Threatened plant translocation case study:

Translocation 'success' is all about detection: experiences with two threatened orchids from the Hunter Valley of NSW

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The species

Diuris tricolor (Pine Donkey Orchid) (Figure 1).

- Widespread terrestrial orchid from the western slopes, plains and tablelands of New South Wales, and the Moreton and Darling Downs districts of Queensland.
- Hunter Valley plants around Muswellbrook form the eastern extent of an east-west trending meta-population extending along the Goulburn River valley to Mudgee. Records exist at ~20 km intervals along this 200 km extent, suggesting that some exchange of genetic material is likely.
- Listed as vulnerable in NSW and as an endangered population in the Muswellbrook local government area under the *Biodiversity Conservation Act 2016* (BC Act).

Prasophyllum petilum (Tarengo Leek Orchid) (Figure 2).

- Terrestrial orchid from the Australian Capital Territory and with outliers in the Kandos, Denman, Premer and Inverell districts on the tablelands and western slopes of New South Wales.
- Hunter Valley plants were until recently considered a distinct yet un-named taxon, *Prasophyllum* sp. 'Wybong' (C.Phelps ORG 5269), but are now placed in synonymy with *P. petilum*.
- Hunter Valley populations are isolated, the next nearest known plants occur near Kandos, some 140 km to the south-west, and Premer, 190 km to the north-west.
- Listed as endangered in NSW (BC Act), the ACT (*Nature Conservation Act 2014*) and the Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*, EPBC Act). *Prasophyllum* sp. Wybong (C. Phelps ORG5269) remains listed as critically endangered on the EPBC Act.
- Although there is a national recovery plan for this species there is no action recommending translocation as a conservation initiative (DECCW 2010).

Figure 1. *Diuris tricolor*. Photo: Stephen Bell

Threatening processes

- Mining for coal and other resources.
- Intensive stock grazing and cultivation.
- Fragmentation and urban development.

Deciding to translocate

Glencore Coal Assets Australia, a major mining company, operates the Mangoola open cut coal mine near Muswellbrook in the upper Hunter Valley of NSW. Mangoola Coal has approval to extract, process and transport up to 150 million tonnes of coal over a 21 year period.

While early ecological investigations found little evidence of either orchid species across their exploration areas, with reduced stocking rates and good rainfalls the subsequent years revealed substantial populations of both. Upon approval in 2007, targeted survey and the translocation and monitoring of *Diuris tricolor* and *Prasophyllum petilum* was specified as a condition of consent. Mangoola Coal has consequently undertaken translocation and monitoring of both orchid species to compensate for those individuals lost to mine operations.

Aim of the translocation

Extensive field surveys targeting *Diuris* and *Prasophyllum* commencing in 2009 revealed substantial populations of both species within approved disturbance areas and adjacent Glencore-owned and managed conservation offset lands. Mangoola Coal consequently proceeded with plans to translocate orchids from disturbance areas into appropriate offsets. The overall aim of the translocation project was to salvage as many orchids as possible, with the intention of establishing additional self-sustaining populations in the locality.

As part of this process, the following ancillary aims were investigated:

- Determine the best method of translocation.
- Establish an appropriate monitoring program yielding usable data.
- Monitor flowering and fruiting in both species.
- Investigate aspects of the biology of both species.

Figure 2. *Prasophyllum petilum*. Photo: Stephen Bell

Translocation working group and key stakeholders

Mangoola Coal environmental staff and consultant ecologists formed the working group for the proposed translocation program, with some input also from researchers at the University of Newcastle. Key stakeholders were Mangoola Coal and the NSW Office of Environment and Heritage.

Biology and ecology

Habitat

Favoured habitat for *Diuris tricolor* is documented as grassy *Callitris* woodlands (e.g., Jones 1993), although in Queensland it is 'eucalypt open forest' (Stanley and Ross 1989). Southern populations of *Prasophyllum petilum* occur in moist grassy patches (*Poa, Themeda, Sorghum, Bothiochloa*) in woodland on fertile soils, under a canopy dominated by Snowgum (*Eucalyptus pauciflora*) and Black Gum (*E. aggregata*) or Blakely's Redgum (*Eucalyptus blakelyi*) and Yellow Box (*E. melliodora*) (DECCW 2010). Populations of both *Diuris* and *Prasophyllum* in the Hunter Valley occur most commonly within grassy woodlands and grasslands derived from former Narrow-leaved Ironbark (*Eucalyptus crebra*) and Grey Box (*E. moluccana*) woodlands, particularly in grasslands of *Dichanthium sericeum, Sporobolus creber* and *Chloris ventricosa*, or *Aristida vagans, A. ramosa* and *Cymbopogon refractus* (unpubl. data).

