes of Genetic Diversity

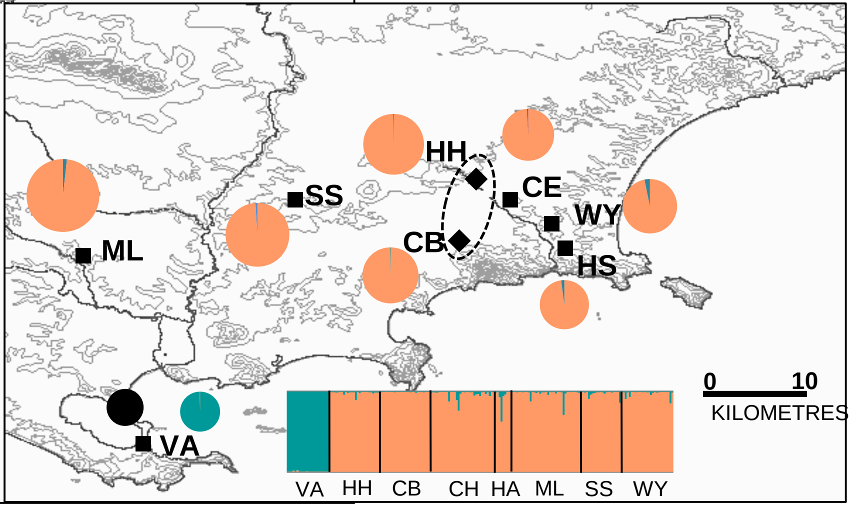




Kalamunda
Sexual
Acacia anomala
Chittering
Clonal
0.20
0.10
0
Nei's genetic distance
Pultanea pauciflora
Coord. 2
Coord. 1
Calm Narrogin
Extracts Rd
GolfCourse Narrogin
Lupton East
Lupton West
Banksia Ionothocarpa
DicA
DicB
DicC
DicD
DiiA
DiiB
Scott Plains
cp DNA haplotype 5
Lambertia orbifolia
Narrikup
cp DNA haplotypes 1-4
0.20
0.15
0.10
0
Nei's genetic distance
Banksia brownii
MILLBROOK - WAYCHINNICUP
VANCOUVER PENINSULA
STIRLING RANGE
COORD. 2 (28.8)
COORD. 1 (21.7)

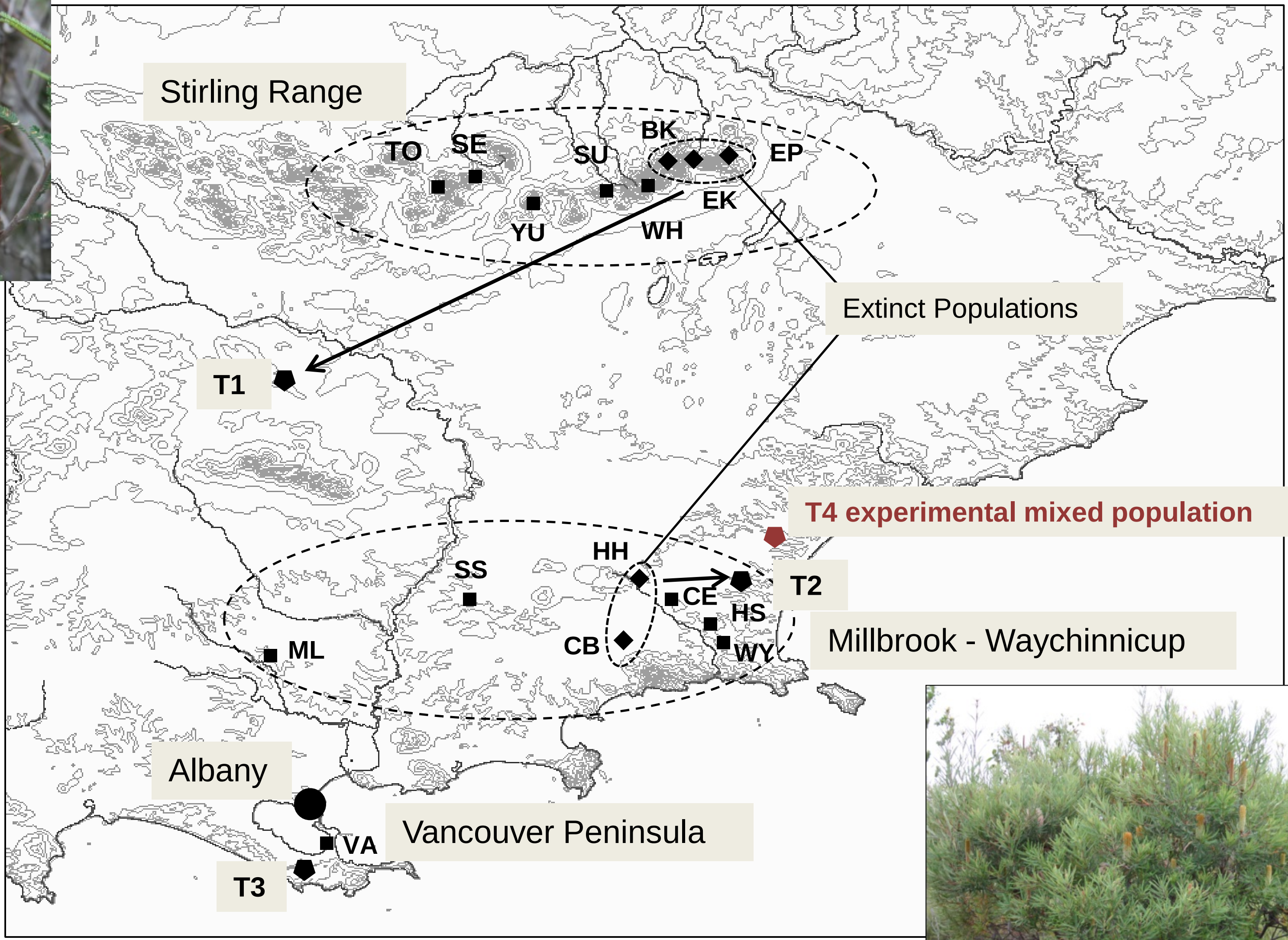
Genetic structure and translocations in *Banksia brownii*



