A spatially explicit approach to support the decision-making process on seed provenance for ecological restoration in a climate change context

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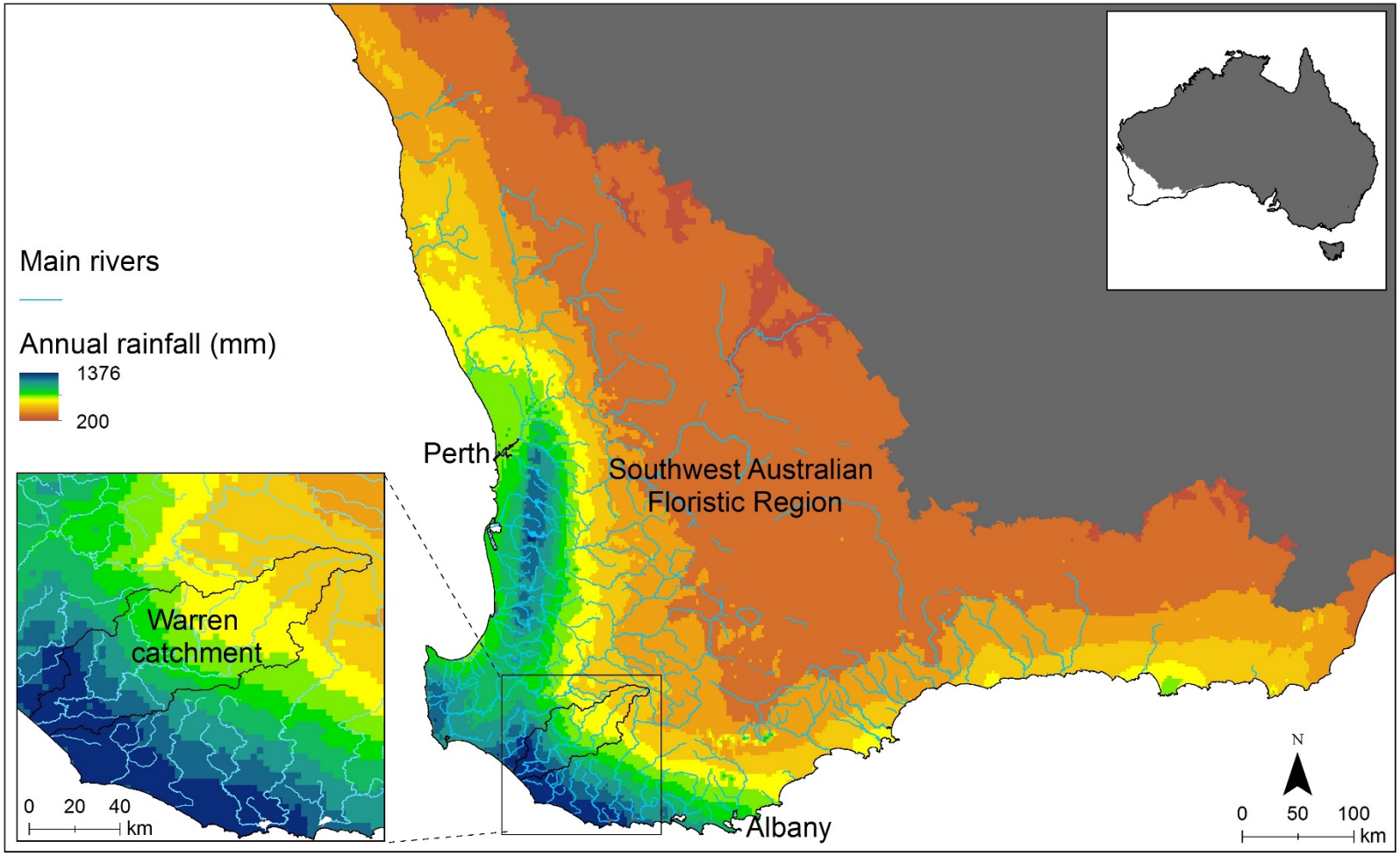
PARKS AND WILDLIFE