Flowering and fruiting

Vizer (2013) investigated aspects of the ecology and biology of *Diuris tricolor* and *Prasophyllum petilum* at Mangoola Coal. He found peak flowering to occur from mid- to late-September, but that less than 20% of plants would be flowering on any particular day at this time. This implied that a 'one-off' survey, even if conducted on the day of peak flowering, would likely overlook more than 80% of individuals in that population. Capsule production was also found during this study to occur in less than 3% of plants for both species, with herbivory identified as an important limiting factor in seed production. For *Prasophyllum petilum*, Wilson *et al*. (2016) analysed annual monitoring data over a 25 year period from the largest known population on the southern tablelands of NSW, and identified the incidence of frost (nights ≤ -4°C) as being instrumental in preventing flowering in any one season. Frost damage to emerging plant parts prior to reaching flowering stage prevents detection during monitoring surveys, influencing annual counts. Warm winters are consequently of benefit to the orchids in that population.

Mycorrhizal fungi

Seed-baiting techniques were used by Vizer (2013) to map the distribution of mycorrhizal fungi across Mangoola Coal lands, finding that the distribution of *Diuris* was more restricted than the fungi.

Mycorrhizal seed-baiting for *Prasophyllum* was less successful, which is not unusual for this genus.

Site selection

The selection of appropriate recipient sites for translocated orchids was governed initially by lands owned and managed by Mangoola Coal. Within these areas, targeted surveys ensured that new recipient sites were not positioned in areas where extensive natural populations would be disturbed. However, recipient sites proximate to natural stands were sought to ensure suitable genetic mixing could occur into the future. Areas supporting existing populations were also more likely to harbour a resident pollinating population of invertebrates, and mycorrhizal fungi. Grasslands of *Dichanthium / Sporobolus / Chloris* and/or *Aristida / Cymbopogon* were specifically sought within the appropriate tenure to match locally known habitat.

An extension to the main translocation program was undertaken over and above the original project approval requirements. This involved establishing recipient sites within areas of recent mine rehabilitation, where the planting of canopy stock and mid-storey species was limited and native grassland was to be established. This addition was experimental in nature as long-term survival of translocated populations within mine rehabilitation was uncertain due to the likely absence of active mycorrhizal fungi in heavily worked soils. Nevertheless, there is now new debate on the use of restored lands to house translocated populations of threatened species (Braidwood *et al.* 2018).

Translocation proposal

An orchid translocation strategy was prepared for and approved by Mangoola Coal in September 2010, and has directed translocation of orchids from 2010 until the present day. Literature reviews reported within the strategy recommended the simple excavation and re-planting of orchid soil 'cores' (*i.e.,* cores of soil containing one or more of the target orchids) with long-handled shovels, followed by watering during times of drought, as the preferred translocation technique.

Pre-translocation preparation, design, implementation and ongoing maintenance

In preparation for translocation, existing grasses in recipient sites were slashed to ground level with mechanical brush cutters, and clippings removed from the site. Translocation of orchids commenced in October 2010 with the extraction and planting of 376 orchid cores into a designated 20 x 20 m plot. Orchids within approved disturbance areas were extracted with shovels, packed into a vehicle tray and transported to the recipient site. Orchids were planted into the ground within a designated grid system at 1 m spacing. Each individual was marked with a small metal stake and notes made of the identity and number of orchids within each core. The site was watered on completion of planting, with only limited follow-up watering if conditions were very hot and dry.

This process was repeated each flowering season for the next five years, where an additional 2,870 orchid cores were translocated into thirteen separate recipient sites. The number of orchid cores translocated varied each year, ranging from 128 during the dry 2012 season, to 1,220 in the wetter 2011. In total, this constituted the relocation of 3,246 orchid cores (1,261 *Diuris* and 1,985 *Prasophyllum*) into fourteen recipient sites (nine in offset areas, five in mine rehabilitation). Over time, some of these individual cores were found to support both of the target species, or multiple individuals, and consequently the actual number of translocated orchids may be closer to 3,500.

Monitoring and evaluation

Monitoring of each orchid core was undertaken annually, commencing with a single inspection and count at peak flowering but expanding to multiple inspections when more was understood of flowering phenology. All inspections were undertaken by the same observer, with data recorded on orchid presence, identity, reproductive status and evidence of herbivory. Amendments to the translocation and monitoring process were progressively made each year to improve final outcomes, with the following four factors seen as critical in orchid detection.