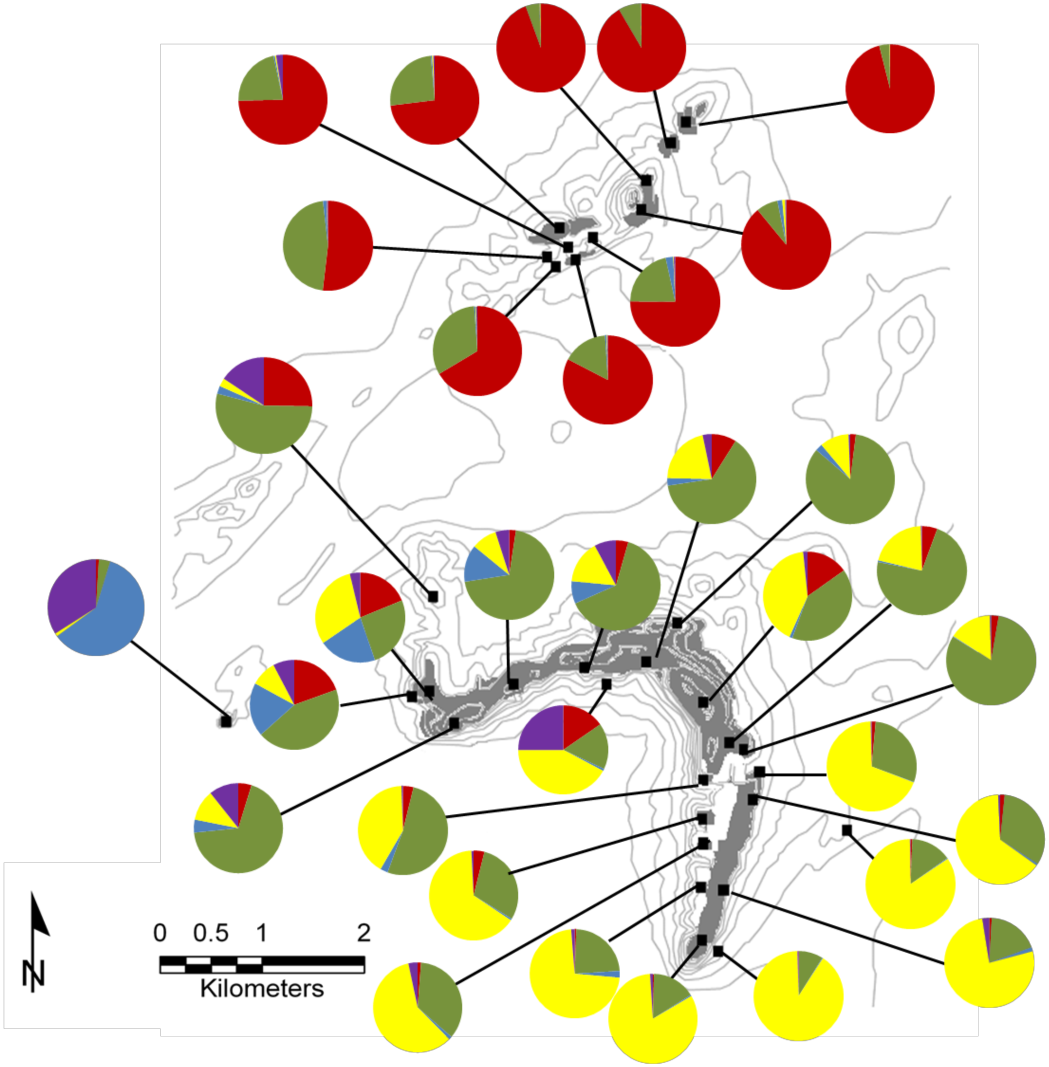


Coates et al Conservation Biology, 2015

Threatened *Banksia brownii* translocations



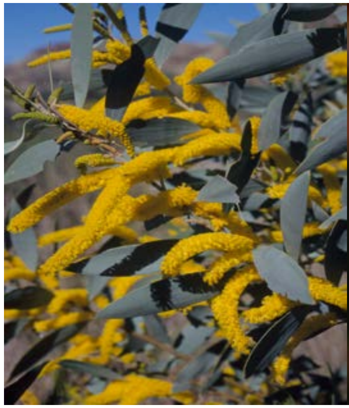
Genetic structure in *Acacia woodmaniorum*



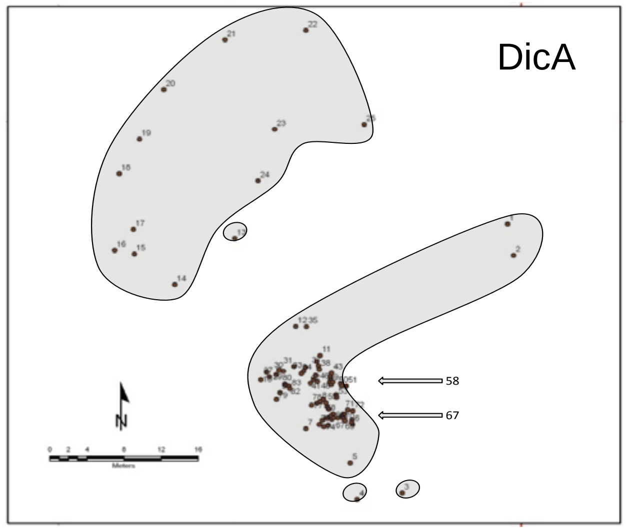