Setting the scene – our case study



Setting the scene – our case study

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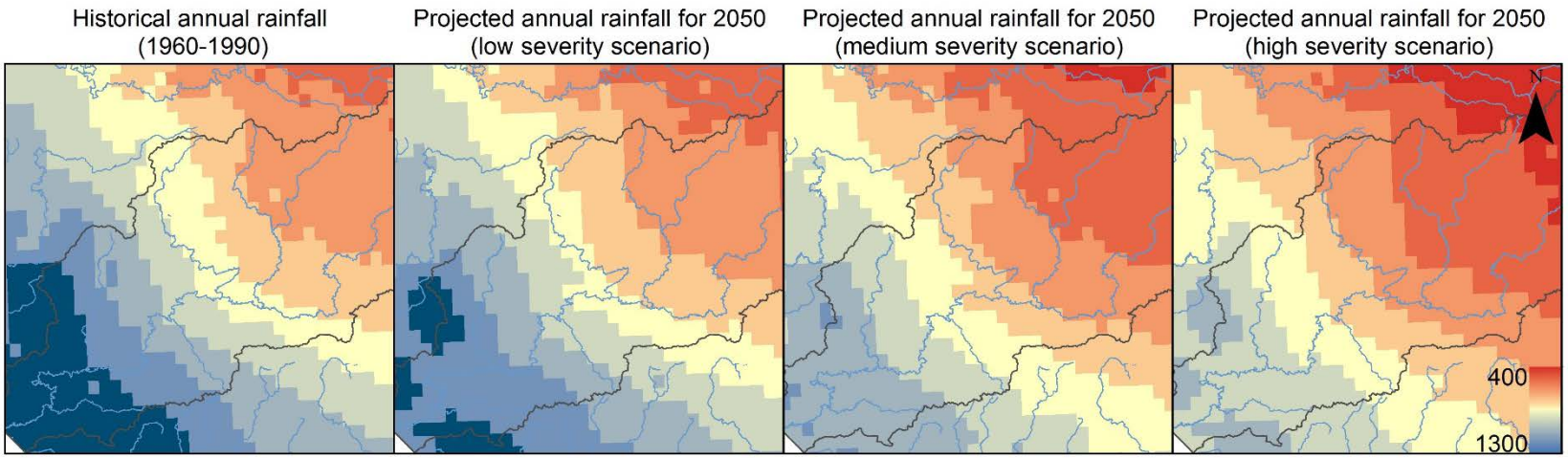
What seed provenance strategies to use in a climate change context?

We focused on 5 plant species: *Astartea leptophylla*, *Banksia seminuda*, *Callistachys lanceolata*, *Lepidosperma effusum* and *Taxandria linearifolia*

Setting the scene – our case study

SWWA has experienced significant climatic changes since the 1970s (15-20% decline in annual rainfall and 0.6 ºC increase in annual temperature)

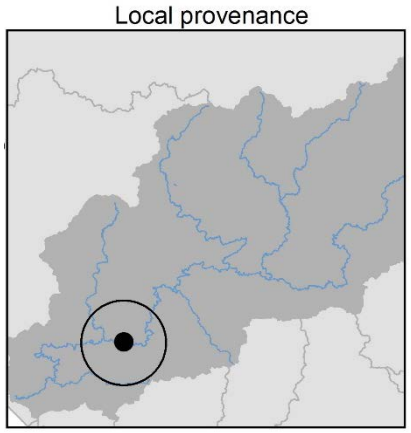
Further drying and warming is projected in a south and westwards direction, with decrease of 8-33% in annual rainfall and increase of 1.5-2.3 ºC in annual temperatures by 2050)



Seed provenance approaches

Most common provenance approach:

✓ **Local provenance** – seeds are collected locally; **local genotypes are best adapted to the local environment**; mal-adapted non-local genotypes can lead to loss of adaptive potential