1. Site vegetation and grazing management

Early recipient plots were demarcated within offset areas only by simple three-strand wire fences, but it soon became apparent that complete exclusion from vertebrate herbivores was necessary. Incidental browsing by macropods and wombats, and potentially also rabbits and hares, resulted in regular removal of flowering orchids and trampling of others. From Year 3, chain wire mesh was installed around recipient plots to replace strand wire fencing and exclude vertebrates, but with this action came excessive grass growth creating new difficulties in orchid detection. In response, a program of grass reduction and removal was instigated, using brush cutters to remove excessive grass growth annually in March. In recent years, despite mechanical reduction of ground biomass, wombats have managed to breach fences in at least one recipient plot, allowing both themselves and other mammals to recommence grazing. During the 2018 flowering season, feral pigs also breached exclusion fences and extracted and consumed a number of orchid tubers.

Some recipient plots still displayed evidence of grazing despite the presence of intact exclusion fencing. On examination, damage to emerging orchids was attributable to invertebrates (particularly grasshoppers), which would chew through leaves and inflorescences at or near ground level (Figure 3). This presented an additional factor to consider when assessing detection rates, one which is yet to be satisfactorily resolved: exclusion cages around individual orchids would prevent access by grasshoppers and pollinating insects alike.

2. Frequency of monitoring

Monitoring in the first few years after translocation involved a single visit only to each recipient plot during the perceived peak flowering period. However, it became evident that orchids not flowering at this time (early or late bloomers) were being overlooked. To increase rates of detection, repeated monitoring of recipient sites was introduced in Year 4 (two visits per plot), and continued in Year 5 (three visits per plot) and into Year 6 to 8 (two visits per plot). Initial visits were timed for just prior to flower emergence, where searches for leaf material could be undertaken before desiccation due to adverse weather or herbivory reduced visible material. Pre-flowering inspections focused effort on looking for leaf material rather than brightly coloured flowers, which translated into increased detection of plants. This process has proven highly beneficial in the documentation of translocation success, as a single inspection only is unlikely to detect all emerging, flowering or fruiting individuals (Vizer 2013). Over the course of five years where multiple monitoring events have been undertaken, observable increases in the detection of translocated orchids have occurred. These increases vary from year-to-year, and are tempered by drought and other environmental impacts, but increased detection rates of up to 24% (in 2016, both species combined) within a single recipient plot have been achieved. An overall mean increase of 12% across thirteen recipient plots (n=3,246) was returned in 2016, a result not achievable in 2017 and 2018 due to drought conditions.

Figure 3. *Diuris tricolor* suffering from invertebrate grazing, the leaves laying on the ground adjacent. The loss of leaves and flowering stems negatively impact on the detectability of that individual. Photo: Stephen Bell

3. Weed competition

Competition from grass and weed species emerged as an additional threat to translocated orchids, particularly for those recipient plots in mine rehabilitation but also in offset lands where high levels of herbaceous weeds proliferated within exclusion fences. Despite regular mechanical removal of ground vegetation in these areas, dense swards of low-growing grass (particularly *Cynodon dactylon*) and spreading mats of Galenia (*Galenia pubescens*), Medics (*Medicago* spp.) and Clovers (*Trifolium* spp.) limited orchid detection. During drought in 2017 and 2018, excessive weed growth from the preceding two wetter years now created a thick, dry weed crust across the ground, potentially affecting orchid emergence.

4. Influence of rainfall

As a rule of thumb, dry winters in the Hunter Valley generally result in below average flowering in terrestrial orchids. Below average rainfall in the three months leading up to flowering place individual orchids under stress, meaning that flowering may be postponed for that season for all but the most robust individuals. Because of this trait, terrestrial orchids have been described as 'time-travellers' (Brundrett 2016), encapsulating the uncertainty in determining their presence in any given area.

Over the course of eight years monitoring nine recipient plots in derived grassland at Mangoola Coal, approximately half of years in the June-to-August period prior to *Diuris* and *Prasophyllum* flowering have received above average rainfall, and half have received below average. Dry years have been reflected in low rates of detection within recipient plots, while wetter years have shown an increase in detection (Figure 4). There are of course other factors contributing to the extent of orchid detection observed, but there is a clear trend associated with winter rainfall. Of the nine recipient plots, all displayed lower detection rates in the drought years of 2017 and 2018, following three seasons of above average winter falls. A similar downward trend was observed for the five recipient plots (n=440) established within mine rehabilitation, monitored over two to three years since 2015.