Genetic connectivity and diversity in inselberg populations of *Acacia woodmaniorum*, a rare endemic of the Yilgarn Craton Banded Iron Formations.
MA Millar, DJ Coates and M Byrne. Heredity in press

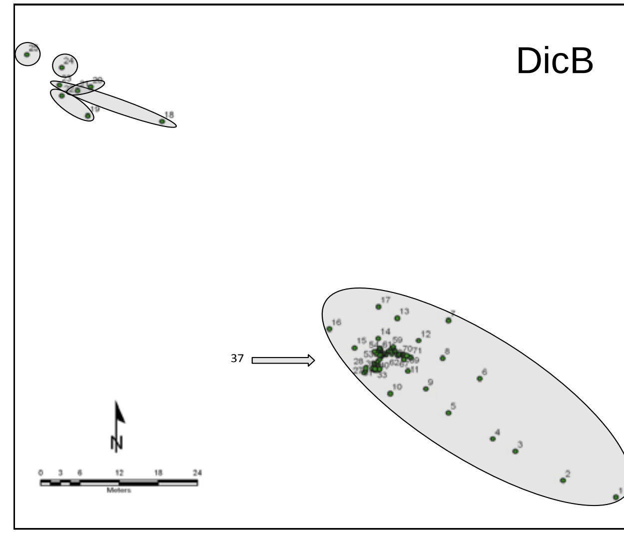
Threatened plants can evolve complex genetic systems