Potential issues

- Can encourage the establishment of populations that may not harbor sufficient evolutionary potential to cope with climate change
- Can encourage the selection of genetically depauperate seed sources (esp. in highly fragmented landscapes)
- Ignores the impact of changing climates

Seed provenance approaches

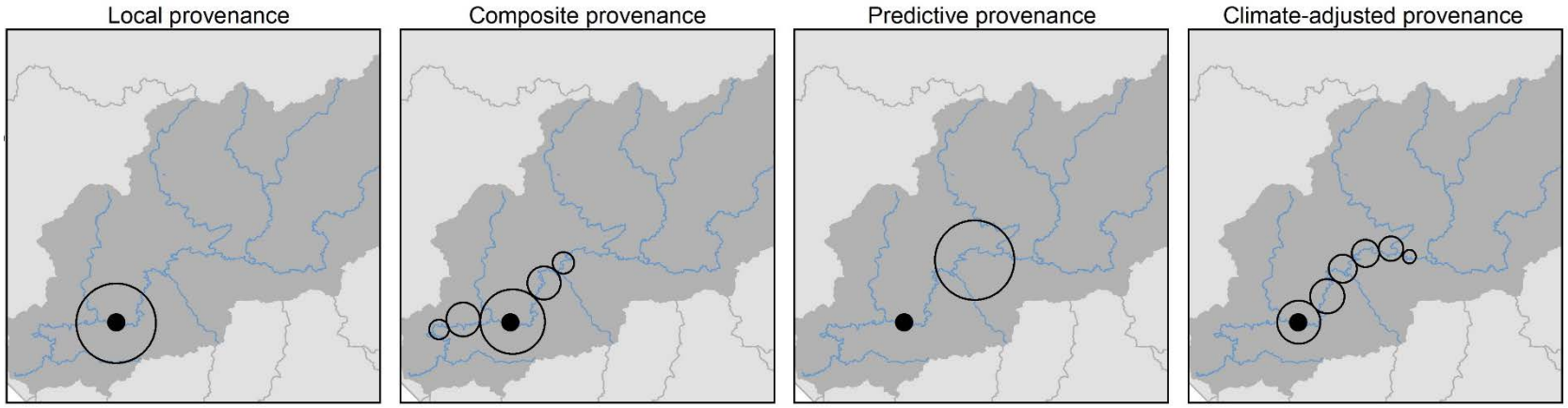
Most common provenance approach:

✓ Local provenance

Alternative provenance approaches:

- ✓ Composite provenance
- ✓ Admixture provenance
- ✓ Predictive provenance
- ✓ Climate-adjusted provenance

Assisted gene flow as a tool for climate change adaptation



Decisions... decisions...

The **decision-making process** for selection of the provenance strategies that are better suited for each specific case is **complex and multifaceted!**

It requires information about:

