Threatened plant translocation case study:

Grevillea scapigera (Corrigin Grevillea), Proteaceae

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The species

- Prostrate, short-lived, fire-killed, disturbance opportunist, woody perennial shrub.
- Endemic to Western Australia.
- No extant natural populations in secure sites.

Threatening processes

- Habitat loss and fragmentation through clearing for agriculture.
- Weeds.
- Salinity.
- Seed and fruit predation.
- Grazing.
- Maintenance of road verges.
- Fertiliser and herbicide drift.

Deciding to translocate

The Corrigin Grevillea was first collected in 1954, and has been known from only 13 small, mainly degraded roadside populations restricted to a 50 km radius area around the Wheatbelt town of Corrigin in Western Australia. The Wheatbelt region has been extensively used for agricultural purposes and over 94% of its 14 million hectares has been cleared. In 1986 the Corrigin Grevillea was presumed extinct. In 1989 a single grafted plant was identified in Royal Botanic Gardens Sydney and was brought to Kings Park in Perth where it was initiated successfully into *in vitro* culture. The following year, naturally occurring plants were discovered near Corrigin, and at the time, up to 35 living specimens were known in the wild. Due to its rarity, the destruction of its habitat, the extreme vulnerability of degraded and isolated roadside remnant populations and the low ability of the species to regenerate on its own, translocation was determined to be critical for the survival of the species *in situ*.

Aim of the translocation

To re-establish at least three self-sustaining populations in the wild in order to improve the conservation status of this critically endangered species.

Translocation working group and key stakeholders

- Botanic Gardens and Parks Authority, Western Australia.
- Department of Biodiversity, Conservation and Attractions, Western Australia.
- Australian Nature Conservation Agency (Commonwealth Government).
- Local Corrigin and Landcare community.
- Kings Park volunteer Master Gardeners.

Biology and ecology

Grevillea scapigera grows after winter rains, and flowers September – December. Inflorescences are produced on new growth and over 1000 flowers can be observed at one time on an average 1.5 m diameter plant. Flowers are protandrous (male parts mature before female parts), strongly scented and produce abundant nectar. These remain receptive for pollination for up to 4–5 days. Flowers are pollinated by a range of insects, especially Hymenoptera and Lepidoptera. Ants frequently visit flowers to feed on nectar, but are unlikely pollinators. Pollen has been successfully placed in cryostorage at Kings Park with no significant decline in viability.

Individual plants flower after 1 year (earlier under cultivation), live ca. 7–9 years, and are killed by fire. Seed is dehisced soon after maturity. On average, three to five fruits per inflorescence are produced naturally, each containing 1 or 2 seeds. Seeds have high viability (usually > 90 % germination *in vitro*) and remain viable for at least four years. Seeds generally require soil disturbance to germinate, although inter-disturbance recruitment can occur following heavy summer rain. Ants could be an important factor for the survival, germination and dispersal of seeds. High levels of seed predation by insects, mainly weevils and looper caterpillars, as well as parrots, occurs.

The Corrigin Grevillea is difficult to propagate by conventional horticultural methods. However, semi-hardwood cuttings, at the correct stage of growth, gave good strike rates. Tissue culture facilitated the production

***Grevillea scapigera* translocation site 1: Twenty years after the site was ripped, fenced and planted. Planting continued for several years and the majority of experiments were conducted on this site due to ease of access. Plants continue to germinate, flower and seed between disturbance events. Native vegetation covers most of this former airstrip. Photo: Bob Dixon**

***Grevillea scapigera* translocation site 2: Good vegetation cover and the most species rich site. Some *Grevillea scapigera* seedling germinants appeared in 2017. Due to the numbers of highly competitive *Gastrolobium spinoslum* on site *G. scapigera* seedling numbers have declined over the years. Photo: Robin Campbell**

of a large number of plants in a relatively short time. Genetically selected clones were secured *in vitro* and have also been cryopreserved to ensure long-term protection of diverse germplasm.

Seed germination treatments trialled include heat, smoke (aerosol and water), gibberellic acid, standard and specific scarification and a mixture of treatments. A precise method of scarification has been shown to be the most effective, and produces average germination rates of over 50%.

