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Front cover: Tim Willersdorf (left) and Craig Nitschke (right) carrying the source *Astelia australiana* for translocation into the locally absent site. Photo: Linda Parker

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Contributing to *Australasian Plant Conservation*

Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the **September to November 2019 issue is 1 August 2019**. The special theme for the issue is **Advancing Australian threatened plant management: Recent actions to save our threatened flora**. If you are intending to submit an article or wish to discuss possibilities, please email the editor, Heidi Zimmer: **editor@anpc.asn.au**.

Authors are encouraged to submit images with articles or information. Please submit images in electronic format, resolution needs to be at least 300 dpi, at least the size that they are to be published, in tif, jpg or gif format. Guidelines for authors and an article template are at: **http://www.anpc.asn.au/apc**.

Using the article template, please send articles, no more than 1200 words, as an MS Word file by email to: **editor@anpc.asn.au**.

This issue

Regular features

From the editor

HEIDI ZIMMER

Hello and welcome to the fourth issue of *Australasian Plant Conservation* (APC) focussing on translocation of threatened plants. The diversity of plants and conservation challenges we've seen in the translocation case studies published so far has been remarkable, and this issue is no different. We begin with an article describing a genotype collecting method which helps users keep track of their *ex situ* collections, in particular which individuals come from which parent plants. We then jump into translocation case studies with John Briggs' article on *Grevillea wilkinsonii*. John's article tracks over 20 years of conservation management of *G. wilkinsonii* in southeast New South Wales, during which, through translocation and natural recruitment, the population has grown from 140 to more than 1500 plants. This story highlights the role of good communication and landholder relationships, and challenging assumptions about what is suitable habitat. Next we move to an article by Alison Shapcott on the translocation of a subtropical coastal heath community in Queensland. Here, entire sections of heath (turves) were translocated from a proposed development site, to a recipient site at the University of the Sunshine Coast, which has since become a great resource for teaching and research. Staying with shrubs, the next translocation case study is on *Androcalva perlaria* in Western Australia. Shane Turner and others describe their experimental translocations of *A. perlaria*, and developing understandings about site suitability and after-planting requirements (e.g., watering) along the way.

We move then into cool temperate rainforest in Victoria, and Linda Parker and Craig Nitschke's case study on translocation of *Astelia australiana*. Long-term monitoring revealed that *A. australiana* populations had been declining for 20 years, and translocation was seen as a way to reduce risk of extinction due to a single wildfire event, as well as to replace a population which had become locally extinct. Initial monitoring results show high rates of survival (>86%) after one year. Staying with rainforest, but moving to Queensland, the next case study is on *Macadamia jansenii,* a species with a wild population of only 60 plants. Alison Shapcott describes a program of translocation which aimed to encapsulate the genetic diversity of the *Macadamia jansenii* wild population, which has important learnings about juvenile plant mortality rates and hardiness.

In a first for translocation case studies in APC, we dive underwater for translocation of *Posidonia australis,* a species of seagrass. Guilida Ferretto *et al.* describe a program (Operation Posidinia) of planting beach-collected fragments of *P. australis* in boat mooring scars – from which the species had been extirpated. Operation Posidonia appears to have been very successful so far, with high survival rates and great community interest. For our last translocation study (for a while) we head back on land to NSW, where Stephen Bell tells the story of *Diuris tricolor* and *Prasophyllum petilum* translocation, to mitigate mining impacts, in NSW. Stephen highlights the importance of detection in reporting survival rates, and gives suggestions on how to improve detection, based on learnings from this project.

We round out this issue with news from the Australian Seed Bank Partnership, which places conservation of Western Australia's *Verticordia spicata* subsp. *squamosa* in the spotlight; a profile of ANPC member Chris Findlay, director of Flora Victoria; reviews of Flora of the Hunter Region and Plants of the Victorian High Country; a translocation workshop report from Lucy Commander and ANPC news and research round up. I hope you enjoy reading this winter issue of APC as much as I have enjoyed putting it together.

Collections management – documenting conservation collections using a genotype collecting method

THE SOUTH EAST NSW BIOREGION WORKING GROUP, MARTIN HENERY, TOM NORTH, LYDIA GUJA AND CAROLINE CHONG

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Background

Many threatened plant species are typically grown from seed for *ex situ* security; for re-introductions, landscape enhancement, translocation and offset actions, with the aim of improving the trajectory of populations. They are also grown from seed for use in research to gain a better understanding of the species in question. However, propagation from seed is not always possible due to difficulties in obtaining viable seed and, if seed can be obtained, there is often a lack of information on whether it can be readily germinated, grown in cultivation and/or plants established from the seed collected.

When seed-based options are limited or there is a high uncertainty of the success of these methods, a practical alternative or complimentary method is the use of non-seed methods such as growing plants from cuttings or other vegetative means. Regardless of the horticultural methods adopted, the key challenge is to identify suitable population sources and to ensure resulting propagules have traceable links to parentage for future research and use in species recovery.

A critical and often overlooked factor is the ability to link *ex situ* individuals to parentage or wild origin which identifies the population source and potential genetic diversity available for research, plant production / seed orcharding and options for translocation or landscape enhancement. A genotype collecting method can be used to help address many of these issues.

A genotype collecting method – providing a tool for addressing the needs for strategic conservation collecting

The key objectives of a genotype collection method are to provide a user friendly tool that will:

- Be able to trace source populations and have control over genotype selection for future planting/re-introduction/translocation.
- Maximise the chance of a successful collection event and enable population locations and specific plants sampled to be readily revisited (where applicable) for follow-up collecting.
- Enable each individual/team to be armed with a user-friendly guide and reference to enable efficient and effective collecting and to ensure a standard protocol for field collections is adopted.
- Be appealing and practical for a wide audience with the goal of it being adopted and used widely and as a standard, enabling more effective comparative analyses across projects and easier access to key standardised information and terminology.

The Genotype collecting method can be considered as two key elements:

1. The Principles that underpin genotype collecting

Genotype collecting or 'maternal genotype collecting' can best be defined as collections that are sourced from a population where multiple maternal genotypes (parent plants, rather than population aggregates) are sampled and accessioned individually. Single and multiple types of germplasm may be collected from an individual plant but are linked by an accession (typically a number or several numbers) to the specific parent plant and to all the subsequent germplasm secured *ex situ*.

This ensures that existing and future users of the germplasm (collected and secured *ex situ*), have access to material from a known source, linked to key information, and therefore ideally suited to:

- Translocations.
- Re-introductions.
- Landscape enhancement.
- Establishment of new populations and offsets.
- Seed orcharding and *ex situ* plant production.
- Research projects.

This approach provides the genetically representative ingredients that many restorative conservation objectives strive for including, separate and traceable maternal genotype collections.

Genotype collecting can be applied to both seed and vegetative (non-seed) collections, noting that although the seed collection is usually not one genotype, each accession is taken from only one maternal genotype (parent plant). Using common terminology for a 'maternal genotype collection' will enable easier access to records and information in the future. This helps readily identify records where germplasm was collected from one maternal plant only as opposed to collections done as a mixed population sample (*i.e.,* those where vegetative or seed material from many individuals in a population are bulked to obtain a representative sample of unknown numbers of parent plants). Conservation projects that require adequate representation of the genetic diversity found in wild populations, and require control of that diversity is where the method comes into its own, not only by having various genotypes secured as separate germplasm. More importantly, it enables control of the genotypes when designing augmentation, reestablishment or translocation trials as the known genetic diversity underpins the method and ultimately improves the likelihood of success.

2. Maternal genotype collection protocol

This protocol is designed to clarify the collection size, lineage, collection method, and provide a link to key information (e.g., number of plants sampled, proportion of population sampled, linked accession numbers). Building upon the principles outlined in original guidelines for germplasm collection and translocation developed by the Australian Network for Plant Conservation (ANPC) (Offord and Meagher 2009; Commander *et al.* 2018), this protocol adopts a 'maternal genotype' sampling method for seed and non-seed collecting as a collection method and checklist. It outlines the key requirements to be considered when collecting living plant samples intended for reintroduction and has been developed with the aim to ensure all field collecting teams use a standard method.

Designing the protocol

The three key aims of standardising collection methods, capturing key information and ensuring lineages retained from source wild material, led to the evolution of two key components:

1. The field collecting and sampling method has to consider the number and size of plants in each population.
2. Each genotype collected needed to be traceable from the propagation and production phase through to translocation readiness.

Collection method checklist

When sampling using a genotype collecting method the following protocols should be used:

1. Establish the extent of the population. This should be the first step before collecting commences.
2. If feasible, make an estimate of the size of the population e.g., '<50 plants' or '50-100 plants' and over 200 m^2 etc. Noting this may not be practical or possible if the population covers a considerable distance/area and/or the vegetation is dense and of mixed species of similar height.
3. Once extent of the population is known, (or estimated), aim to sample plants
   a. from across this population
   b. determine a minimum distance between sampled plants ideally greater than 10 m (to reduce the chance of collecting closely related samples). Topography and extent of population can influence this distance.
4. Record the estimated minimum distance in the field book records for the collections. If tagging of sampled plants is an option, aim to tag an agreed number of plants with unique labels. This should be done in numeric order and ideally be spread out across the sample area.
5. Try to place the tag in a visible place as these plants may be re-visited in the future for re-collecting and research. An option to assist re-visiting the plants sampled is to attach a piece of flagging tape so that it is approximately 150 mm to 200 mm long. This helps to relocate the tags when re-visiting and re-collecting. If tags are not being used identification and location will be covered by each field book entry.
6. Collect a herbarium specimen containing flower or fruit.

When sampling material in the field:

Vegetative material:

1. Write a plant label; include the plant name and collection number (these can be pre written to save time in the field).
2. Place the label in the cutting bag. It is good practice to duplicate the collection number on the bag in case the label goes missing.
3. Take the cuttings.
4. Lightly mist the cuttings, seal the bag and avoid crushing during transportation. Keep as cool as possible and out of direct sunlight.

Seed:

1. Seed dispersal can be unreliable and we suggest bagging the developing seed and re-visiting to harvest.
2. Check pollination has occurred and early seed development is in progress. Avoid bagging flowers as this will prevent pollination and reduce seed set.
3. Place 3 to 4 bags (ideally) on a single plant.
4. The seed collection event is only recorded at harvest. This involves the creation of the field notes. It is always separate to the cutting field notes
5. To harvest; cut the bags from the plant and write the collection number on each bag.
6. Tie all the bags harvested from one plant together so it is clear they come from the same maternal genotype.

Considering timing and frequency of collecting

Carefully planning the timing and frequency of collections trips can have a huge impact on the likely success of a collection activity. Knowing as much as possible about the plant, the location and in particular the likely timing of flowering and seed set can make a huge difference.

When combining seed and non-seed options, consider conducting two or more trips to enable greatest chance of success, for example:

- First trip: Locating and assessing population, tagging of plants distributed across population, taking a herbarium specimen, collecting cuttings from the tagged plants, bagging fruit for follow up collection.
- Subsequent trip/s: Re-visit population and collect seed from bagged plants, re-collect cuttings if previous cuttings have not succeeded.

Field book sample for 'genotype collection' events – What your field book may look like

1st page of field book entry:

On the first entry for a population sequence, highlight the following two items above the normal fields. (These are in addition to the standard field book data/entries)

1. Use standard wording such as 'Maternal genotype collections' or 'genotype collections' to indicate the nature of the collecting method.
2. Indicate the number range of sampled collections from this population (e.g., JKS 20 – JKS 30) and the total number (e.g., 11 collections). Data items for this need to be determined after writing up all the collections made from one population on one day.

Note: There is no need to repeat this information for the rest of the population sequence, as the number range of collections (2 above) implies it is carried over.

Then continue with the Standard field book data:

Permit/Scientific License number: where applicable and in keeping with legislation relevant to the collecting event, the location and species being collected.

Collector and No.: using surname and all other initials if known (e.g., J.K. Smith, not J Smith)

Date and Country, State and District: fields should be completed at the start of the day and when they change, only.

Locality: either 'generalise' the locality for the whole population sequence (e.g., '1-2 km from road intersection') OR note that some details of locality change slightly through the sequence as GPS coordinates change, and record these changes.