Species adaptive capacity

Common garden trials & transplantation experiments; genomic screening

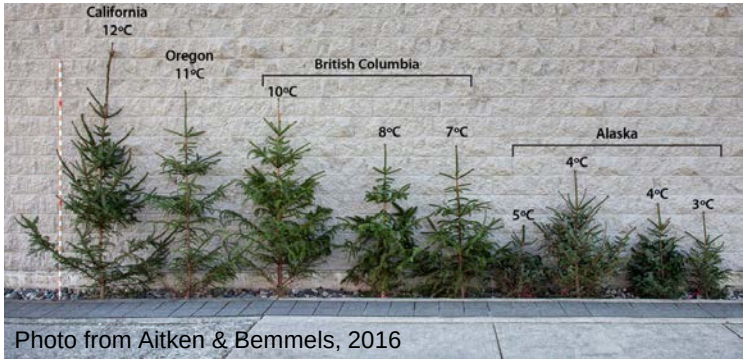
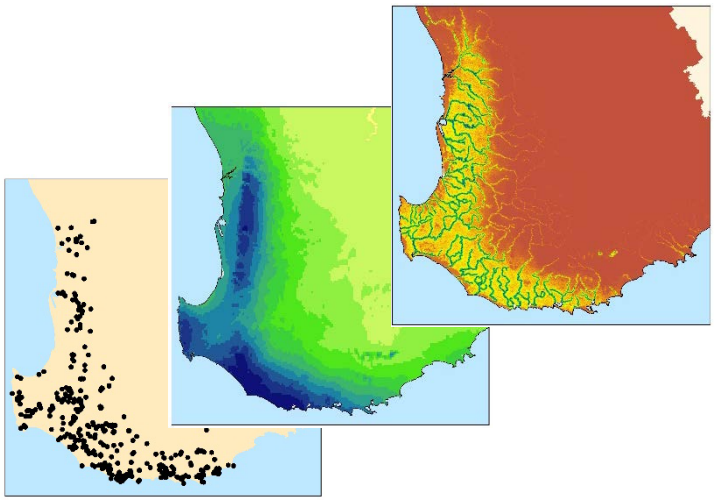


Photo from Aitken & Bemmels, 2016

Climate gradient

Species exposure to climate change

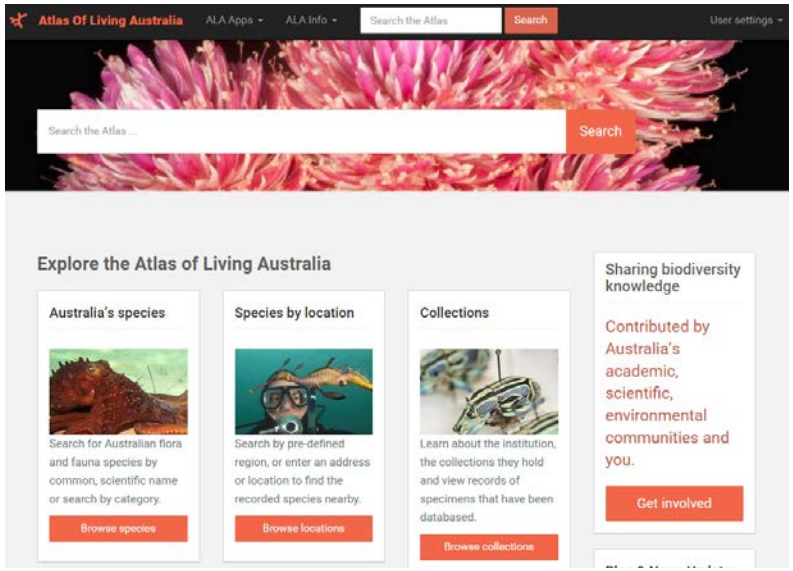
Species distribution models



A spatially explicit approach to aid in the decision making process for provenance selection

Approach to assist provenance selection:

- ✓ **Structured**
- ✓ **Spatially explicit**
- ✓ **Recognizes the spatial nature** of provenance and climate change
- ✓ **Articulates the use of different sources** of information in an optimized manner (that attends to the often lower availability of genetic data)