Initial genetic analysis was carried out on all known plants at the time (Rosetto *et al.* 1995) and showed high genetic variability and little differentiation among surviving populations. This suggested that existing plants comprised a single genetic provenance, and that plants could be pooled with little risk of outbreeding depression. Ten genotypes that included over 87% of the known genetic variability were chosen for propagation to establish the translocated population (Rossetto *et al.* 1995).

Site selection

Possible sites were investigated within the geographic range of *G. scapigera*. Three were selected provisionally: two re-introduction sites where the species was still present in small numbers and one introduction site. Two more sites were added later, where the species had not been recorded before. The latter sites were selected as the last remaining native vegetation remnants in the region, very close to known sites for the species. Soil samples collected from all sites were compared with samples from the largest remaining population and found to be very similar. The vegetation at all sites was alike and defined as scrubheath or kwongan, with many species occurring in all sites.

Translocation proposal

A key step was the appointment of a recovery team, which included researchers from Kings Park, staff from the (then) WA Department of Conservation and Land Management (CALM), the Australian Nature Conservation Agency and members of the local community.
The involvement and enthusiasm of the local community was very important and interest was kept high through regular meetings and site visits with local Landcare groups and schools. The proposal was assessed by two independent reviewers as to whether it met CALM's policy on plant translocations, before being given approval for the translocation process to commence.

Pre-translocation preparation, design, implementation and ongoing maintenance

The Corrigin Landcare group provided and erected an electric fence at one site in order to protect the translocated plants from trampling by the many macropods found in the area. Trials were carried out on the exclusion of grazing by rabbits (which were capable of entering the fenced areas) by using wire cages. The necessity for shelter was also clarified by trial planting in sparse native vegetation and in a cleared area, the former initially giving much better results, and further trials indicated plants often performed better in cleared open areas. The other 2 sites (0.2 ha each site) were fenced with rabbit proof wire to exclude rabbits. Three plantings were initially carried out, in July 1993 (235 plants), June 1994 (140 plants) and June 1995 (52 plants). Phytosanitary guidelines for the translocation of *G. scapigera* were prepared and adhered to, the guidelines were primarily to reduce the risk of introducing diseases, particularly root pathogens, and weeds to the translocation sites. No flowering plants were translocated, avoiding the risk of inter-species pollen transfer within the nursery and resulting hybrid seed of nursery origin. Ten clones representing 87% of the known genetic diversity of the species were used in the initial translocation. Additional genotypes have been added over time as new wild plants were found. Translocations using large numbers of plants derived by tissue culture were begun in 1996 after pilot studies indicated translocation was feasible.

Monitoring and evaluation

Monitoring began and continued every month following planting, for the first 2 years, to record information on survival and growth rates, flowering patterns, numbers of flowers and seed produced as well as damage caused by pests such as rabbits, parrots and seed eating insects. Monitoring for the first 2 years indicated vast seasonal variations which may in part be due to the quality of the greenstock (plants) at time of planting, vagaries of the weather (lack of rainfall) and wide variation between clones.

The introduction of a trickle irrigation system improved the success rate of plantings and increased seed production when compared to non-irrigated plants (Dixon and Krauss 2001). However, the life span of irrigated plants was substantially reduced.

Monitoring of sites was then reduced to twice a year, recording survivorship, pests, weeds, estimates of seed production and any new recruits of seedlings. There was a wide variation in seed production – the best site produced over 1 million seeds in 2006.

Genetic erosion between founders and offspring was assessed in 1999 at one translocated site (Krauss *et al.* 2002). Poor genetic fidelity in the founding population was found (8 clones, not 10, were present, and 54% of all plants were a single clone), and significant erosion of genetic variation (offspring were 22% more inbred and 20% less heterozygous than parents). Ultimately, the genetically effective population size of the founding translocated population was estimated to be two. Our results highlighted the difficulty of maintaining genetic fidelity through a large translocation program. This genetic erosion was addressed by avoiding over-represented clones and increasing the numbers of poorly represented clones. Many of these poorly represented clones were recovered from *ex situ* cryogenically or tissue culture stored germplasm. However, further research is required to identify the intensity of inbreeding depression associated with elevated inbreeding in these translocated populations, and to assess the long-term consequences.