Outcomes

Measuring the success of a translocation project in terrestrial orchids is more about the detection of individuals than it is about perceived survival. A number of factors can influence whether or not individual orchids are detected during a specific monitoring event, but the absence of detection is not necessarily an indication of an absence of life. *Diuris* and *Prasophyllum* emerge, flower and fruit over several weeks in any given flowering season, and a single monitoring inspection cannot be expected to detect all surviving orchids. Any future translocation efforts with terrestrial orchids need to incorporate an intense monitoring program over several weeks if an accurate portrayal of survival is to be gained.

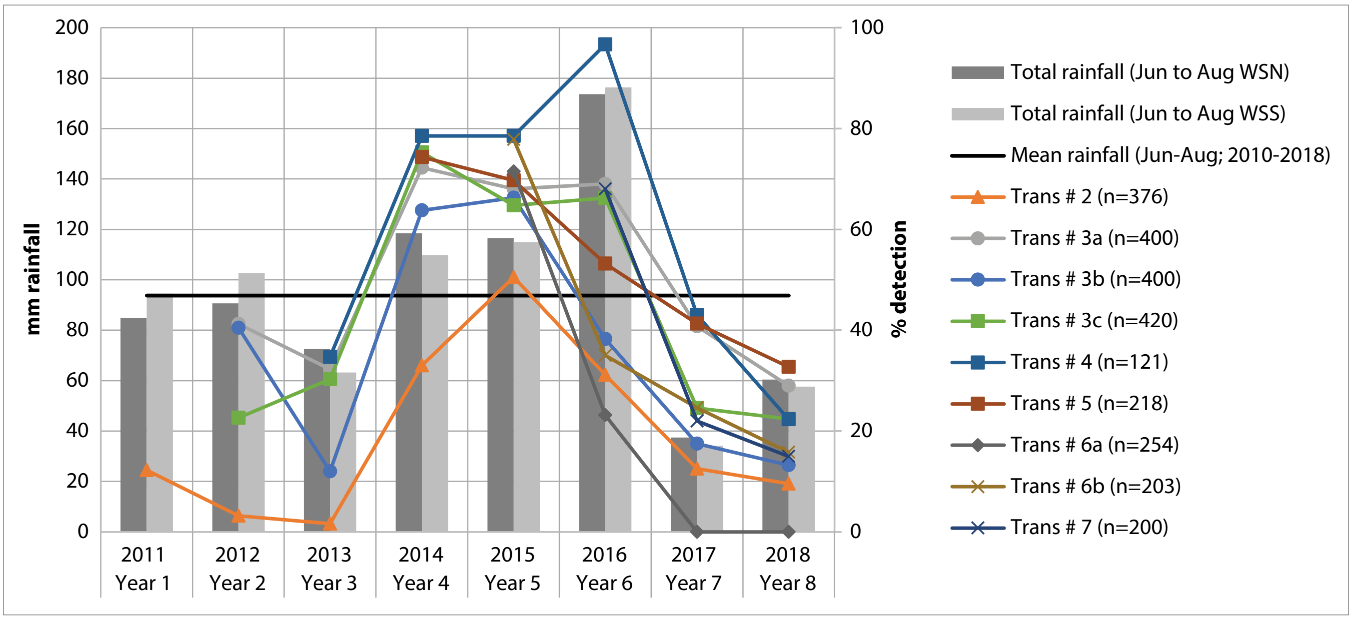

Figure 4. Rainfall received and 3-month average (June to August) at Mangoola (WSN and WSS weather stations) during the course of monitoring across nine recipient plots within derived grassland, over a period of two to eight years (n=2,592).

What we learned

Over the course of eight years of translocation and monitoring, some key points have emerged. Consistent and successful detection of translocated individuals is the primary driver behind reported survival rates, and in this vein:

- Selection of recipient sites should comprise habitat with little or no exotic weed species.
- Systematic order to planting within translocation sites greatly assists monitoring of individuals.
- Contract field staff undertaking translocations must adhere to agreed planting layouts, so that individual orchids can be readily re-located during monitoring.
- A single monitoring event will not detect all live orchids, meaning that 'survival' rates will be under-reported.
- Fencing of translocation sites from mammalian herbivores (macropods, wombats, hares, rabbits) is essential for monitoring.
- Herbivory by invertebrates, such as grasshoppers, can remove all active growth from an individual affecting detection during monitoring.
- Management of competing grasses and other biomass is essential to maintain optimum flowering conditions and to assist detection during monitoring.
- Prevailing weather conditions (strong winds, intense heat, drought) prior to monitoring will influence the detection of individuals.
- Translocated *Diuris* individuals survive better than *Prasophyllum* individuals when planted into mine overburden.

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