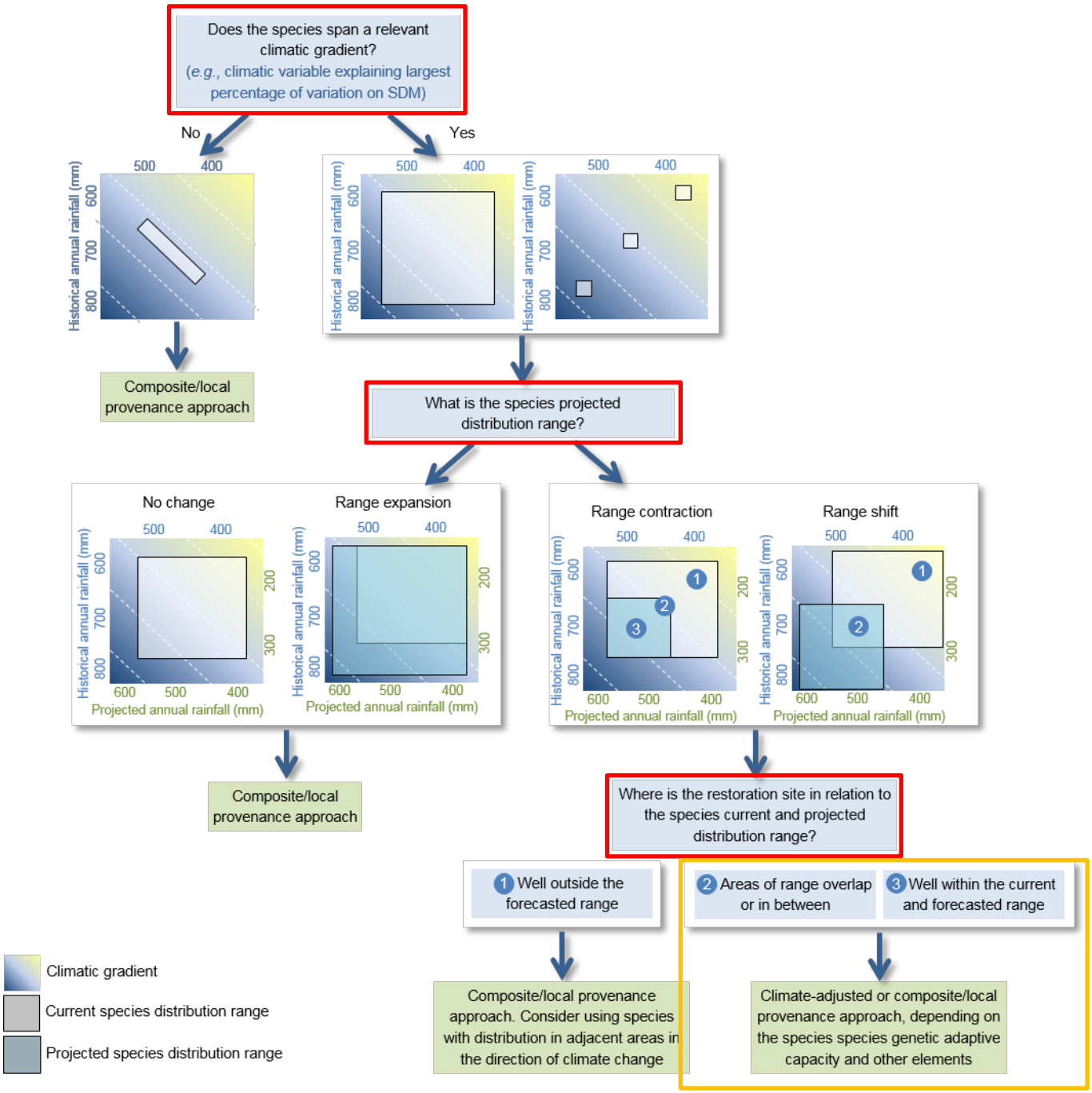


A spatially explicit approach to aid in the decision making process for provenance selection

Approach to assist provenance selection:

- ✓ **sequential query of spatial information** (species occurrence data, climatic layers, & SDMs) to filter through a **set of questions related with the biogeographic settings of the target species – restoration site**
- ✓ Depending on these settings, other lines of evidence may need to be considered

1. Does the species span a relevant climatic gradient?
2. How is the species distribution range projected to change?
3. Where is the restoration site located in relation to the species current and projected range?