Predation of seed is a major problem. Insect damage is very high, the two main pests are a native weevil and looper caterpillar. These can be controlled by the careful use of pesticides spraying 3 weeks before seed harvest. Cape Weed *Arctotheca calendula* (Asteraceae) is a problem, especially after the exclusion of rabbits. The use of low rates of the non-selective herbicide Lontrel™ has been very effective for its control.

Subsequent actions

In 2008, an Interim Recovery Plan (IRP) was published (DEC 2008). The objective of this IRP is to abate identified threats and maintain and/or enhance the habitat of natural and translocated populations; gain an understanding of the recruitment dynamics of the species; obtain *in situ* recruitment (through artificial or naturally occurring disturbance), maintain the soil seed bank and ensure the long-term preservation of the species.

***Grevillea scapigera* translocation site 150 year seed burial trails. 2017 seed harvest (7th harvest after 14th years in the ground). Kings Park and Botanic Garden Volunteer Master Gardener Len Burton and Bob Dixon former Manager Biodiversity and Extensions. Photo: Robin Campbell**

***Grevillea scapigera* inflorescences. Photo: Siegy Krauss**

Additional recovery actions have included:

- Appropriate land managers have been made aware of the location and threatened status of the species.
- Declared Rare Flora (DRF) markers have been installed at all roadside populations.
- Dashboard stickers and posters that describe the significance of DRF markers have been produced and distributed.
- Approximately 3,300 seeds from 21 plants are stored in DBCA's Threatened Flora Seed Centre (TFSC) and 2,000 seeds are stored at the Botanic Gardens and Parks Authority (BGPA) for propagation and research purposes.
- BGPA holds 17 different clones *in vitro* and in cryostorage.
- Opportunistic surveys in areas of suitable habitat following disturbance is ongoing.
- The Great Southern District Threatened Flora Recovery Team is overseeing the implementation of this IRP and reports annually on progress.
- Further genetic research (Ayre 2014) showed that measures implemented to control the erosion of genetic diversity have been successful, with heterozygosity constant and mean effective number of alleles increasing in third generation plants.

Outcomes

The original aim, which was to establish three self-sustaining translocated populations, was met and exceeded with the establishment of > 200 adult plants each, in secure, threat-free sites. In 2014, there were an estimated 455 individuals across all translocation sites. At the Corrigin airstrip site, there were 150 plants present in 2014, all but two from *in-situ* germination. In 2017, 307 plants were present. Regular contribution of seed to the soil seedbank, recruitment and survival of plants continues. All sites are well vegetated with indigenous species and recent monitoring indicates species richness, flora and fauna, continues to increase. The seed burial trials, initiated in 2003, show seed viability remains very high after 14 years, averaging 76%. Sites have not been actively managed for several years but appear to be self-sustaining mainly due to indigenous species outcompeting weeds.

What we learned

- It is possible to establish new populations of this species.
- Using an experimental framework when establishing translocations can provide critical information for long term translocation success.
- Fencing, weed control and summer watering improves survival of planted seedlings.
- Good quality (weed free, biodiverse, well vegetated) sites are important for translocation purposes.
- Network (contact people) on a regular basis to maintain professional and voluntary partnerships. Volunteers were essential due to the volume of work, lack of resources and to obtain funding (grants).
- Rabbit-proof fencing was critical, with a minimum area of 0.2 ha to allow expansion of plantings and/or future inclusion of other rare species on site if desired.
- Irrigation systems significantly improved survival rates, increased growth rates, flowering and seed production, but can reduce the life span of plants.
- Large numbers of plants en-masse can lead to an increase in seed predation.
- It was important to monitor on a regular basis *e.g.*, once a month at least for the first 2 years. This includes checking on pests/diseases, fencing and maintaining watering systems.
- Monitoring genetic variation can assist in management of genetic diversity through time.
- Maintaining genetic stock for a long period *e.g.*, cryostorage and/or seed storage is critical for managing worst-case scenarios of extinction in the wild.
- Plants generated from cryostored material performed well on site and produced large quantities of viable seed.
- Monitoring for multiple generations (>20 years for *G. scapigera*) is required to determine if translocated populations are naturally self-sustaining in the long-term.

References and further reading

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