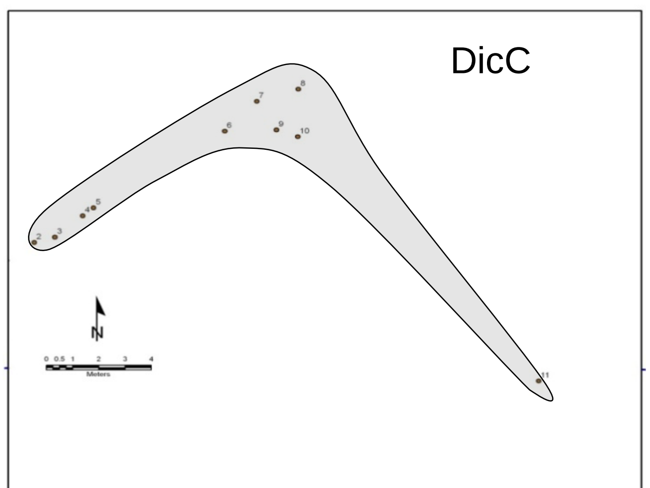
- Hybridisation and apomixis
- Clonality
- Chromosome change
  - polyploidy
  - complex heterozygosity
  - dysploidy
  - chromosome races

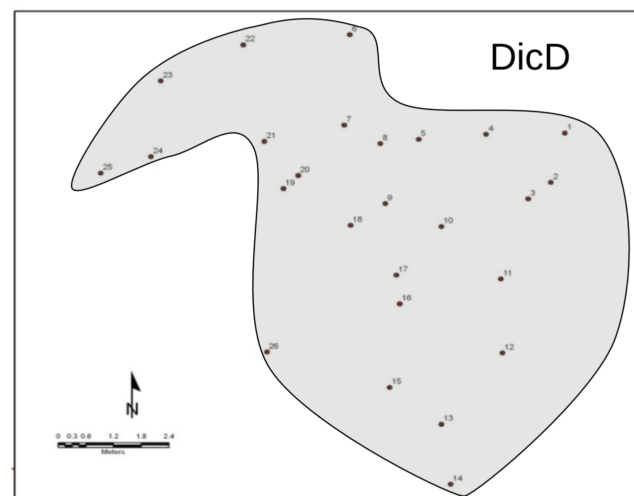



Clonality in *Banksia ionothocarpa* subsp. *chrysophoenix*

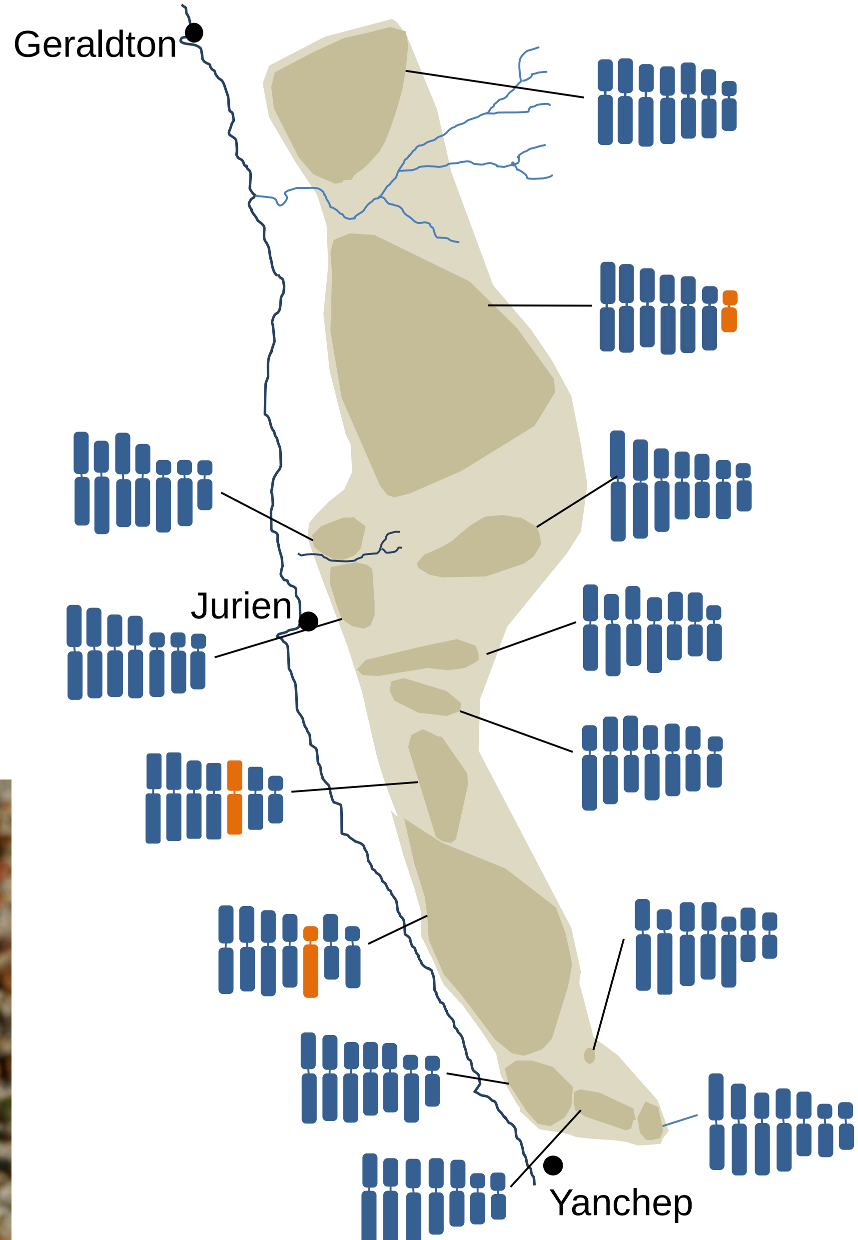








Chromosome variation in *Stylidium crossocephalum*



Morphological variation and apomixis in two Mulga populations

Implications for translocations

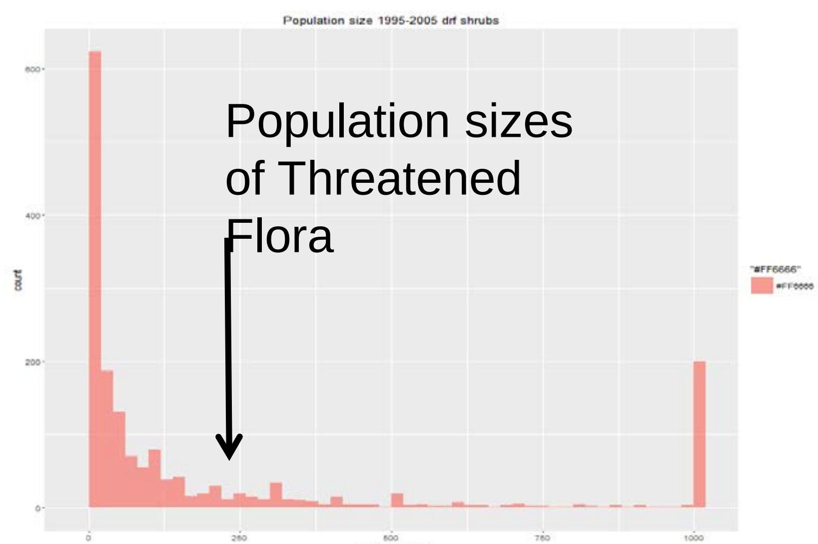
Significant population genetic and phylogeographic structure within species will have implications for:

- Defining conservation units
- Germplasm collection strategies
- Planning habitat restoration (provenance variation)