Does the species span a relevant climatic gradient? (e.g., climatic variable explaining largest percentage of variation on SDM)
No
Yes
Historical annual rainfall (mm)
500
400
600
700
800
Composite/local provenance approach
What is the species projected distribution range?
No change
Range expansion
Range contraction
Range shift
Projected annual rainfall (mm)
200
300
Composite/local provenance approach
Where is the restoration site in relation to the species current and projected distribution range?
1 Well outside the forecasted range
2 Areas of range overlap or in between
3 Well within the current and forecasted range
Composite/local provenance approach. Consider using species with distribution in adjacent areas in the direction of climate change
Climate-adjusted or composite/local provenance approach, depending on the species species genetic adaptive capacity and other elements
Climatic gradient
Current species distribution range
Projected species distribution range

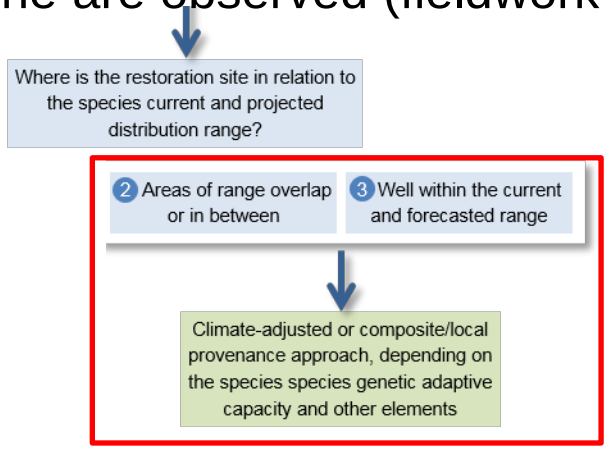
We need some measure of the species adaptive capacity

If provenance trial and/or genomic screening data is not available, neither are the resources to generate it, **knowledge developed on related species should be used**.

If not available, other elements need to be considered to help answering the question **if is there likely or not genetic adaptation across the climatic gradient?**

- Although widespread, species are habitat specialists and occur in isolated island-like systems, or topographic features occur that may obstruct dispersal and/or force isolation

- Signs of climate-driven plant health decline are observed (fieldwork or remotely sensed-data)