Habitat: when moving from one collection to the next in the population (with GPS coordinates changing), please note any change to habitat, especially aspect, and make clear which data is carried over from one record to the next. For closely adjacent collections, usually everything is carried over and should not need to be rewritten.

Latitude, longitude and altitude: all fields should be completed using either grid reference or GPS. It is essential for Datum to be recorded in the first entry of a population sequence. Latitude and longitude should be recorded in degrees, minutes and decimal seconds.

2nd page of field book entry:

Plant description and notes:

- **A description of the plant**: including height and width, and any other significant information e.g., 'weeping form'
- **Area (or distance along a watercourse or road):** covered by the sampling of the population. Note this may not be the entire population area.
- **The target** (aimed-for) **minimum distance between plants sampled:** it does not need to be written on every entry, rather only at the start of each population sequence. There is no need to record the distance between individual plants actually sampled, as this can be estimated by mapping the points later (if required).
- **Estimate of the size of the population:** if practical e.g., '50-100 plants' etc.

Herbarium specimen: record which sample has a voucher from the population and any duplicates and their destination.

Record what was collected: including seed, cuttings or whole plant, and/or voucher.

Phenology: record whether voucher specimens (only) have bud, flower, fruit etc.

Template which flags to the collector factors to be included in pre-collecting planning e.g., Mt Imlay

MATERNAL GENOTYPE PRE-COLLECTION Check-List (Population)	
Population descriptor	
Permit No.	
POPULATION SAMPLING Information	
Estimated area of population	
Estimated population size	
Target minimum distance	
Target no. of plants to be sampled from this population	

Field book number range for the population and field book number(s) for population vouchers to be recorded in the field

Template insert for field books which flags to herbarium registrar the need for additional information to be added to each record in the prescribed sequence.

All other standard collection information still needs to be entered on each page of book particularly the item type of living material.

MATERNAL GENOTYPE COLLECTION (Population)	
Population descriptor	
Permit No.	
Field book number range for this sequence	
HERBARIUM Voucher	
Field book number(s) of the herbarium voucher(s) for this population	
POPULATION SAMPLING Information	
Estimated area of population	
Estimated population size	
Minimum sampling distance	
No. of plants sampled from this population	

The above method covers a conventional collecting scenario and can be used as a template or guide to edit and modify where needed on a case by case basis for each particular scenario.

Summary

This collection method can be applied and adapted for any species when the aim is to conduct translocations or reintroductions and where tracking of genotypes/populations is desired. It is particularly valuable for non-seed collecting methods where the tracking and management of lineages can be a challenge and is often resource hungry. It also enables *ex situ* collections sourced using this method to provide a genetic representative and translocation applicable resource that can be tapped into for future conservation, research, and plant production programs.

The method has been applied and adapted to a range of conservation projects and implemented by many collection teams and across many jurisdictions and is available for use by all involved in the collection of flora for scientific and/or conservation purposes.

Acknowledgements

The South East NSW Bioregion working group is a group of Botanic Gardens including in partnership with the NSW Office of Environment and Heritage (Editors note: now Department of Planning, Industry and Environment), who are, in collaboration with land managers and custodians, working to improve the population trajectory and knowledge of the rare and significant flora and the biota from the south east bioregions of NSW (covering the area south of Sydney to the Victorian border). Its members are:

- Australian National Botanic Gardens.
- Wollongong Botanic Gardens.
- Booderee Botanic Gardens.
- Eurobodalla Regional Botanic Gardens.
- Australian Botanic Garden Mt Annan.
- NSW Office of Environment and Heritage (Editors note: now Department of Planning, Industry and Environment).
- Illawarra Grevillea Park.

This group has pioneered much of the development, trial and initial implementation of the genotype collecting method.

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Threatened plant translocation case study:

Grevillea wilkinsonii (Tumut Grevillea), Proteaceae

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The species

- Mostly large, upright, long-lived (20+ years) shrubs. At Gundagai the plants are prostrate.
- Endemic to south-east NSW.
- Known from nine natural sub-populations distributed along a 6 km stretch of the Goobarragandra River and from eight plants at Gundagai.

Threatening processes

- Habitat loss and significant habitat fragmentation through agricultural development.
- Grazing by domestic stock.
- Woody weed competition (mainly blackberry).
- Flooding.

Deciding to translocate

The Tumut Grevillea was discovered as recently as 1982 and was not formally described until 1993. In 1992 it was only known from a single small population of 140 plants on a road verge and on an adjoining Travelling Stock Reserve. The first Recovery Team was established in 1992 and this team developed and published the first formal Recovery plan in 1993 (Butler and Makinson 1993). The focus of this plan was on propagation and enrichment planting to bolster the population size. The first plantings of this species into the wild thus date back to 1993 when staff from the Australian National Botanic Garden (ANBG) undertook a small trial planting on a Travelling Stock Reserve (which also contained part of the natural population) and on adjoining private land (Site 1). The 1993 planting of eight plants on private land had done particularly well - expanding from eight plants to 350 adult and sub-adult plants plus at least another 100 seedlings by 2012 (Taws 2013). In 2000 the NSW Office of Environment and Heritage (OEH) thus commenced an enrichment planting project on another private land site where 13 natural plants survived (Site 2). Over the next several years 50 new individuals were successfully established and by 2005 the first natural recruitment from these plantings was observed.

Tumut Grevillea flowers. Photo: John Briggs

Following this success, plantings at two other sites (one on private land (Site 3), the other on public land (Site 4)) within the natural range of the species were commenced in 2008. These plantings were considered necessary as the existing natural populations were small and surviving in very small patches of remnant native vegetation where there was very limited scope for the populations to expand.

Aim of the translocation

The primary aim of the first translocation by OEH was to enhance a small existing population of 13 plants and hasten colonisation of the species into adjoining suitable habitat that had been fenced and cleared of a major blackberry infestation. Subsequent translocations were aimed at establishing new populations in relatively secure sites within the known range of the species where threats had been removed and suitable habitat was available to support self-sustaining populations.

Translocation working group and key stakeholders

- NSW Office of Environment and Heritage (formerly NSW National Parks and Wildlife Service) – to oversee development and implementation of translocations since 2000, including liaison with landholders, propagation and planting, ongoing monitoring and maintenance of translocation sites.
- The various Tumut Grevillea Recovery Teams operating since 1992 – preparation and updating of the Recovery Plan between 1993 and 2001, which included recommendations for translocation actions.
- Australian National Botanic Gardens and Society for Growing Australian Plants – propagation of seedlings and initial translocation plantings.
- Participating landholders – agreement to have plantings undertaken on their properties and assistance with watering and weed control.

Biology and ecology

- Flowering occurs in October and plants usually commence flowering once they are three years old.
- Insect pollinated and known to self-pollinate.
- Seed capsules ripen in December and usually contain only one seed.
- Seeds are gravity dispersed and appear to also be dispersed by ants.
- Seeds are physically dormant. Dormancy appears to be naturally broken through seed coat weathering. Seeds sown in cultivation often take between 12 and 18 months to germinate.
- New seedlings have first been observed on planted sites five years after planting.
- Individuals are known to live at least 25 years.
- Within its main occurrence the species occurs as an upright shrub in riparian shrub communities and sometimes extends into adjoining eucalypt woodland. At Gundagai the small population there occurs in White Box dominated grassy woodland.
- Soils are variable and range from sand and sandy loams to dark red-brown loams derived from Serpentinite rock.

Site selection

The 1993 planting site was chosen because it was adjoining a known natural population and thus had generally similar site characteristics. Most of the planting was on a Travelling Stock Reserve, but eight plants were planted on a section of uncleared private land located immediately across the river. This private land site was, however, drier and steeper than other sites supporting known populations.

Site 2 was chosen because it already supported 13 naturally occurring individuals and contained adjoining suitable habitat that the landowner was agreeable in allowing to be planted (following fencing and weeding) to enhance the existing population. At that time very few landowners with potential planting sites were willing to participate in such a program.

In 2008 planting commenced within the natural range of the species at two other sites: Site 3 on private land and Site 4 on national park.

Site 3 was chosen because it comprised a 0.75 km section of previously cleared river frontage that had been fenced, weeded and planted to native vegetation under a Landcare grant. At that time there was no readily available public money available to specifically assist the Grevillea recovery program so this Landcare planting site provided an ideal opportunity for expanding the Grevillea planting program. The site also supported some rocky areas still largely dominated by native grasses where it was thought the Grevillea could in time colonise naturally. Importantly, the landholder was enthusiastic about adding the Tumut Grevillea to the Landcare planting.

Site 4 was chosen because it was within the known natural range of the species and contained a 300 m section of river frontage that supported largely weed free native vegetation that seemed to be ideal potential habitat for the Grevillea. It also contained suitable areas into which it was expected that the Grevillea would in

Flowering shrub planted at Site 3 in 2013. Photo: John Briggs

time colonise. In 2004 this narrow tongue of park was fenced from the adjoining grazing property to exclude domestic stock in anticipation of it becoming a Tumut Grevillea translocation site. Between the time this section of park was fenced and the initial plantings commenced two Grevillea plants became naturally established on the river frontage.

Translocation proposal

The first Recovery Team was established in 1992 and this team developed and published the first formal Recovery Plan in 1993. This plan was then revised in 1995 (Butler 1995). The focus of these Recovery Plans was on propagation and enhancement planting. In the late 1990s, the Recovery Team was reconstituted and produced an updated NSW and national Recovery Plan (NSW NPWS 2001). This plan included many additional actions aimed at achieving protection and appropriate management of all the known sites as well as maintaining the option for further enhancement plantings. Implementation of the translocation action included in these plans did not involve preparation of a formal translocation proposal. Development of the current conservation project for the Tumut Grevillea under the NSW Saving our Species Program involved the input of an expert panel comprised of some representatives from the previous Recovery Team. The Saving our Species Project maintains translocation plantings as a priority management action for this species.

Pre-translocation preparation, design, implementation and ongoing maintenance

Plants for the 1993 planting were raised from cuttings taken from the adjoining natural population. Few details on the planting are available, but it is believed that the seedlings were planted in winter into hand dug holes and that no follow-up watering was undertaken. The eight individuals planted on private land represented five clones. It appears survival rates were high based on the first recorded counts in 2008.

Planting at Site 2 commenced in 2000 and was on private land where the owners were enthusiastic to host the planting project. The site consisted of an alluvial river terrace with deep fertile soil and also a rocky spur running up from the river terrace. Prior to commencement of planting an extensive infestation of blackberry was poisoned with herbicide and later the dead blackberry was burned to clear the site of debris. This planting also involved plants grown from cuttings that were taken from both natural plants growing at the site and also from individuals planted in 1993. Twenty three plants were initially placed in hand dug holes spaced about 5 m apart and each plant was protected within 60 cm high rabbit netting guards. Twelve clones were eventually represented in the planting and after a number of replacement plantings a total of 50 plants

Tumut Grevillea plantings above flood zone at Site 3. (2013 plantings at centre left and 2015 plantings at centre right). Photo: John Briggs

OEH staff member Sarah Goldin planting Tumut Grevillea at Site 3 in 2013. Photo: John Briggs

were established over a five year period. Plants were not regularly watered post planting and survival rates on the rocky ridge were only about 50%. Regular removal of blackberry and other herbaceous weeds such as Patterson's Curse and St John's Wort were required.

Planting at Site 3 commenced in 2008 after the interest of the landowners came to the attention of OEH. Prior to the Grevillea translocation the site had already been fenced, weeded and planted to other local native vegetation. Plants propagated from cuttings were again used for the first two years of translocation. Cuttings were sourced from plants growing from the 1993 planting and also from the closest natural population to Site 3. In 2010 an OEH officer had success in growing the species from seed and these individuals were found to have a stronger root system and have more vigorous foliage growth than cutting progeny. Thus from 2010 onwards plantings have generally involved progeny grown from seed as this also has the advantage of including greater genetic diversity. Seed has been sourced from both the 1993 plantings and also from the nearest natural population.

Planting at Site 4 also commenced in 2008. This site was selected because it had secure tenure, was within the natural range of the species and supported native vegetation which provided suitable habitat into which to plant.