- Conservation of genetic resources and reserve design

Small populations, habitat fragmentation and viability

- fewer pollinators and changed pollinator behaviour
- increased inbreeding
- reduced reproductive output
- reduced demographic connectivity
- reduced genetic diversity
- reduced adaptive potential

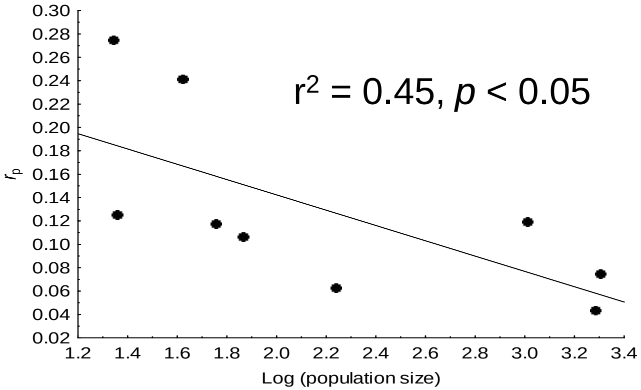
Many populations of threatened flora occur in small isolated populations with reduced reproductive output and no recruitment evident



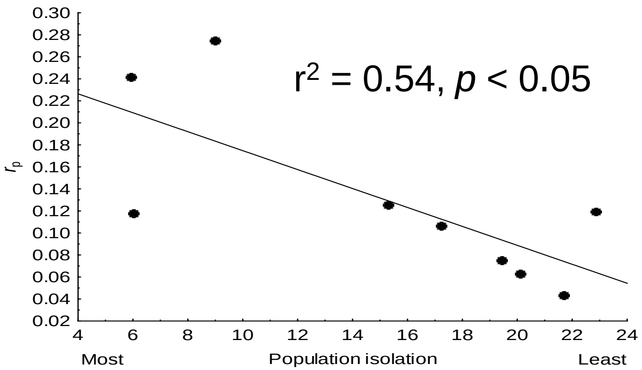
Calothamnus quadrifidus

- Long-lived woody shrub
- Bird – mammal pollinated
- Numerous flowers per inflorescence
- Flowers protandrous – geitonogamous pollination
- Canopy stored seed
- Common but patchy distribution in scrub/heath