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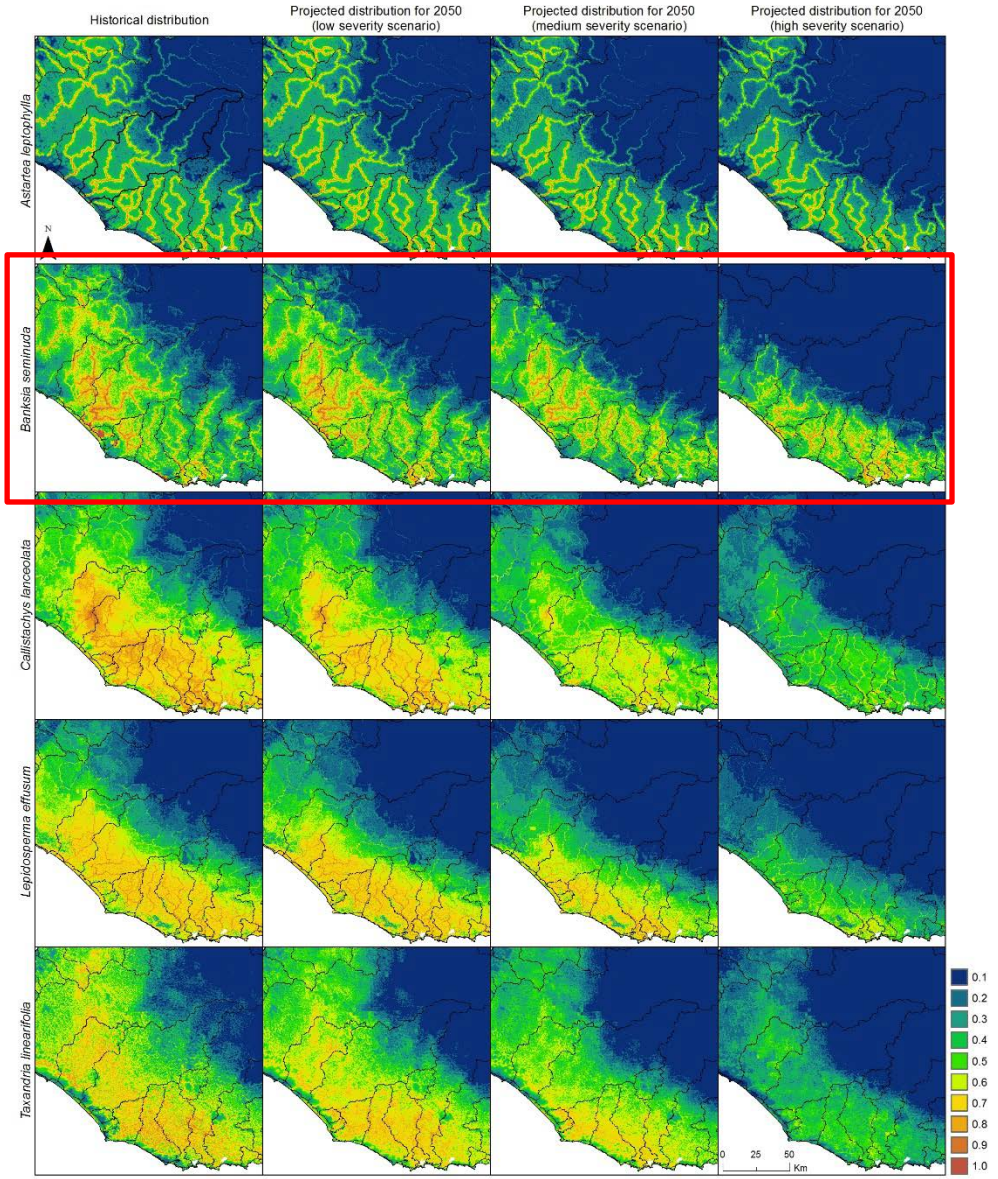
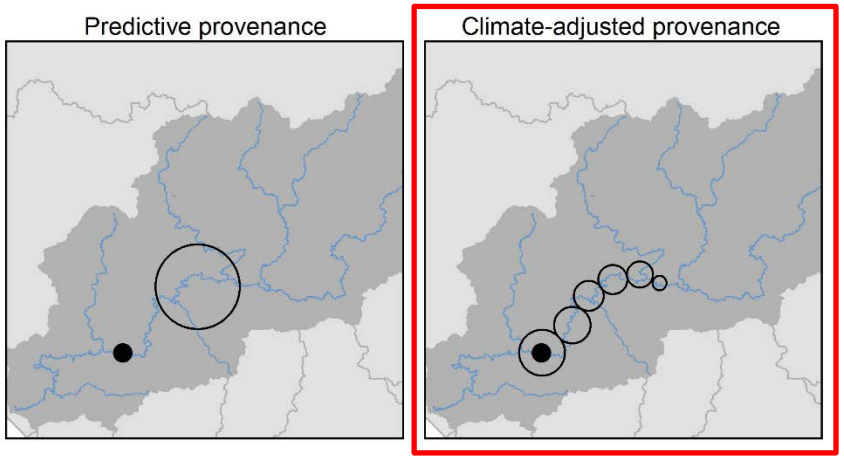