All plantings since 2008 have been planted into hand dug holes and 60 cm high rabbit netting guards have been used to reduce trampling by wombats and browsing by wallabies. Guards are generally removed after two or three years. Water crystals are added to reduce the frequency of watering. Hand watering of about 16 l per plant about every three weeks after planting through until March has increased survival rates to about 95%. Total plantings of 129 plants at Site 3 and 80 plants at Site 4 were undertaken in the winters of 2008 and 2009. Since 2013 a total of between 40 and 50 plants have been planted across these two sites each winter/spring.

Monitoring and evaluation

There are no records of regular monitoring of the 1993 plantings. The first formal post planting assessment was made in 2008. At that time the eight plants placed on the private land had increased to 128. This population has rapidly expanded since then and in November 2017 totalled 763 plants (Taws 2018). Most of the plants on the Travelling Stock Reserve section have survived and there has been some recruitment, but not nearly to the same degree as on the private land site.

Annual counts of survivorship have been undertaken at all planting sites commenced since 2000.

The survival rate on the alluvial terrace section of Site 2 was almost 100%, however no recruitment occurred in that area, presumably due to the dense grass cover (both native and exotic) there. In contrast, only about 50% of each of the new and replacement plantings on the rocky ridge section survived the first summer. Despite the greater difficulty in establishing plants on the rocky ridge section, after 5 years the first natural recruitment was observed in this section of the site, presumably because competition from the grassy groundcover was significantly less. By November 2017 the initial population of 50 plants had expanded to 222 (Taws 2018), despite the loss of half the original planting to a flood in 2012.

Survival rates at Sites 3 and 4 had been high (about 85%) until 2012. The losses until then were mainly due to a few plants being excavated by wombats and some losses of the most recent plantings due to a series of floods in 2010. A record flood event in March 2012 destroyed 80% of the plantings. Only 28 of the 129 plants established at Site 3 survived and only 23 of the 80 plants established at Site 4 survived.

Survival of the replacement plantings at these two sites since 2013 has been about 95% and a total of 183 plantings at Site 3 and 86 plantings at Site 4 have been established by November 2017. The first recruitment at Site 4 of 11 seedlings was observed in autumn 2017. Only one seedling recruit has been observed so far at Site 3.

Every few years a census of the total population (natural and planted) is undertaken. The population count includes assigning individuals to one of three height class categories (<0.2 m, 0.2–1 m and >1 m).

Figure 1 shows the overall positive population trend since 1998, including a breakdown of the number of plants that are natural and those that are planted or derived from plantings.

Riparian habitat damage from 2012 record flood at Tumut Grevillea planting Site 4. Photo: John Briggs

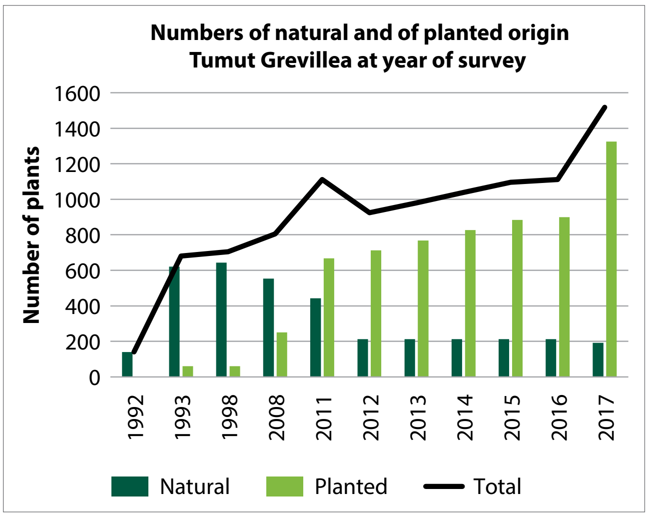

Figure 1. Numbers of Tumut Grevillea growing naturally and of planted origin

Subsequent actions

The decision by the Recovery Team to commence the second translocation was at least in part influenced by the success of the 1993 translocation where most plantings had survived with little post planting attention and some recruitment had been observed by 2000. The success of the translocation at Site 2, particularly the extensive natural recruitment commencing within five years of the first planting, meant that the two subsequent translocations could be commenced with confidence they were likely to also be successful. Following the success so far, an enhancement planting of the Gundagai population commenced in 2017, as did the commencement of a fifth planting site within the main distribution of the species.

The major flood events in 2010 and 2012 that caused a drastic reduction in the previous plantings at Sites 2, 3 and 4 (80% loss at sites 3 and 4) also reduced the natural populations by 50% and scoured the river bank, greatly reducing the amount of riparian habitat. These flood events have led to a revised planting strategy which is now targeting suitable habitat above the 2012 flood level.

A significant challenge to a future expansion of the conservation program is that very few additional sites remain within the species' known natural range that retain substantial native vegetation and that would thus be immediately suitable as future re-establishment sites. There is, however, potential for future trials to combine replanting sites with both the Tumut Grevillea and other native vegetation to create more suitable conditions for the species to recruit naturally.

Outcomes

Natural recruitment from the first two translocation plantings has been so successful that 87.3% of the 2017 total population of 1,517 plants is comprised of plantings and the progeny of plantings (Briggs, unpublished data; Taws 2018). The proportion of plantings and the progeny of plantings of the total population is expected to increase further over time.

What we learned

- In appropriate habitat it is relatively easy to establish new self-sustaining populations of this species.
- The extensive natural recruitment arising from the 1993 planting on a dry rocky slope has shown that previous understanding of suitable habitat for the Tumut Grevillea has been blinkered by a lack of knowledge of its previous distribution due to historic loss of populations prior to the species being discovered.
- Recruitment within planted populations has been most successful where the plantings have been on sites dominated by other native vegetation and there is a sparse groundcover that has allowed seedling establishment.
- Regular summer watering greatly improves survival of planted seedlings (from about 50% to 95%).
- Seedlings grown from seed rather than cuttings are more robust and have a better survival rate.
- Protection from wallaby browsing, at least in the population establishment stage, is essential at some sites.

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Threatened plant translocation case study:

Wet and Dry subtropical Coastal Heath translocation

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The species (community)

Approximately 15 hectares of coastal heath (10 ha 'dry', 5 ha 'wet' heath) including habitat for Ground parrot (*Pezoporus wallicus*), Lewin's rail (*Rallus pectoralis*), vulnerable Acid frogs (*Crinia tinula, Litoria freycineti, Litoria olongburensis*) and five plant species that were listed as vulnerable or rare within Queensland at the time the project commenced; *Acacia attenuata* (vulnerable), *Acacia baueri*, *Boronia rivularis, Blandfordia grandiflora, Schoenus scabripes*.

Threatening processes

The site was threatened by a housing development proposal.

Deciding to translocate

Translocation was suggested as an option to compensate for the potential impact on the wet and dry heath as well as habitat for several specified animals and threatened plants.

Aim of the translocation

The aim of the translocation was to compensate for the loss or damage due to the proposed development of 15 ha of coastal heath and establish populations (of the five listed plant species) equivalent to the ones being impacted by the proposed development. An additional aim was for the translocation to replace equivalent appropriate habitat for the listed bird and frog species. The specific translocation aims were defined by a comprehensive set of performance criteria.

Translocation working group and key stakeholders

A steering committee oversaw the translocation; composed of members from University Sunshine Coast (Dr Alison Shapcott chair; Dr Neil Tindale, USC Facilities management), Sunshine Coast Regional Council (initially Maroochy Shire Council) and Stocklands Bundilla (the developer). There was an ecologist who made assessments of the translocation at key stages (Dr Mike Olsen, Landscape and Mine Rehabilitation);

Figure 1. Systematic placing of whole turves using modified machinery. Photos: Stocklands Bundilla

Figure 2. Left: First control Burn. Photo: Tom Lewis. Right: A control burn in 2016 in a dry heath section of the translocation. Photo: Peter Dufourq

an ecologist who was employed by Stocklands (Christopher Dean, Australian Farm Forestry) to direct the on-site translocations, who developed the translocation plan and prepared the reporting document. In addition, the contractors undertaking the translocation (Halls contracting) were required to employ an ecologist (Arborcare) to oversee the actual in-site translocation in accordance with the translocation plan. Plus Stocklands employed ecological consultants to prepare initial site assessment surveys (James Warren and Assoc).

Biology and ecology

The five listed plant species all regenerate after fire from seed, and only two were known to resprout after fire. This understanding of the fire ecology of the species shaped some of the methods later selected, as well as ongoing management. Relatively few of the species recorded as present in the heath, and intended to be translocated, were known to have been propagated either by seed or by cuttings previously. Hence, translocation of the existing heath species was determined to be the best way to maintain the species composition in the compensatory habitat. Preliminary trials and studies had demonstrated that translocation of whole turves rather than just topsoil would result in higher success rates and significantly lower ongoing management of weeds.

Site selection

The source site was the area proposed for development adjacent to the Mooloolah River National Park. The University of the Sunshine Coast (USC) was selected as an appropriate recipient site after initial site assessments for compatible drainage, proximity, habitat suitability, and soil types.

Translocation proposal

The source site was subject to a development application for a housing development. The preparation of a set of measurable performance criteria and evaluation of alternative options and feasibility was undertaken first under directive of Sunshine Coast Council (initially Maroochy Shire Council prior to council amalgamation) prior to development approval being granted. This involved the establishment of the USC campus as a potential recipient site for a proposed translocation to compensate for the loss of the habitat to be impacted.

Pre-translocation preparation, design, implementation and ongoing maintenance

After development of the set of agreed performance criteria and formal legal agreements between the three parties, a detailed translocation plan was then developed by the developer's ecological consultant (Christopher Dean, Australian Farm Forestry) in consultation with all parties. This determined how the translocation was to be undertaken in order to achieve the performance criteria and included staging plans as well as monitoring plans. Specific detailed studies were undertaken to determine the population size, extent, density and genetic composition of the five plants species and these were used to fine tune expectation and design.

We opted to translocate entire turves of heath in a systematic manner and their locations on the recipient site as best matching habitat specificities and original proximity as was possible. The parts of the development site that were translocated captured the largest sections of the populations of the listed plant species, and other sections were relocated within the site to conservation zones. Individual plants of the listed plant species were propagated from material on the development site and used to supplement plants that did not survive the translocation.

The recipient site was scraped clean of weeds and topsoil prior to placement of the turves to remove weeds and to lower the soil level to minimise changes in drainage. There were distinctive management sections created within the translocated site according to different parts of the source site. These divisions were maintained to enable fire breaks between different management units within the site. The turves were moved from the source site and placed on the same day on the recipient site. Shade cloth was used to line the truck tray wall to reduce wind damage. The recipient site was fenced to keep out kangaroos and the fence also lined with shade cloth to reduce grass seed entering the site from adjacent sports fields. After completion, monthly monitoring of the site was undertaken for three years. This included assessment of the performance criteria for species composition, structure, and abundance and reproduction of the listed species. Spot spraying of weeds was undertaken as needed. After the final assessment against the performance criteria was made by the independent ecologist the project was deemed to have been successful and the site was handed over to USC for ongoing management.

Subsequent actions

USC management committee was established and met for several years to establish ongoing maintenance by the USC facilities management. A detailed fire management plan for the site was developed. Each management block has its own fire schedule and the USC has been able to engage with the local rural fire brigade to use the site as a training site. USC students have contributed to the weed monitoring of the site. Weeds have mostly been observed along the edges of the management blocks. These have been successfully managed by close mowing/slashing up to the edge of the translocated turves. An Honours student undertook a comprehensive re-evaluation of the site against the original performance criteria. Students are now actively using the site for many different studies and projects.

Outcomes

The translocation was very successful. It found that the fire management is a key element to the ongoing success of the site. The use of large whole turves leads to much lower ongoing management, particularly of weeds.

What we learned

Carefully planned and executed translocations of whole large turves are the best choice. Translocations of species that require fire for regeneration need to factor fire in as part of ongoing management.