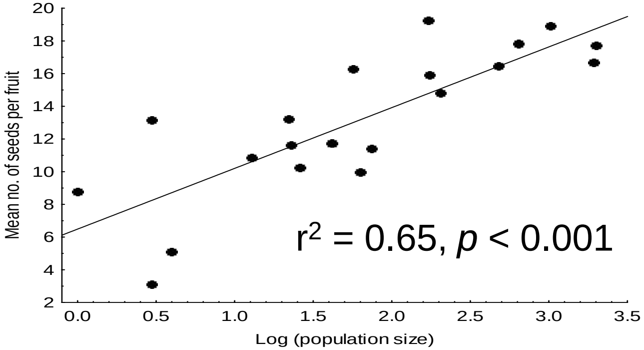
Calothamnus quadrifidus



- As populations become smaller and more isolated fewer fathers contribute pollen to seed production on individual plants.



- Over time this will lead to increased inbreeding in small isolated populations



- Over time this will lead to reduced reproductive output

Thresholds of size (200-300 plants?)

Yates et al. Biol Cons 2008

Banksia sphaerocarpa var caesia

- Long-lived woody shrub
- Bird – mammal pollinated
- Numerous flowers per inflorescence
- Flowers protandrous – geitonogamous pollination
- Canopy stored seed
- Common but patchy distribution in scrub/heath

population size, shape, isolation, and mating system variation in *Banksia sphaerocarpa var caesia*

As populations get smaller

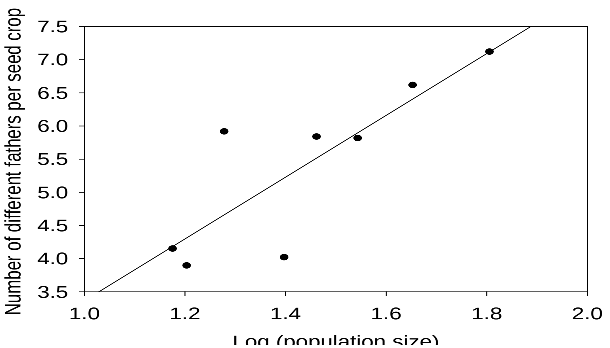
❖ Fewer fathers contribute to a seed crop

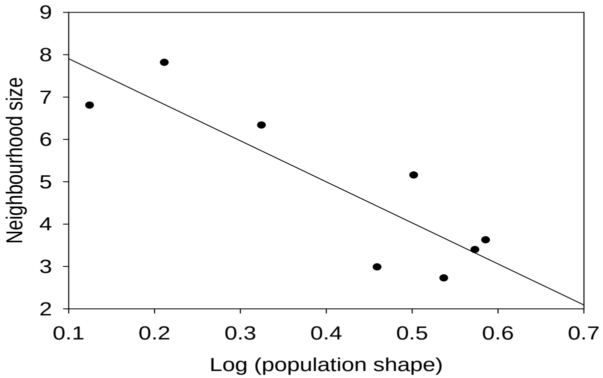
As populations become more linear

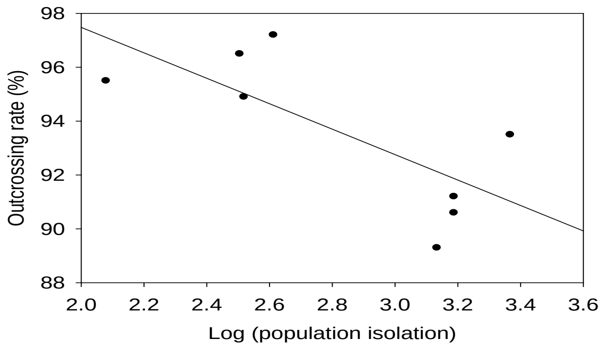
- Neighborhood size decreases

As populations become more isolated

- Outcrossing decreases







Increased inbreeding (reduced seed quality)