Final remarks

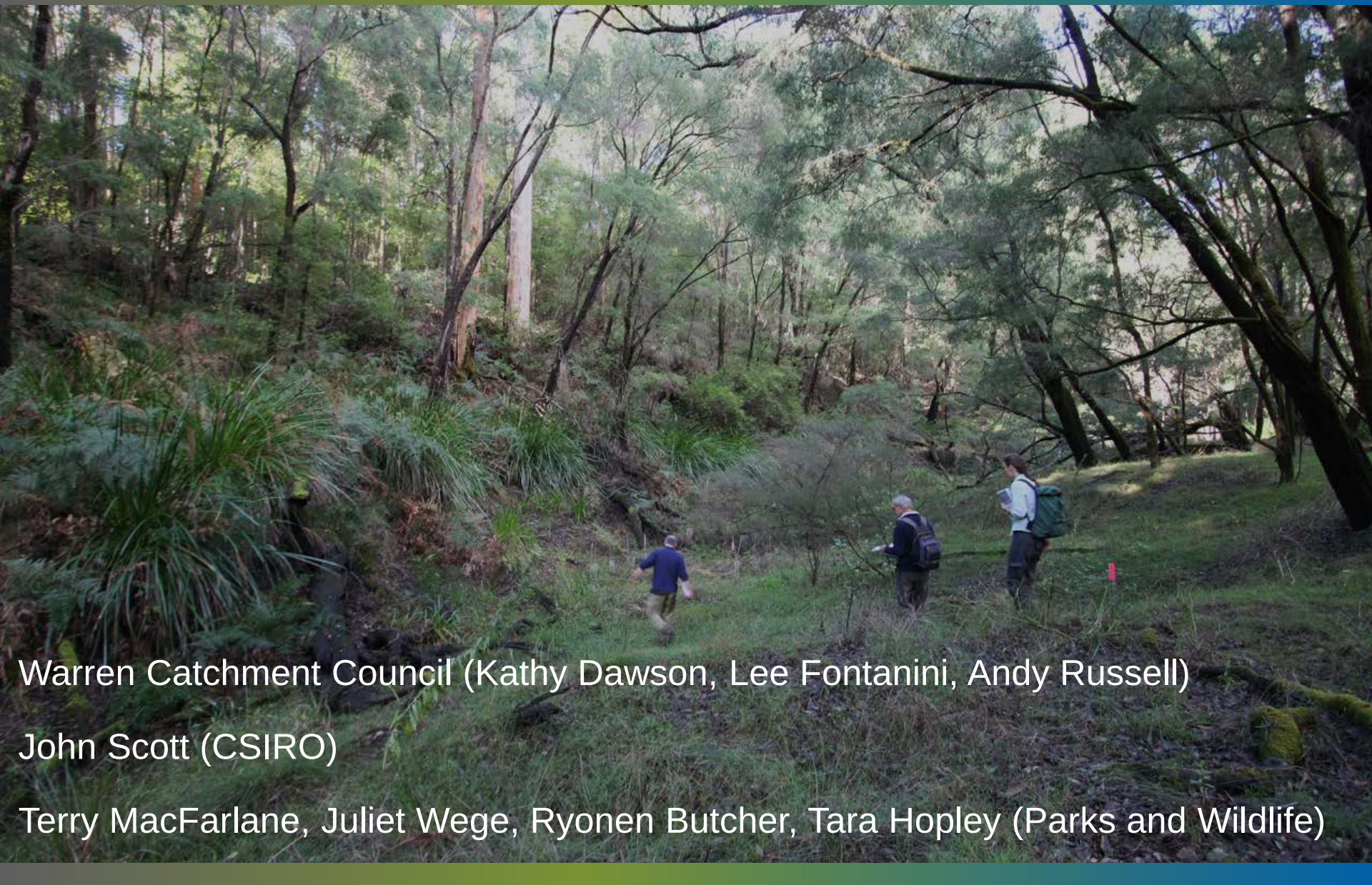
- ✓ All conservation decisions are made in the presence of some level of **uncertainty**, and often we need to accept a certain **level of risk**
- ✓ Uncertainty on climatic data/SDMs & genetic adaptive capacity data
- ✓ However, uncertainty and lack of information should not hamper efforts to implement climate change adaptation on ecological restoration activities

Final remarks

- ✓ We have suggested a **structured, spatially explicit approach** to aid in the decision making process for provenance selection
- ✓ It can be used within an **adaptive management approach** that weighs our confidence on the data available, by using different spatial distances for seed collection
- ✓ A **climate-adjusted provenance** is a more flexible and safe approach for assisted gene flow than climate predictive provenance



Acknowledgements



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