Figure 3. ***Blandfordia grandiflora*** **regeneration and flowering 1.5 years post burn on Compensatory Habitat site. Photo: Alison Shapcott**

Figure 4. Resprouting three weeks after a controlled burn. Photo: Peter Dufourq

Figure 5. Monitoring ***Acacia baueri*** **regrowth after fire. Photo: Alison Shapcott**

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Figure 6. Regeneration 11 months after a controlled burn. Photo: Peter Dufourq

Threatened plant translocation case study:

Androcalva perlaria (Pearl-like Androcalva) Malvaceae

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The species

- Low growing, shorter-lived perennial shrub.
- Endemic to Western Australia.
- Seven extant natural populations.
- Narrow geographic range (~800 km^2).

Threatening processes

- Habitat loss and fragmentation.
- Grazing.
- Mining.
- Altered hydrology and water quality.
- Weed competition.
- Altered fire regimes.
- Climate change.

Deciding to translocate

Androcalva perlaria was first collected on the south coast of Western Australia in 1993. Intensive surveys in 2006 and 2007 of 124 wetlands identified three additional populations with several more recently discovered (Grange Resources Limited 2009). Currently, seven natural populations are known which collectively contain no more than 400 individuals. Five of these populations are found on farms in bushland fragments. The largest population is found along a roadside reserve. The second largest (~70 plants) occurs within a proposed mine and may be removed in future (Grange Resources Limited 2009). Due to the future mine impacts as well as a lack of long-term protection within a reserve, two experimental translocations were implemented at two different locations.

Aim of the translocation

Two research-only translocation trials were conducted to establish some principles for undertaking large-scale conservation focussed translocations. The first translocation (2012) gathered baseline information about the general *in situ* plant performance and no specific treatments were assessed. The aim was to identify critical factors that may reduce overall translocation success using a site that reflected the attributes of natural *A. perlaria* populations (*i.e.,* wetland habitats), had long-term security (C Class Nature Reserve) and was in close proximity (< 5 km) to natural populations.

A second translocation was established (2014) that was based on the outcomes of the first translocation.

The second trial tested several treatments, aimed to improve overall survival, plant health and performance in response to: 1) two different planting sites; 2) different propagating material (cuttings vs seeds); 3) addition of fertiliser and 4) the use of an anti-stress agent (Acetylsalicylic acid [Aspirin]) to temper the potential effects of transplant shock.

Figure 1. Top: Proposed Southdown minesite where *A. perlaria* plants are found naturally (large plant in the foreground) and where a research translocation was implemented for this species in 2014 (the location is indicated in this image by the presence of the bamboo stakes and white pin flags in the background); middle left: Six month old translocated *A. perlaria* plant at the Mettler Nature Reserve site that is indicative of the poor health of the majority of plants found at this location; middle right: Six month old translocated *A. perlaria* plant at the proposed Southdown minesite that is indicative of the excellent health of the majority of plants found in this location; and bottom: healthy 18 month old translocated flowering *A. perlaria* plant at the proposed Southdown minesite. All photos: Shane Turner.

Translocation working group and key stakeholders

- Kings Park Science – to oversee development and implementation of both translocations, the production of plants and ongoing monitoring and maintenance of translocation sites.
- The University of Western Australia – School of Biological Sciences – for development of the experimental approach, the analysis of data and reporting of research findings.
- Department of Biodiversity, Conservation and Attractions, Western Australia – Albany District – for organising the approvals process for the translocation, as well as logistical support.
- Albany District Threatened Flora Recovery Team – assisted with site selection, report findings to the relevant stakeholders and as a point of contact for the local community.
- Grange Resources –provision of funds to support both translocations and the use of one translocation site.

Biology and ecology

- Insect pollinated.
- Small arillate ant dispersed seeds.
- Recruits from seeds which are physically dormant and form a persistent soil seed bank.
- Dormancy is broken by heat (*i.e.,* fire) so recruitment is mainly after a fire.
- Rapid growth.
- Shorter-lived (~10 years).
- Mediterranean climate with hot dry summers and cool wet winters.
- Restricted to fringing vegetation around wetlands.
- Found in close association with threatened ecological communities.

Site selection

A potential translocation site was initially identified through a desktop assessment of bushland remnants. The search focused on wetland areas with a similar vegetation assembly to natural *A. perlaria* populations, land with secure tenure and security, and a general absence of plant disease and weeds. Mettler Lake Nature Reserve (~400 ha) was selected which is within 8–20 km of natural *A. perlaria* populations. The specific location reflected the natural attributes of *A. perlaria* sites such as similar soil, adjacent to a wetland and a ~60% vegetation similarity.

In response to the relatively poor plant performance a second translocation trial was established two years later. For comparative purposes, the original Mettler site was used again as part of this trial with a second translocation site selected at the proposed minesite, adjacent to natural *A. perlaria* plants. This second site was selected as the natural *A. perlaria* plants at this site were in good health. At both sites, a series of identical treatments were assessed to determine whether the poor results observed in the first trial were due to specific site problems or other causes.

Translocation proposal

Two translocation proposals were developed using a template provided by the (then) Department of Parks and Wildlife (DPaW). The proposal was written in the context of scientific research rather than for achieving specific conservation outcomes. Both were assessed by two independent reviewers to determine whether they met DPaW's policies and guidelines. Written feedback was provided after the initial review process with revised proposals resubmitted for final approval.

Pre-translocation preparation, design, implementation and ongoing maintenance

For the first translocation, a small fire was put through the site (May 2012) before the trial was installed in July 2012, to reduce interspecies competition and to provide increased resources (water, light and nutrients).

For this trial, 235 plants were produced (cuttings) from 78 different genotypes six months prior to planting. The whole site was fenced (~20 m x 20 m wire fence to 1.2 m tall) to deter herbivores. After six months initial survival was high (~70%), but after nine months (April 2013) the fence was deemed inadequate because many plants were significantly eaten. A second taller (1.5 m), more secure fence was installed which prevented further herbivory.

The second trial (July 2014) tested different plant treatments. Cutting-derived plants were produced through directly striking cuttings into forestry pots while seed derived plants were sown directly into pots. The two sites selected were 1) Mettler Lake fenced site (same site as 2012 translocation) and 2) the proposed minesite, adjacent to healthy *A. perlaria* plants. Within each site, plants were randomly placed in lines 1 m apart, with subsets receiving fertiliser and/or Asprin. Plants were assessed at the beginning, after 6 weeks, then 6 monthly thereafter for up to two years.

Monitoring and evaluation

Plants were regularly assessed for survival, health, growth, flowering and fruiting. After nine months for the first translocation it was evident that plants were struggling with only 46% of plants alive and 67% of these showing significant signs of stress. Over the next few years survival continued to decline and plants continued to exhibit significant signs of stress and produced limited growth.

Monitoring for the second translocation was undertaken using the same regime. Interestingly, plants at the new site performed much better in terms of overall survival (91.3 ± 3.1%), plant health (4.5 ± 0.6) and growth (100 ± 39 cm wide) compared to the other (Mettler) site where plants performed much more poorly *i.e.,* lower survival (41.3 ± 11.8%), poorer plant health (2.8 ± 0.5) and smaller growth (33 ± 14 cm wide). Within both sites consistent and significant treatment effects were noted.

Subsequent actions

The translocation program was completed and no further monitoring has occurred since August 2016. Nevertheless, given that the project was principally for scientific purposes we believe all the goals that we set out to achieve have been attained. Outcomes and approaches assessed during both translocations have been summarised as an industry report to inform and guide future translocation attempts undertaken on this species should mining commence in the future.

Outcomes

The original aim, which was to assess the feasibility of undertaking a successful translocation on *A. perlaria* exceeded all expectations with the successful long-term (>2 years) establishment of over 150 plants that have since flowered and produced viable seeds. While the initial site (*i.e.,* Mettler site) did not meet expectations the use of a second site (proposed minesite) proved that a high level of success (>90%) can be achieved. Poor site selection was by far the biggest single factor affecting translocation success. Plants at the proposed minesite have grown at rates similar to plants observed in natural populations (Turner *et al.* 2013).

What we learned

When attempting a translocation for the first time do not overcomplicate things – keep it simple and small and use this initial attempt to establish a series of first principles to base, develop and inform future translocation attempts. Supplementary watering was not essential for establishing this species from tubestock (>90% survival without irrigation). Plants performed exceptionally well in suitable habitat (in this case a site where *A. perlaria* plants occur naturally) so spending the time to carefully identify suitable planting sites based on floristic assembly, soil types, aspect and landform is likely to be a good investment of resources.

Acknowledgements

This translocation program would not have been possible without the assistance and financial support of Grange Resources and in particular Brendan Corry, Michael Everitt and Glenda Stirling. Southdown manager Peter Diprose and Jenny North are also thanked for their assistance in providing quick and easy access to the Southdown translocation site as well as on site accommodation. Sarah Barrett, Susanne Schreck, Dylan Lehmann and Susan Whiteley are also thanks for their valuable support and assistance with planting and monitoring.

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Threatened plant translocation case study:

Astelia australiana (Tall Astelia) Asteliaceae

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The species

- Long-leaved, tufted, perennial herb.
- Reproduces both sexually and vegetatively.
- Long-lived (30+ years).
- Endemic to cool temperate rainforests and riparian forests of Victoria.
- Narrow and fragmented distribution in the Central Highlands (14 sites) and Otway Ranges (one site).
- Overall abundance is estimated at 10,000 plants.
- Abundance within sites is highly variable, from areas in which it is the dominant component of the understorey with ~4000 individuals to areas with fewer than 10 individuals.

Threatening processes

- Grazing by introduced herbivores (deer species).
- Wildfire.
- Diseases caused by *Pythium* and *Phytophthora* species.
- Seed predation through frugivory.
- Changes in stand structure.
- Habitat fragmentation.
- Climate change.

Deciding to translocate

Astelia australiana is listed as a threatened species (Cutler and Murphy 2010) due to the decline and fragmentation of its populations attributed to successive wildfires in the 1920s (Willis 1939). It is associated with the cool temperate rainforest community, which is also listed as a threatened vegetation community in Victoria, due to significant decline in its extent, which is attributed to an increase in wildfire frequency since European colonisation (Department of Sustainability and Environment 2009; SAC 1992). Long-term (20-year) monitoring of *A. australiana* populations revealed that the species has continued to decline across its range with a 57% reduction in abundance in monitored population between 1993 and 2013.

Aim of translocation

This translocation involved two translocation programs. The first program was a trial with the aim to assess if translocation was a viable option for the species and to assess if seed or seedlings could be used for translocation. The second program had several aims:

- To increase the species range.
- To reduce the risk of a single wildfire taking out remaining populations.
- To mitigate the risk of climate change on the species by moving individuals into a few higher elevation sites.
- To replace a population that had gone locally extinct in 2016 at one site.

Translocation working group and key stakeholders

- School of Ecosystem and Forest Sciences, The University of Melbourne.
- Conservation Ecology Centre, Otway Lighthouse Rd, Cape Otway, VIC 3233.
- Parks Victoria.
- Department of Environment, Land, Water and Planning (DELWP).
- Foundation for Australia's Most Endangered Species (FAME).

Biology and ecology

The Central Highlands and Otway Ranges are climatically similar with high mean annual rainfall (>1000 mm), mild summers with mean maximum temperatures of less than 27°C and mean annual temperatures between 5–14°C (Busby 1992; Hijmans *et al.* 2005; Peel 1999). *A. australiana* sites are characterised by cool temperate rainforest vegetation typically dominated by an overstory of Myrtle Beech (*Nothofagus cunninghamii*) and Southern Sassafras (*Atherosperma moschatum*), a middle stratum of Soft Tree Ferns (*Dicksonia antarctica*) and a lower story of fern species dominated by Hard Water Fern (*Blechnum wattsii*). The sites are generally limited to gullies adjacent to watercourses (Hill *et al.* 1988; Peel 1999; Worth *et al.* 2009).

Site selection

We used maps of the current distribution of cool temperate rainforest and watercourses across Victoria and overlayed predictions of suitable habitat from a species distribution model we developed for *A. australiana*. We then overlaid land tenure and forest management zones to identify potential translocation sites on public land and within special protection management zones. Permits were applied for and granted. Potential sites were then visited, and their suitability was assessed. Sites were rejected if there was evidence of deer presence, if the slopes were too steep, or if forest structure resulted in low light availability in the understorey.