Size threshold 300 plants

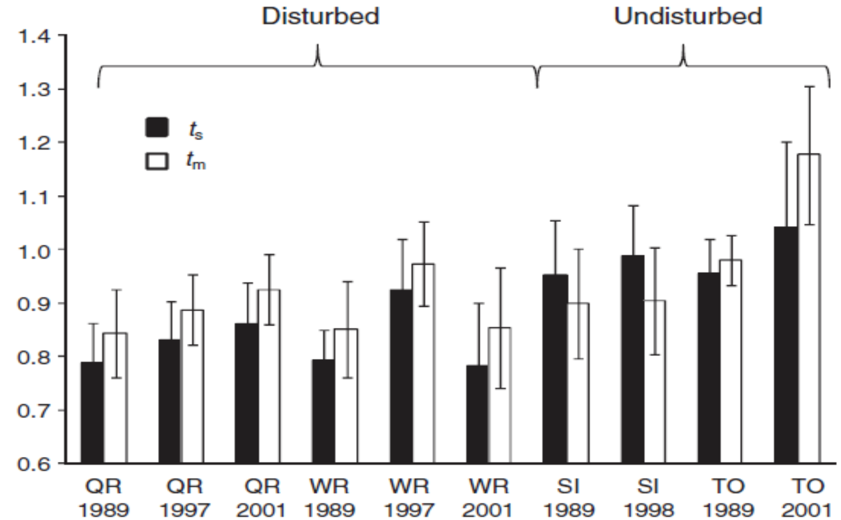
Llorens et al. Mol Ecol 2012

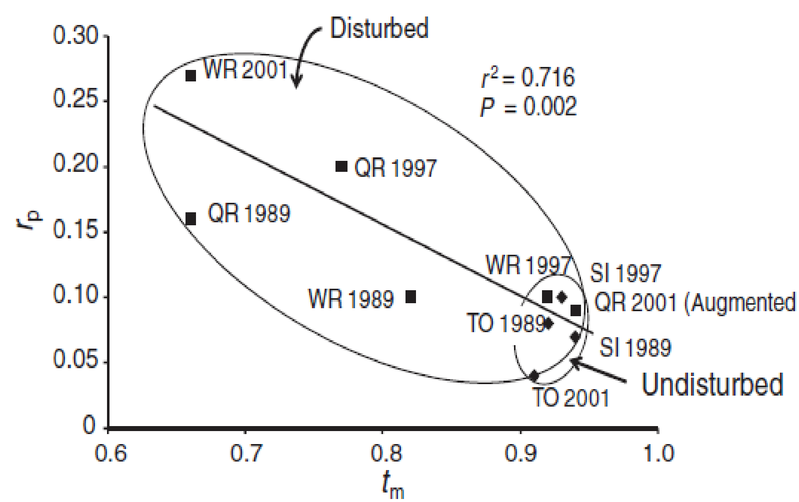
Banksia cuneata

- Long lived woody shrub
- Bird and insect pollinated
- Numerous (100's) flowers per inflorescence
- Flowers protandrous - geitonogamous pollination
- Canopy stored seed serotinous)
- High fecundity(11,500 per adult plant)
- Rare, patchy distribution, scrub heath
- Population sizes mostly < 100

Coates and Sokolowski (1992) *Heredity*

Habitat disturbance associated with habitat fragmentation and increased inbreeding in *Banksia cuneata*





Mating system change and levels of inbreeding can be critically influenced by:

- Population size

Calothamnus quadrifidus, Banksia cuneata, Banksia sphaerocarpa var caesia

- Habitat disturbance

Banksia cuneata, Banksia sphaerocarpa var caesia

- Population isolation

Calothamnus quadrifidus, Banksia sphaerocarpa var caesia

- Population shape

Banksia sphaerocarpa var caesia

Implications for translocations

- Increased inbreeding and increased inbreeding depression are significant issues in small/isolated populations
- These effects became evident with population sizes of 200 - 300
- Population shape can also be a significant factor

