Biodiversity revegetation with provenance mixing for climate change adaptation

Photo credit: DELWP 2009

Mixing local provenances with the same species from climate analogue areas promotes adaptability and tolerance to future climate conditions.

By 2030, annual average temperatures in Australia are predicted to rise by 0.6-1.3°C. While changes will vary across the continent and regions, Victoria's overall climate is expected to get hotter and drier. Plant species have evolved to occupy a particular niche based on a range of biotic (competition, presence of pollinators) and abiotic (light, soil nutrients, water availability, temperature) conditions. Even slight changes in the climate have the potential to change the suitability of an area for a species, which can be detrimental for their local persistence. This is particularly pertinent if they are on the edge of their tolerance range or are restricted by human landscape alteration.

The Department of Environment, Land, Water and Planning (DELWP) invests in revegetation for biodiversity benefits in accordance with the targets of Protecting Victoria's Environment: Biodiversity 2037. DELWP's Revegetation standards prioritise planting species which maintain and/or restore the Ecological Vegetation Class (EVC) of the area. We recognise the need to revise provenance approaches in revegetation projects we invest in. This is to ensure current and future revegetation works are suitable for our changing climate. Adjusting species provenance as part of new revegetation work will increase genetic diversity within, and gene flow between, populations, building resilience into the landscape.

What are provenances?

A provenance in this context is defined as the original place where a seed or other plant material comes from. Different provenances are assumed to be genetically distinct.

Why consider mixing provenances when revegetating?

Prior to 2020, a local provenancing approach was recommended whereby "seed/cutting material should be collected from within or as close to the site as possible". While this prioritises suitability for local conditions, a lack of genetic diversity limits the extent to which populations can adapt to change.

Replacing current species with new ones increases diversity, but risks the new species becoming invasive and out-competing others. This also risks impacting dependant species and can be difficult to anticipate. Provenance mixing has its own risks: outbreeding depression may occur, or new genes can be so pervasive that it leads to the extinction of the local genome. However, this is seen as the lower risk option that will provide the benefits of improved resilience and adaptation. Overall, the risks of not catering for climate change impacts on revegetation are likely to be greater than those involved with selection of alternative genetic sources (Greening Australia, 2020).

How should provenance adjustment be done?

The proposed method, called the combination approach (Fig 1), incorporates a climate adjusted strategy into the current strategy of local provenancing. Seed for a local species is sourced from various locations across the climatic gradient in the direction of predicted climate change. While the proportion of local and climate adjusted seed which should be planted is flexible and dependant on availability, we recommend 70% local seed, 20% from hotter and drier climates (preferably 10% from a 2050 analogue location and 10% from a 2070/90 analogue location) and 10% from a wetter, cooler climate.

Biodiversity revegetation with provenance mixing for climate change adaptation

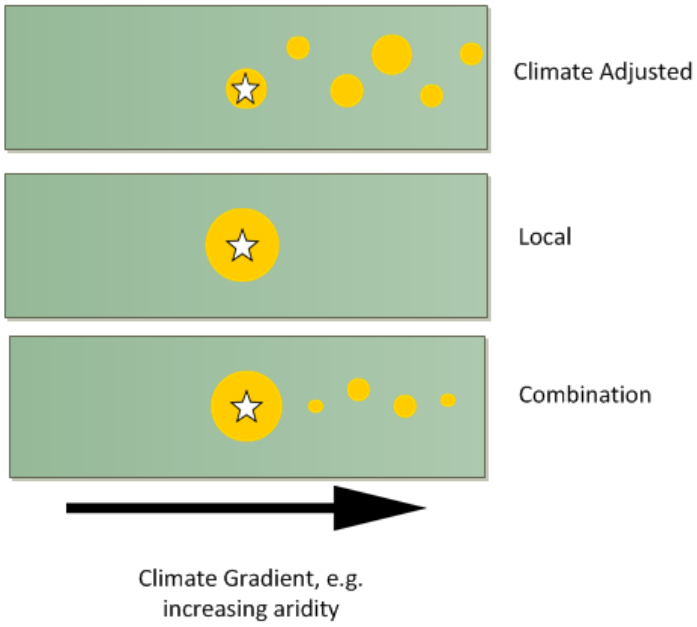


Figure 1: Provenance strategies for revegetation. The star indicates the revegetation site, the yellow circles represent seed sources with the size of the circle representative of the relative quantities of seed sourced. Modified figure from Hancock et al (2018), McDonald et al (2017) and Prober et al (2015a).

Sewing seed from hotter, drier conditions directly introduces traits which are likely to suit future conditions, however a small amount of mixing with seed from wetter, cooler climates further aids genetic diversity and may reveal other beneficial adaptations.

When revegetating, we recommend selecting 10-20 species which are appropriate for the EVC of the site and readily available. Plant four or five provenances per species in case some fail to thrive, making sure to use good quality seed from a wide range of plants (at least 10 from each provenance).

Where to source seed

It is essential to understand climate projections in your area, to know where to source seed stock. For different plant life forms (e.g. trees), species planted now are likely to experience the effects of climate change well into and in some cases beyond the span of current climate models.

A climate analogue is an area that experiences similar climatic conditions but are separated in space or time (i.e. with past or future climates). The Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-analogues/analogues-explorer/) has an interactive tool which allows you to determine the likely climate analogue of your area in 2030, 2050 and 2090. Seed sourced from these areas constitute climate-adjusted provenances.

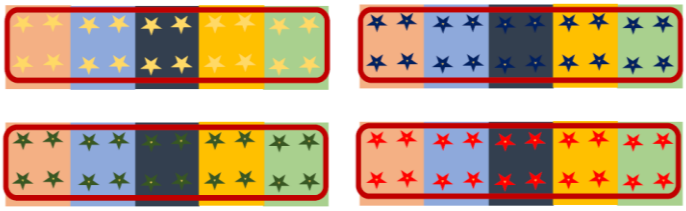
Setting up a Climate Future Plot for monitoring

A Climate Future Plot is an experimental setup which allows land managers undertaking revegetation with climate-adjusted provenance mixing to collect monitoring data to contribute to a Victoria wide study. Provenances don't have to be laid out in this way but including an experimental plot will help improve understanding and methodology over time.

These plots require careful planning in accordance with *Establishing Victoria's Ecological Infrastructure: A Guide to Creating Climate Future Plots*.

Figure 2 illustrates an example of a site layout. A suggested setup size is 50m long by 6m wide but may vary depending on plant spacing.

Figure 2. Example provenance layout for (left) one species (stars) containing five different provenances (squares), and (below) four species (stars - each colour representing a species) and five provenances. Each species and provenance plot (five provenances) should be surveyed individually (red rectangle). Modified figure from *Establishing Victoria's Ecological Infrastructure: A Guide to Creating Climate Future Plots.*



Monitoring of plots should occur annually after each summer for the first 5 years, then 5 yearly thereafter. Sites should be checked after major weather events or other disturbance.

Replication and detailed record-keeping are key to reliable and consistent monitoring. Information can then be collated, analysed and results used to inform future plantings.