Translocation proposal

To enable translocation, we completed a procedure statement for Translocation of Threatened Native Flora in Victoria plan. This plan involved explaining the aim and methods of the translocation and also obtaining written endorsement of the translocation proposal by two external referees. Once our proposal was approved we conducted a trial translocation of 54 individuals to assess the viability of translocation as a management tool for *A. australiana*. We then successfully obtained a Biodiversity On-ground Actions Regional Partnerships and Targeted Actions Project grant from DELWP to conduct translocations at additional sites.

Pre-translocation preparation, design, implementation and ongoing maintenance

The trial translocation of 54 individuals involved moving eighteen individuals into each of three sites (the source site (control), a locally absent site adjacent to the source site (1 km away); and a distant site (22 km away)). Plants were removed from the source site using a shovel to loosen the soil around their roots. The plant roots were then wrapped in a wet cloth and they were placed into large bags for carrying out of the site. The translocation site was cleared of understory vegetation using a shovel to relocate them as needed. *A. australiana* individuals were planted in shallow holes. Translocated plants

Tim Willersdorf (left) and Craig Nitschke (right) carrying the source *Astelia australiana* for translocation into the locally absent site. Photo: Linda Parker

had high survival rates, between 83–89%, and growth was similar between all sites. This trial also involved translocation of seeds and 10 seedlings into the same three sites.

The second translocation involved moving 200 individuals from five source sites and planting them into five sites including the distant trial site described above (additional 25 plants). We translocated into one site where *A. asteliana* had recently become locally extinct, likely due to browsing by deer. This site is now fenced to exclude browsing (25 plants). We established new populations of 50 individuals each at two new sites within the Central Highlands and one site in the Otway Ranges. The translocation procedure was the same as described for the trial translocation. Multiple source sites were used to ensure genetic variability within the new populations.

Monitoring and evaluation

Translocation sites have been monitored on an annual basis with monitoring involving the recording of survivorship and growth. To date the translocation has been considered a success as survival has been high > 86% after one year. We have also had reproduction in the control trial translocation population. The monitoring will continue to determine if translocated individuals are able to become self-sustaining populations.

What we learned

- *A. australiana* can be successfully translocated.
- Translocation sites should be free of introduced herbivores or fenced.
- Seeds and seedlings did not translocate well.
- Translocated individuals should be planted in soil that is free draining. They should not be planted in saturated soils adjacent to watercourses as this will lead to increased mortality.

Translocated *Astelia australiana* in one of the distant translocation sites. Photo: Linda Parker

Outcomes

A. australiana individuals that were involved in the initial trial translocation had high survival rates (89%, 83%, and 83% at the absent, present, and locally absent sites respectively). Growth in terms of number of green leaves, leaf length and leaf width did not differ across the three site types. As most translocated individuals survived, our results suggest that the species may be absent from sites for other reasons than habitat limitation. Dispersal limitation or low success of seed-based recruitment may explain the absence of *A. australiana* at these sites, however, habitat population dynamics can be complex and these factors alone may not explain a species absence at all sites. Translocation appears to be a viable management option to expanding the range of *A. australiana* and overcoming dispersal limitation. It would also reduce the effects of isolation on its population demographics. Current research focusing on *A. australiana* genetics, within and between populations, should inform the degree that isolationism is having on the species and how future translocation efforts can be undertaken to promote genetic diversity and gene flow.

Acknowledgements and permits

This research and translocation was undertaken by Linda Parker as part of her PhD at The University of Melbourne under the supervision of Dr Craig Nitschke, Dr Sabine Kasel and Dr Cristina Aponte. We thank Ben Smith, Heidi Zimmer, David Lockwood, and Tim Willersdorf, for field assistance. We also thank Jack Pascoe, Mark Le Pla and staff from the Otway Conservation Ecology Centre (CEC) for assistance with the translocation of individuals in the Otway Ranges sites. Funding for this research was generously provided by The Holsworth Wildlife Research Endowment, The Victorian Government through the Department of Environment, Land, Water and Planning (DELWP) Integrated Forest Ecosystem Research program (IFER). The Foundation for Australia's Most Endangered Species (FAME) is supporting our current research examining the species genetics to better understand its dispersal and population dynamics to inform future translocation and conservation management.

All research was conducted with approval from DELWP and research permits were issued under The Flora and Fauna Guarantee Act 1988 and The National Parks Act 1975 (10006488) and The Forests Act 1958 (FS/14/3694/1/3).

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Threatened plant translocation case study:

Macadamia jansenii (Bulburin nut), Proteaceae

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The species

Macadamia jansenii (Bulburin nut) is Endangered (under the *EPBC Act*) and only known in the wild from a single population of around 60 plants (>1m in height) distributed over 1 km along a single creek within Bulburin National Park, Queensland, 180 km north of the other Macadamia species. The Australian Government Threatened Species Strategy lists the Bulburin nut as one of 30 threatened plant species with priority for conservation and a commitment for action by 2020.

Threatening processes

Weeds, fire, human interference.

Deciding to translocate

The Macadamia recovery plan (Costelo *et al.* 2009) recommended a reintroduction program to safe guard against chance extinction.

Aim of the translocation

To establish new populations of the species in the wild.

Translocation working group and key stakeholders

Macadamia Conservation Committee (MCC), University Sunshine Coast (USC), Australian Macadamia Society (AMS), Macadamia Conservation Trust (MCT), Gidarjil Cultural Heritage Corporation (representing traditional owners), Queensland National Parks (rangers responsible for Bulburin National Park).

Biology and ecology

M. jansenii is a long-lived rainforest species with wild trees growing up to 12m in height. The species is thought to be insect pollinated, and survey work indicated that the plants produce few seeds in the wild, which is similar to wild populations of other Macadamia species despite often abundant flower production. The wild population has a pulsed size distribution with low levels of recruitment evident. *(Editors note: A pulsed size distribution indicates that recruitment into the population has been event-based rather than constant).* Population genetic studies indicated moderate genetic diversity and no significant inbreeding which was not expected given the very small population size. Genetic studies on other Macadamia species have found that moderate genetic diversity and low inbreeding levels are maintained by pollen dispersal among closely located small populations and this information was used to guide reintroduction site selection (Neal 2007, O'Connor *et al.* 2015).

Figure 1. Undertaking the original wild population survey, Alison Shapcott with Gidarjil Caring for Country Rangers. Photo: Alison Shapcott

Figure 2. *Macadamia jansenii* in flower in the wild. Photo: Alison Shapcott

Figure 3. Left to right: Collecting plant material for cutting from the wild population with Gidarjil Caring for Country (CRC) rangers and QPWS ranger for Bulburin National Park. Alison Shapcott and Macadamia propagators. Photos: Alison Shapcott

Site selection

We used species habitat suitability distribution modelling (SDM) within the local region to identify areas most likely to be suitable for reintroduction (Shapcott and Powell 2011). We then ground-truthed potential sites for ecological and practical suitability and accessibility for planting. Two sites were selected within Bulburin National Park in collaboration with local QPWS rangers; one at a higher altitude than the existing population in order to allow for anticipated future climate change (Powell *et al.* 2014). A further two sites within land owned and managed by the Gidarjil Cultural Heritage Corporation representing traditional owners were also selected and occurred close to the wild population. All sites were located within the potential range of long distance dispersal of pollen by insect pollinators, among themselves and the wild population, based on genetic estimates (Neal 2007).

Translocation proposal

The translocation/reintroduction proposal was developed by USC in collaboration with all stakeholders including the MCC and was submitted to the Queensland National Parks as part of obtaining permission to take cuttings from the wild population for propagation.

Pre-translocation preparation, design, implementation and ongoing maintenance

Original population maps of individual plant locations and sizes were used to relocate individual plants to take cuttings from all plants larger than a minimum size specified by the EPA permit. The same plant identification codes were given to samples for propagation as used in the original population genetics study which conducted a complete population genetic survey (Shapcott and Powell 2011). Plant identification codes were maintained throughout the reintroduction program. Cuttings were selected as the propagation method in order to capture the genetic diversity of the population and because very few seeds are produced; propagation by cuttings is a method well established by the macadamia growers industry. This method enabled multiple copies of clones representing individual plants to be created. The four new populations were each planted with a complete set of clones, representing approximately 85% of individuals in the wild population greater than 3m tall. The plantings were conducted over four stages, each 1-2 years apart. The location, identity and survival of all plants at each planting site was documented, and plants that died were replaced with the same clone. Clones were re-established in the nursery from the original set of "mother plant clones". Prior to the last planting in 2017, 40 plants had successfully established across the four sites (average 10 per site). This is comparable with the 60 plants in the wild population which is spread across three subpopulations (Shapcott and Powell 2011), and is similar to that of many wild populations of Macadamia (Costelo *et al.* 2009). The low survival rate of translocated plant was, in part, attributed to at least two severe flooding events during the project. This reintroduction aimed to mimic wild populations with minimal ongoing maintenance and site disturbance, following on from initial watering in when planted as well as a supply of hydrated water crystals. The Gidarjil rangers lead ongoing site monitoring and remove weeds.

Subsequent actions

A recent new search has located additional plants in the wild. A final census of both the reintroduced and wild populations is scheduled for 2019 after which the project will be assessed. A complete set of clones has also been established at Tondoon Botanical Gardens in Gladstone so that any new propagation or new reintroduction does not need to interfere with the wild population. A new planting is now also scheduled for 2019. The Macadamia Conservation Trust (MCT) through Tondoon Botanic Gardens is planning to establish additional 'insurance populations' at four Botanic Gardens and/or other secure sites.

Outcomes

While the populations are currently small we have successfully reintroduced this species within its natural range with hardy plants that do not require human interference.

What we learned

There is high mortality among young plants less than 1m tall both in wild populations and in reintroduced populations. We found plant establishment to take two years. A project that repeatedly introduces plants over time is more likely to be successful in the long term and a two-year period is needed to assess if plants will become established. Projects should plan for plant replacement as a high mortality rate of young plants is common in wild and introduced populations and should not be seen as a sign of project failure. The good will, generosity and persistence of those involved have been essential for this project.

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Figure 4. Left to right: *M. jansenii* cuttings ready for planting. Planting *M. jansenii* on Gidarjil property. *M. jansenii* established for several years. Photos: Alison Shapcott

Threatened plant translocation case study:

Posidonia australis (Strapweed), Posidoniaceae

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The species

- Species of seagrass, also known as marine flowering plants or angiosperms.
- Slow-growing and long-lived species.
- Endemic to temperate Australian waters, listed as Endangered in 2012 (*NSW Fisheries Management Act 1994*) and 'Threatened Ecological Community' in 2015 (*Australian Environment Protection and Biodiversity Conservation Act 1999*).
- Distributed sub-tidally on soft sedimentary environments in shallow and mostly sheltered waters.

Threatening processes

- Catchment disturbance and pollution.
- Coastal development.
- Dredging.
- Boat mooring and other boating-related activities.
- Invasive species.

Deciding to translocate

Posidonia australis meadows occur in six NSW estuaries (Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie) have experienced large reductions in distribution since the mid-1900s. It is at risk of becoming locally extinct in some estuaries due to ongoing impacts.

One of the ongoing impacts for loss of *P. australis* in NSW estuaries is traditional swing moorings (Glasby and West 2018). These moorings are composed of a large concrete block connected to a heavy chain that drags along the seafloor as the boat swings on its axis due to shifting wind and tides, directly removing seagrass shoots (Demers *et al*. 2013). Swing moorings create bare patches or scars that destabilise the sediment and change hydrodynamic conditions, resulting in fragmented meadows (Figure 1).

Natural recolonisation of bare patches by *P. australis* is very slow, taking over 20 years for a single scar to be revegetated naturally (Meehan and West 2000). The present restoration project was therefore started to determine whether *P. australis* shoots can be transplanted to promote seagrass recovery in these bare patches.