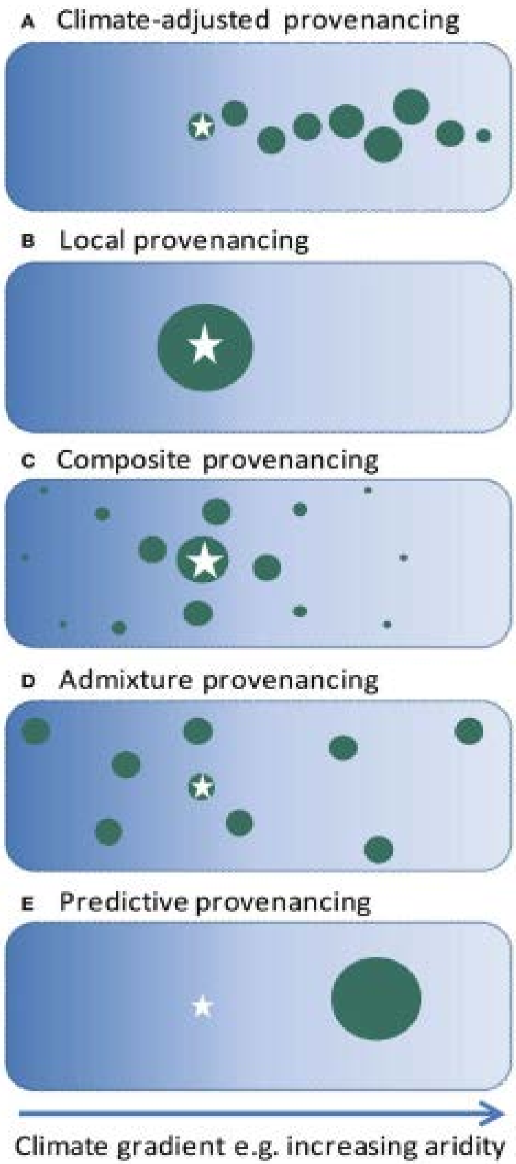
Genetics in conservation management: Revised recommendations for the 50/500 rules, Red List criteria and population viability analyses

Richard Frankham [a,b,*], Corey J.A. Bradshaw [c], Barry W. Brook [c]

Table 1
Topics addressed in this perspective.

Topic	Current recommendation	Revised recommendation
1. Avoid inbreeding depression	$N_e = 50$	$N_e \geqslant 100$
2. Maintain evolutionary potential	$N_e = 500$	$N_e \geqslant 1000$
3. Extrapolating from N_e to N	$N_e/N = 0.10–0.14$	Use different N_e/N according to life-history of species, but current default is 0.1–0.2
4. Fragmented populations and connectivity	Evaluate on case basis	Evaluate, but distinguish current and historical gene flow
5. Genetic factors in PVA	Often none	Routinely include inbreeding depression
(i) Inbreeding depression	Lethal equivalents = 3.14 on juvenile mortality, if included	Routinely apply realistic levels (~12 lethal equivalents on total fitness)
(ii) Evolutionary potential	Ignored	Include in long-term and environmental-change contexts
6. MVPs	Persistence probability inconsistent	Apply common standard and specify (suggest 99%)
	Duration inconsistent	Standardise and specify in generations (suggest 40)
	Important factors often ignored	Routinely include all systematic and stochastic factors (including genetic)
7. IUCN Red List Criterion C	Population size	
Critically Endangered	<250	<500
Endangered	<2500	<5000
Vulnerable	<10,000	<20,000

Propagule sourcing strategies and when to mix



Selecting recipient sites

Assessment of potential recipient sites

- Habitat is matched as close as possible to source location (Case Study 4.3)
- Future climate projections and the sustainability of the species and population(s)
- Determining that ecological functions identified in Chapter 3 are present such as pollinator services, and /or soil mycorrhizal fungi critical for establishment of mature plants and new recruits (e.g. orchids) (Case Study 4.1)
- Whether the habitat area is large enough to support a self-sustaining population
- History of past land uses and degree of disturbance at the site
- Ongoing threat management that may be required, and whether any threats present at the site can be controlled or eliminated, e.g. fire management regimes in circumstances of multiple use sites;
- Potential risk from threats that may not currently be evident, including salinity and water table changes, and diseases such as *Phytophthora* spp., *Armillaria* spp. and myrtle rust
- Security of land tenure
- Compatibility of current and future management of the site with managing a translocated population (e.g. fire management, restoration site
- Whether any adjacent land uses impact on the translocation site (buffer?)

Ecological impacts on the recipient community

Key questions

1. Is the species or a closely related species invasive elsewhere?

2. Does the species display any traits that may facilitate invasion in the context of the recipient site?.

3. Was the species historically widespread, dominant or abundant?

4. Is there potential for interference between the translocated species and closely related or functionally similar resident species?

- Hybridisation? (e.g. if the species share a pollinator) (see Section 3.3.2b and Case Study 4.1).
- Impacted through direct competition for resources and/or transfer of pests or pathogens.

5. Is there any potential for the species to transform ecosystem structure or function?

(e.g. a newgrowth form, taller individuals, nitrogen fixing) or disrupt current processes (e.g. changed flammability).