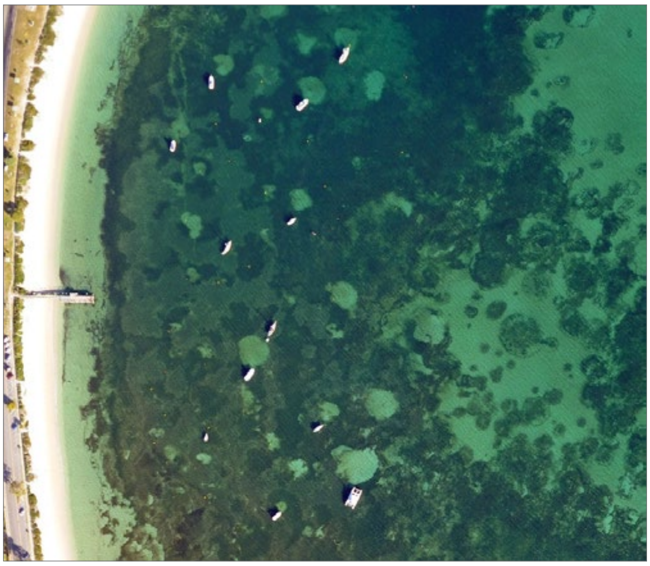

Figure 1. Effects of boat moorings in Shoal Bay, Port Stephens, NSW. The remaining seagrass is visible as dark patches surrounded by some bare light-coloured sand where moorings scour the seafloor. Photo: Tim Glasby

Aim of the translocation

Seagrass restoration is still a young science; however, recent works have produced encouraging results (Bastyan and Cambridge 2008; McLeod *et al.* 2018). In NSW, an important limitation for *P. australis* restoration is the low level of sexual reproduction (Gobert *et al*. 2006) and the unsuitability of harvesting source shoots from declining protected meadows. This project aimed to find a solution: 'Operation Posidonia' asks citizen scientists to collect detached shoots washed up on the beach after storms, which are then used to revegetate damaged meadows.

Translocation working group and key stakeholders

'Operation Posidonia' is a team composed of investigators from the following institutions:

- Centre for Marine Science and Innovation, UNSW Sydney – responsible for planning, planting, performing ongoing monitoring and maintenance of the transplanted site.

- NSW Department of Primary Industries, Fisheries – responsible for collection and maintenance of fragments in tanks prior to transplant, planting and involved in planning and development of restoration methods.
- School of Biological Sciences and Oceans Institute, University of Western Australia – providing guidance with regards to planning, improving techniques and planting.
- Citizen scientists are volunteers from the Port Stephens Community – assisting with on-shore collections of naturally detached fragments and including 18 community groups.
- Anchorage Marina – collection spot where volunteers can store freshly collected shoots and keep them submerged until collection by NSW DPI staff.

Biology and ecology

- *P. australis* has a large root system for anchorage and nutrient uptake from soft sediments, and a rhizome network for nutrient storage and translocation to aboveground shoots consisting of 2-5 leaves. Growth can be vertical (orthotropic rhizome), or horizontal (plagiotropic rhizome) by ramifying across the seafloor through vegetative reproduction. Although sexual reproduction (seeds born from fertilized flowers that develop within fruit) has been reported, it is rare in NSW populations (Gobert *et al*. 2006).
- *P. australis* creates extensive and structurally complex meadows that provide habitat for a wide variety of invertebrates and fishes.
- *P. australis* is slow to recover from physical damage and damaged meadows may take years to become re-established, even after the apparent cause of damage is removed.

Site selection

Port Stephens is near the central coast of NSW and has a large area of seagrass (14,000,000 m^2) but also numerous swing moorings within seagrass meadows (Glasby and West 2018). Boat moorings have been responsible for a loss of 30,556 m^2 of *P. australis* (Glasby and West 2018), making Port Stephens the second most impacted estuary by boat moorings in NSW. Port Stephens was selected to optimise restoration techniques because it is within a Marine Park where *P. australis* is a dominant species and is the headquarters of DPI Fisheries, who lead the development of the novel seagrass transplanting methods.

Translocation proposal

This proposal was funded by the NSW Environmental Trust under its Restoration and Rehabilitation grants program. Key contributions from local volunteers were secured after extensive consultation with local stakeholders including scientists, boat mooring owners, local aquaculture managers, journalists specialising on marine matters and members of Community Groups from within the OCCI (Ocean and Coastal Care Initiatives) organisation.

'Operation Posidonia' (www.OperationPosidonia.com**)** was launched via a public event at the Anchorage Marina (the main collection point for detached *P. australis* fragments). Social media sites were used to attract volunteers and share updates. Short films were produced to explain the importance of *P. australis*, threats posed by boat moorings and to explain the life-cycle of the project. Public outreach also involved presenting to high school classes and giving presentations to local community groups.

Pre-translocation preparation, design, implementation and ongoing maintenance

'Operation Posidonia' outreach program has enabled the collection of more than 1000 *P. australis* fragments between October 2018 and April 2019. Fragments consist of shoots with attached rhizome. A pilot trial began in May 2018, replanting 267 fragments within two boat mooring scars (10 plots of 1 m x 2 m). Planting and monitoring were carried by SCUBA-divers (Figure 2). The fragments were anchored with wire pegs into old mooring scars consisting of either bare sediment (with or without stabilising jute-mats) or patches colonised by faster-growing seagrasses.

Figure 2. ***Posidonia australis*** **transplantation sequence. Top left: Example of a fragment suitable for restoration; top right: beach collection by volunteers part of 'Operation Posidonia Storm Squad'; bottom left: Planting fragments into bare sand; bottom right: fragments nine months post planting. Photos: Harriet Spark, Adriana Vergés and Giulia Ferretto.**

After 4 months, we recorded on average 55% shoot survival with plots with jute-mats reaching 70% survival. Nine months later, some fragments had grown new shoots, with overall shoot density increasing and approximating our starting shoot densities, indicating fragments had overcome initial transplant stress, and were now established and growing.

Subsequent actions

After encouraging results from the pilot trial, the first round of restoration began in January 2019, revegetating in four additional boat mooring scars. 432 fragments were planted in 18 plots of 1 m x 2 m using different techniques (restoring on bare sediment with or without stabilising jute-mats and on scars colonised by faster-growing seagrasses). Monitoring is currently taking place every two months. The morphological traits of all transplanted shoots were measured prior to planting, including leaf length and width, rhizome length and type of growth (horizontal/vertical). Fragments were also tagged with a unique ID that includes collection details such as location and date. This information will aid in identifying the factors that most influence restoration success.

Outcomes

Initial results indicate that fragments of *P. australis* collected from the shore and transplanted into a healthy and suitable environment can show high survival. After nine months, there is evidence that the fragments have overcome initial transplant stress and become established, producing new shoots to recover to initial planting shoot densities. Ongoing monitoring will determine whether individual traits of restored shoots or specific planting techniques (e.g., using jute mats to stabilise sediment) influence restoration success. This information will then be used to optimise future restoration programs.

What we learned

- Beach-collected detached fragments of *P. australis* can overcome transplant stress in less than a year.
- *P. australis* beach-collected fragments can establish within old boat mooring scars and grow.
- Beach-collected fragments are an effective, non-destructive source of planting units for use in restoration.
- Direct community engagement is an effective conservation and restoration tool that provides on-ground assistance and can raise awareness and community buy-in.

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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.

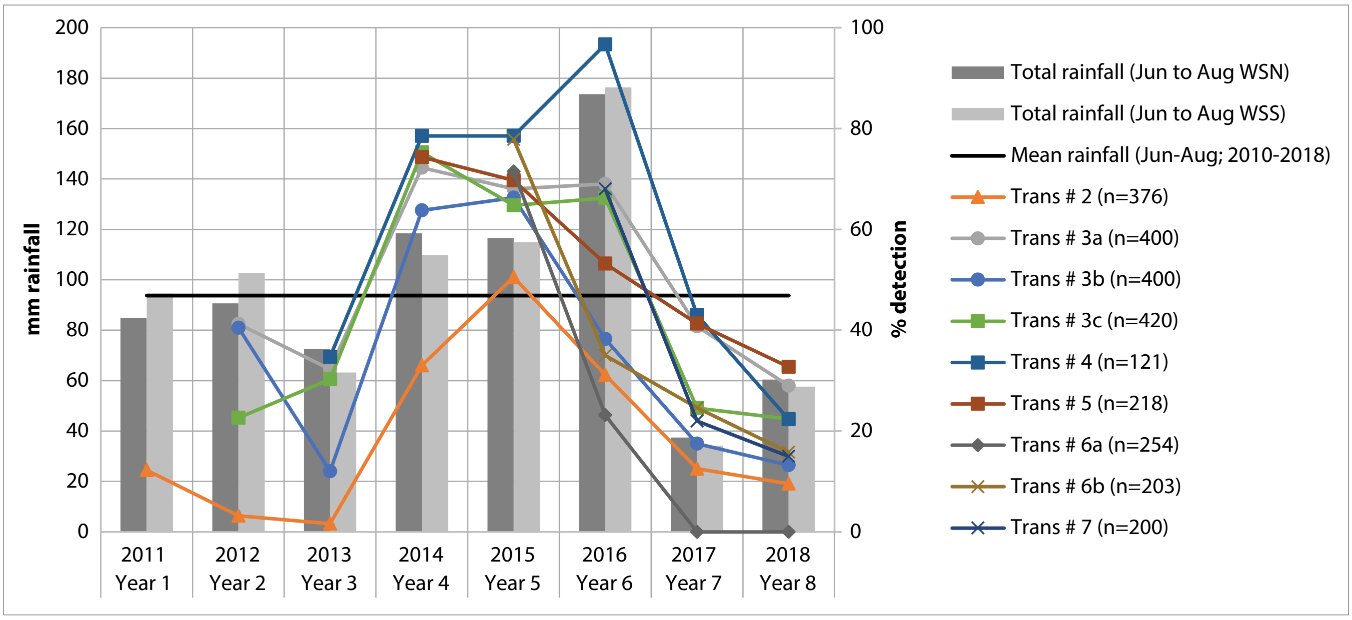

Figure 4. Rainfall received and 3-month average (June to August) at Mangoola (WSN and WSS weather stations) during the course of monitoring across nine recipient plots within derived grassland, over a period of two to eight years (n=2,592).

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.

Acknowledgements

The ongoing financial support from Mangoola Coal over eight years to establish and monitor the orchid translocation project is gratefully acknowledged. Logistical support from environment staff at Mangoola has been freely given by Ben de Somer, Tasman Willis, Damien Ryba and Nathan Lane.

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News from the ASBP

Towards recovery of the Scaly-leaved Featherflower

ANDREW CRAWFORD*, LEONIE MONKS AND ALANNA CHANT

Department of Biodiversity, Conservation and Attractions

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The Scaly-leaved Featherflower (*Verticordia spicata* subsp. *squamosa* A.S.George) has been rare for as long as it has been known. Since its discovery in the 1950s only nine populations of the species have been found over an area of approximately 160 km^2 in the Three Springs and Mingenew areas in the mid-west of Western Australia. This area has been extensively cleared in the past, with most of the known populations now occurring on narrow road verges, or in small patches of remnant vegetation on private property (Stack *et al.* 2004).

The number of mature plants known for the species has always been low. The total number of plants in the wild was at its highest in the mid-1990s but still the number of plants totalled less than 50 (Stack *et al.* 2004). This period, when the number of known plants was at its peak, coincided with the first seed collections of the species being made for conservation purposes by staff from the Department of Biodiversity, Conservation and Attractions' Threatened Flora Seed Centre.

The Threatened Flora Seed Centre is a seed conservation facility that was established in the early 1990s with the primary purpose of collecting and preserving seed of plant species of conservation significance in Western Australia. The aim of these seed collections is to ensure genetically representative samples of species are available for future recovery work such as translocation. To achieve this goal, best practice for seed collection and storage are followed (Offord and Meagher 2009).

By the year 2000, an estimated 4500 seed had been collected from most of the known populations. Due to concerns about the long-term viability of the known populations, particularly the small road verge populations, plans were prepared for a translocation into a healthy patch of remnant vegetation on private property, within the known distribution of the species. Propagation of the species was known to be difficult and therefore it was decided using a combination of both cutting material and seedlings would be the best strategy to produce plants for translocation. A small number of plants were planted in 2001, followed up with further plantings in 2002, 2005 and 2009.

By 2017 only two of the known wild populations of the *Verticordia* still had living plants totalling six individuals. In the translocation, only around a quarter of the plants that had originally been planted were surviving (18 plants). Although low in number, these translocated plants had become crucial for the ongoing recovery of the species due to the critically low numbers of wild plants at this time. Despite the translocated plants having flowered in the intervening years, no evidence of natural recruitment had been seen. Smoke has been found to stimulate germination of this species from the soil seed bank (Yates *et al.* 2000). As no fires occurred in the vicinity of the translocated and natural populations this lack of smoke to stimulate germination may be a possible explanation for the apparent absence of recruitment not only in the translocated population, but also the natural populations.

As part of the Australian Government's Threatened Species Strategy, the Scaly-leaved Featherflower, along with 29 other species were prioritised for action to improve their conservation trajectory by 2020 (Australian Government 2019). The actions planned to achieve this outcome for the Scaly-leaved Featherflower were the collection of propagation material (both seed and cuttings), translocation, and the protection of the remaining habitat on private property. This work began in 2017, when plans were developed to supplement the existing translocation, in addition to establishing a new translocation site and reintroducing plants to a population that had recently gone extinct. Additional seed collections from the remaining wild plants were also planned for the summer of 2017–18.

The value of having seed collections stored safely in an *ex situ* seed storage facility were highlighted with this project. Having existing seed collections enabled the generation of seedlings to be undertaken immediately.

The Scaly-leaved Featherflower (*Verticordia spicata* subsp. *squamosa*). Photo: Andrew Crawford

A translocated seedling of *Verticordia spicata* subsp. *squamosa*. Photo: Alanna Chant

Additionally, the genetic diversity represented by these old collections is likely to be far greater than that represented by the current wild populations as the number of extant plants was now far less than when the collections were originally made. The germination of seed from collections made over a decade previously also provided the opportunity to compare the viability of the collections to what they had been when first collected. The good news is that whilst germination was low (ca. 50%) for some collections, this was comparable to what the germination had been when these collections were first tested.

Seed collections to improve the size of the *ex situ* collection and to replace seed used for the translocations were undertaken as part of the strategy in the summer of 2017/18. Unfortunately, 2017 proved to be a poor season for the flowering of the *Verticordia*, with little to no flowering of the remaining wild plants. A small number of plants in the translocated population had flowered and a decision was therefore made to collect seed from these plants. Bags were placed over the old flowers, which hold the seed containing fruit, to catch them when shed. These bags were retrieved in early 2018 and resulted in a seed collection of around 500 seed. This highlights one of the advantages of having *ex situ* seed collections that can be drawn upon to undertake translocations as there are no guarantees that seed will be able to be collected in a given season. It was also the case for this species that there would have been insufficient time to germinate and grow plants from the seed collected in 2018 for it to be ready for planting by winter of 2018.

Over eighty plants were planted into the translocations in the winter of 2018. Most of these plants were still surviving by the end of summer 2019. Plans are now underway to add additional plants to all of these translocations. As a result of these recovery actions, undertaken by the Department of Biodiversity, Conservation and Attractions and supported by funding from the Australian Government as part of the Threatened Species Strategy, and the Northern Agricultural Catchment Council, the future of this species is now looking brighter.

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Germinating seed of *Verticordia*

Verticordia have an indehiscent fruit contained within the old, faded flower. It is difficult to visually distinguish between old flowers that have a seed containing fruit and those that do not. The storage unit for seed collections is therefore the old flowers. To estimate how many seed are in a collection a sample of flowers is cut to determine the proportion containing seed. This process is combined with the germination test so that the viability of seed can be estimated. Germination testing begins with the old flowers being soaked in a smoke water solution and then the seeds are excised. These seed are placed into petri dishes on agar containing gibberellic acid (100 mg/l) and incubated at 15 °C. Once seed germinate, they are transferred to soil and grown into seedlings ready for translocation.

a. A seed of *Verticordia spicata* subsp. *squamosa* excised from the old flower; b. A germinating seed of *V. spicata* subsp. *squamosa*; c. A *V. spicata* subsp. *squamosa* seedling ready for translocation. Photos: a, b. Andrew Crawford; c. Leonie Monks.

ANPC member profile

Chris Findlay

What is your current position?

I am a director of Flora Victoria. Flora Victoria specialises in the seed production and direct seeding of indigenous grasses and wildflowers for ecological restoration and landscaping projects, and environmental contracting including remnant vegetation management.

What projects are you working on at the moment?

Flora Victoria is currently working on several direct seeding projects for landscape architects and local and state government. Much of our work is linked to development and infrastructure and could be categorized as landscaping, as there is currently limited interest and funding available for ecological restoration using direct seeding. We are also greatly increasing our wildflower seed production to supply extra diversity and appeal to our direct seeding projects.

We have also started an exciting project that puts us right back on the ecological restoration track, a mine project for Kalbar Resources under the direction of Paul Gibson-Roy. This project aims to restore over 300 hectares of diverse grassy woodland, native grass will be used extensively with indigenous trees and shrubs in gullies to prevent erosion. Native grass will also be incorporated into new pastures. All of this will take place on degraded farmland, some of which has been planted with Blue Gum and Radiata plantations. The plan is to set up a 15-hectare seed production area to produce up to 3 tonnes of over 100 species of indigenous plant seed per year, including endangered species to re-create a local vegetation type that is almost extinct.

Chris Findlay

How did you end up working in plant conservation?

I have always been fascinated by plants, flowers in particular. One of my first memories is the taste left in my mouth after chomping into a Daffodil bulb as a toddler. I started growing annual bedding plants as a teenager, then on to Dahlias, herbaceous boarders and cottage gardens. The more flowers the better. Then one day I found myself in the bush in Spring surrounded by more flowers than I could ever have imagined. It was life changing and my career has been shaped by this experience from that moment on. I studied Horticulture at Burnley and worked in the indigenous and native gardens there for two years, developing my newfound passion by turning the indigenous garden into a collection of over one hundred species of my favourite grasses and flowering plants. I grew an extreme wildflower garden, enjoyment wise it was the highlight of my career. During this time, I teamed up with a friend working in the Burnley Nursery and started Flora Victoria to create flowering grassland landscapes for a Melbourne council. This lasted for three years before moving on to a job where I was introduced to the seed production and direct seeding of native grasses. After that I re-started Flora Victoria in 2005 with the aim of restoring endangered Victorian Volcanic Plains grasslands. It's been harder than expected as direct seeding has not yet been widely adopted by our industry as a viable method of revegetation. I hope things change soon because direct seeding provides the only way to increase the range of our shrinking endangered grassy ecosystems and the species that rely on them for their survival.

What is your favourite plant and why?

Brunonia australis because it is unique, beautiful and can be found in many habitats across Australia. It ranges from light to vivid sky blue, a rare hue in the world of flowers. It belongs to a monotypic genus and until recently was the sole member of the monogeneric plant family *Brunoniaceae*. Stumbling across a dense patch of *Brunonia* in full bloom is always a delight.

Why do you think the ANPC network is important and what do you see as our priorities?

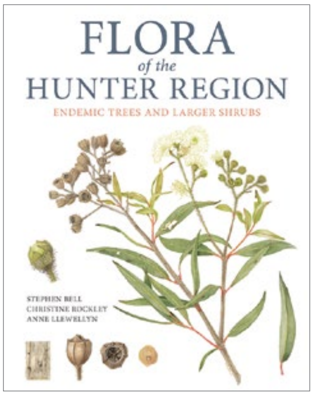
To me the ANPC network is a conduit between researchers and practitioners, giving us all insight, inspiration and knowledge we can use to improve our focus and our work. It highlights some of the fantastic work done to conserve species, the importance of genetics in restoration, field work that unveils the mysteries of plants and their ecosystems, translocation and restoration projects and much more.

I believe an important priority for the ANPC is to support and encourage the use of direct seeding, and a level of seed production capable of supplying the large-scale ecological restoration needed to halt the loss of species in this country. Offsetting lost habitat needs to include the creation of new high-quality habitat capable of supporting our rare and threatened species. There is no other way of reversing the overall loss of our unique biota.

Book reviews

Flora of the Hunter Region: Endemic Trees and Larger Shrubs

Stephen Bell, Christine Rockley and Anne Llewellyn
Hardback. March 2019. $79.99. ISBN: 9781486311026. 136 pages. 290 x 230 mm. Publisher: CSIRO Publishing



Working regularly with modern floras and field guides, one often notices limitations when it comes to rare and lesser known taxa. Specific descriptions, precise habitat and distribution information and indeed detailed imagery of the fine features required for their field identification are often lost in the quest to fit the overwhelming diversity of Australia's native flora into a user-friendly format. Coupled with the frequent modern preference for colourful photographs over diagnostic illustrations, it is easy to see why field identification of many of these rarities can present a challenge to amateurs and pros alike.

And so, it was with great enjoyment that I read Stephen Bell, Christine Rockley and Anne Llewellyn's *Flora of the Hunter Region.* A regional guide based on the botanically rich Hunter Valley in NSW, this book doesn't just seek to rectify the limitations outlined above, it raises the bar of what a modern guidebook with a specific focus can deliver. The beautifully presented pages combine comprehensive information about each species with detailed botanical art produced by graduates of the University of Newcastle's Bachelor of Natural History Illustration course, a fantastic concept.

Working through the book, each species is given a full two page spread. Each profile contains a wealth of information on the first page including notes on etymology, distribution, habitat, ecology, similar and related species and a summary of key diagnostic features as well as a complete taxonomic description. The accompanying distribution maps are also clearly displayed and easily interpreted. The second page is solely devoted to the botanical illustrations, providing a wonderfully presented display for easy reference to a specimen in the hand.

The illustrations really are what sets this book apart, however, with the detailed artworks highlighting the key diagnostic features of all species within. Reminiscent of the fine art found in older botanical references like Stan Kelly's Eucalypt guides from the 1960's, the images complement the descriptions wonderfully and clearly display crucial details often difficult to capture in a photograph. Their presence also means this book is not just for seasoned professionals – by displaying the diagnostic features so clearly, the often-complex terminology surrounding plant identifications is made clear for the beginner and the artworks make for a wonderful coffee table book for those with a more casual interest.

Another interesting feature is the authors' choice to focus on the 54 endemic trees and shrubs from the Hunter region only. By doing so, they have been able to give these often-overlooked species an in-depth treatment and in some cases shed light on species very poorly known or recently described for the first time. Easily cross referenced with other available, more comprehensive guides that cover the Hunter and adjoining regions, this guide really does complete the picture of the region's unique diversity in a very thorough manner of which the authors should be proud.

I for one am already looking forward to the second volume covering the Hunter's smaller shrubs, cycads, orchids and forbs which is to follow soon. Be it for field identification, research or merely to appreciate the art, this book and the coming second volume are ones to add to the must-have list.

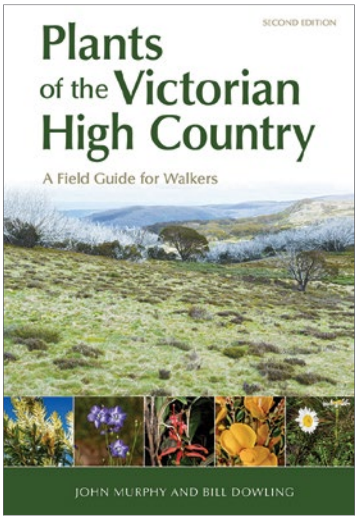
Gavin Phillips, Royal Botanic Gardens, Sydney

Plants of the Victorian High Country – A Field Guide for Walkers Second Edition

John Murphy, Bill Dowling

Paperback. October 2018. $39.99. ISBN: 9781486309016. 168 pages. 215 x 148 mm. Publisher: CSIRO Publishing

This is a great field guide for those who are new to alpine flora. It's very functional in terms of looking up species and it has really great pictures. I feel like I have been waiting for a book like this for a long time! Compared to the Kosziousko Alpine Flora, the size of this book makes it much more user-friendly, as a field guide. All species are organised into five broad plant functional groups. At the start of each functional group, there is a simple straight forward botanical key. This is great, because it makes it easy to search in the book and identify plants if you don't know the common or the scientific name of a plant. Species information is succinct and informative, the book briefly describes lifeform and the elevation zone where you may find the plant, as well as details of floristic characteristics.



I have enjoyed taking it on camping trips and getting my less botanically inclined friends hooked into alpine plants. I think it gives a nice focus in a group when you are just hanging back at a camp site and having a go at the ongoing plant quiz.

All in all, this is definitely a long-waited product and well worth your money and the space on your shelf.

Khorloo Batpurev, Arthur Rylah Institute

Workshop reports

SA Threatened Plant Translocation Workshop a resounding success

DR LUCY COMMANDER

Email: translocation@anpc.asn.au

The South Australian Threatened Plant Translocation Workshop was held on Friday 3 May 2019 in the Ingkarni Wardli Building, The University of Adelaide, with 12 speakers presenting to a total of 57 participants.

Material in the new *Guidelines for the Translocation of Threatened Plants in Australia* was covered as well as seven local South Australian translocation case studies and a lively panel discussion. Selected presentations are available to download from the ANPC website.

Lucy Commander, lead editor of the *Translocation Guidelines*, gave an introduction to translocation, an overview of the Guidelines, tips for success when preparing a translocation proposal, and suggestions for translocation design and management.

Additional aspects of translocations were covered by Michelle Waycott (pre-translocation assessment), Doug Bickerton (decision making, policy and approvals), Dan Duval (seed banking), Martin Breed (genetics and provenance), and Kylie Moritz (monitoring and evaluation).

Case studies on South Australian species highlighted the complexities of translocation projects. James Trezise explained his research on Yundi Guinea-flower (*Hibbertia tenuis*), Alex Mason spoke on Silver Daisy-bush (*Olearia pannosa* ssp *pannosa*), Tim Field presented on Spiny Daisy (*Acanthocladium dockeri*), Geraldine Turner spoke about Whibley wattle (*Acacia whibleyana*) and Kylie Moritz presented on Monarto Mintbush (*Prostanthera eurybioides*). South Australian habitats were also showcased, as we heard from Jerry Smith about the Adelaide Mt Lofty Ranges, and from Veronica Bates on Kangaroo Island.

Participants represented over 10 volunteer groups, two universities, landcare groups, government departments, local councils, NGOs, consultancies and a winemaker. Everyone enjoyed the opportunity to catch up with colleagues and to meet new people.

Kylie Moritz (a current ANPC committee member) and Doug Bickerton, both from Department for Environment and Water in South Australia are to be congratulated on putting together such an interesting and informative program.

This event was supported by the South Australian Murray-Darling Basin Natural Resources Management Board through funding from the NRM levies and Volunteer Small Grants. Funding was also provided by The Environment Institute (*University of Adelaide*) *and the Threatened Species Recovery Hub.*

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

THE UNIVERSITY of ADELAIDE

ENVIRONMENT INSTITUTE

Threatened Species Recovery Hub
National Environmental Science Programme

Presenters and participants at the South Australian plant translocation workshop. Photo: Kylie Moritz

News

Editors' note: News excerpts are clipped from a diversity of sources. To read the articles in full follow the links attached to each clipping. The views expressed in these articles are those of their authors and do not necessarily represent the opinion of the ANPC.

ANPC News

Translocation case studies now available online

Nineteen threatened plant translocation case studies have recently been published on the new ANPC website. Originally published in *Australasian Plant Conservation* in 2018 and early 2019, excerpts from these case studies are presented in the new 3rd edition of the ANPC's Guidelines for the Translocation of Threatened Plants in Australia. Download the PDFs here **https://www.anpc.asn.au/translocation-case-studies/**

Cover of the APC issue themed Translocation of threatened plants – part 2.

Saving the Brilliant Sun Orchid (*Thelymitra mackibbinii*) from extinction

The ANPC is working with the Royal Botanic Gardens Victoria (RBGV), Friends of the Grampians Gariwerd (FOGG) and the Australasian Native Orchid Society (Victoria Group) Inc. on this project over the next few years. The threatened *Thelymitra mackibbinii* has less than 60 naturally wild plants remaining. The RBGV has grown 600 plants from all remaining provenances, with improved genetic viability. These plants will be re-introduced and fenced for protection under this project. Guided community surveys will also be undertaken for any additional plants that may not have been seen previously, as well as for the small bee that is required for pollination.
https://www.anpc.asn.au/brilliant_sun-orchid/

Brilliant Sun Orchid (*Thelymitra mackibbinii*). Photo: Noushka Reiter

ANPC's Translocation Guidelines

Find out more about the third edition of the ANPC's Threatened Plant Translocation Guidelines and the role of the ANPC in these three short videos:

Dr Lucy Commander – Project Manager Translocation Guidelines
https://www.youtube.com/watch?v=HvpWTfp-bqM&feature=youtu.be

Dr Judy West – Executive Director, Australian National Botanic Gardens
https://www.youtube.com/watch?v=SExsBPLZlP0&feature=youtu.be

Dr Sally Box – Threatened Species Commissioner
https://www.youtube.com/watch?v=rN5Lwjb0Cd4&feature=youtu.be

Dr Lucy Commander – Project Manager Translocation Guidelines.

Cuttings: Plant news from around Australia

NSW Office of Environment and Heritage (OEH) updates its translocation policy

Translocation will play an integral part in securing the future of threatened species in NSW, and it has been identified as a priority action for over 150 threatened species under Saving our Species (SoS). OEH recently developed the OEH translocation operational policy to guide the planning, assessment and implementation of translocations in NSW and includes both plants and animals. It also includes establishing ex situ threatened plant populations, climate change and translocation of organisms threatened by development. The ANPC's threatened plant translocation guidelines will continue to play a significant role in defining best practice for plant translocation in Australia. If you are going to undertake a translocation in NSW, we recommend that you download and read the OEH translocation operational policy before you begin planning.
https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/programs-legislation-and-framework/translocation

PhD Scholarship available in Alpine Plant Ecology

While mountains are generally considered to be cool environments, the strong solar radiation can cause the surface temperatures of plants, bare soil and rocks to far exceed air temperatures. Leaf temperatures are also affected by a plant's habit (prostrate, standing, cushion, rosette), pubescence or reflective tomentum. While there is some information about the freezing resistance of Australian alpine plants, very little is known about how extremes in both low and high temperatures, and the combination of extreme climate events (i.e., heat-waves and drought), will impact on plant growth, performance and reproduction. The resilience of the alpine landscape in the face of dramatic climate changes is therefore unknown. Through a combination of field and laboratory-based studies, and utilising key research infrastructure via the Australian Mountain Research Facility (AMRF), we are seeking a competent PhD candidate to address these knowledge gaps surrounding thermal and drought responses, by simulating a future micro-climate environment with experimental treatments using shrub, forb and graminoid species that are representative of ecosystems across the Australian Alps.
https://susannavenn.wordpress.com/students/

Data-deficient species (not listed under the Biodiversity Conservation Act 2016) webpage created

The NSW Threatened Species Scientific Committee assesses the risk of extinction of species using criteria that are modelled on the IUCN Red List approach. Sometimes the Committee is unable to complete an assessment due to a lack of information. The Committee has created a web page to share information on species where assessments have highlighted that information

gaps exist. These gaps hinder the accurate assessment of the threat status of certain species, and so, these species cannot be listed as threatened under the NSW Biodiversity Conservation Act 2016. Currently only two reptiles and one plant have been assessed as data deficient but other species will continue to be added over time. The Committee would like to encourage researchers, students and conservation organisations to consider adding these species to surveys proposed to be undertaken within the species' distribution or to consider initiating some targeted surveys or research. The Committee sees this as an excellent resource for devising Higher Degree Research projects which are highly relevant to conservation in NSW.
https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/nsw-threatened-species-scientific-committee-publications/assessment-reports/data-deficient-species-not-listed

New USA plant conservation guidelines now available

The USA Center for Plant Conservation is pleased to announce the publication of CPC Best Plant Conservation Practices to Support Species Survival in the Wild. For the first time we have consolidated our guidelines to cover plant conservation practice from soup to nuts. We urge practitioners to review the new guidelines that reflect updated knowledge about best scientific practice. "One in five plant species are at risk of extinction worldwide. Growing concerns for the loss of plant genetic diversity and species' extinctions, as well as advancing knowhow to make successful conservation collections, motivates CPC Network scientists to collect seeds from wild populations and bank them. The great diversity of plants throughout the world helps define our sense of place and our cultural heritage. Plants have great economic value—providing food, shelter, medicine, and the basis of our livelihoods."
https://saveplants.org/wp-content/uploads/2019/05/CPC-Best-Practices-5.22.2019.pdf

New Research: The Aussie plants facing extinction

New research by the Threatened Species Recovery Hub has identified the top 100 Australian plant species at risk of extinction. Researcher Dr Jennifer Silcock from the University of Queensland said three quarters of Australia's threatened species are plants. "Knowing which plants are at greatest risk gives us a chance to save them before it is too late," said Dr Silcock. "This list of Australia's top 100 imperilled plants will help conservation managers prioritise where to direct efforts to prevent extinctions.
http://www.nespthreatenedspecies.edu.au/news/new-research-the-aussie-plants-facing-extinction

Feral brumby culls found by scientists to be crucial in ensuring survival of native ecosystems

New research looking at the impact of feral horses in Australia's alpine parks system has concluded that aerial culling is needed to ensure the survival of native ecosystems. The peer-reviewed research by a group of 25 scientists found feral horses cause "widespread environmental degradation, destroy ecosystems, eliminate populations of native species and spread weeds".
https://www.abc.net.au/news/rural/2019-02-02/brumby-culling-found-to-be-crucial-in-ensuring-native-survival/10771160

Can we use native plants to predict floods?

Ecologist Dr Matt Prescott describes how native plants can be harbingers for extreme weather events. The flowering patterns of native plants offer a valuable early warning system for detecting changes in the weather, while their roots and leaves could be used to build a network of 'green dams', which would reduce Australia's vulnerability to the disastrous effects of extreme floods and droughts. Native plants possess unique abilities to detect and signal changes in the weather, thousands of years of experience of coping with the extreme climate change and a track record of stabilising soils, water tables and communities over millions of years.
https://www.australiangeographic.com.au/topics/science-environment/2011/02/can-we-use-native-plants-to-predict-floods/

Trees remember heatwaves

An Aussie eucalypt can 'remember' past exposure to extreme heat, which makes the tree and its offspring better able to cope with future heatwaves, according to new research from Macquarie University. This finding could have important implications for restoring ecosystems and climate-proofing forestry, as the number of hot days and heatwaves increase due to climate change.
https://www.scimex.org/newsfeed/trees-remember-heatwaves

'Seed bank' to preserve native plants

The bush tucker industry is booming across Australia, but some plants that have a cultural and economic significance to remote Indigenous communities are at

risk. Now there's a proposal to create a new national seed bank to help preserve them.
https://www.abc.net.au/radio/programs/am/seed-bank-to-preserve-native-plants/10818690

Amendments to the EPBC Act list of threatened species

The Minister for the Environment, the Hon. Melissa Price MP, has amended the list of threatened species under the Environment Protection and Biodiversity Conservation Act 1999 to include one new plant species, the Haines Orange Mangrove (Bruguiera hainesii), in the Critically Endangered category. The full list of amendments, including transfers of species between listing categories and removal of species from the list, is available here
http://www.environment.gov.au/news/2019/02/18/amendments-epbc-act-list-threatened-species

Amateur naturalist finds new population of endangered wild macadamias

Thirty-seven new trees of the endangered Macadamia jansenii species have been found in Bulburin National Park, south of Rockhampton. Until September last year, the Macadamia Conservation Trust of Australia thought only 90 of the trees existed in the wild. Retired cane farm manager Keith Sarnadsky found the most recent population of jansenii plants using a satellite imaging service on the internet. "It was just a matter of looking for specific details like the colour of a new flush of growth and the habits of the known plants we had," he said.
https://www.abc.net.au/news/2019-02-19/new-endangered-macadamia-population-found/10794520

Australia's 10 worst invasive species, study

New research by the Threatened Species Recovery Hub has shown that invasive or pest species are a problem for 1,257 threatened species in Australia, or about four out of five species. The research which has been published in the scientific journal Pacific Conservation Biology also identified the top ten invasive species based on how many threatened species they impact. Lead researcher Stephen Kearney from the University of Queensland said many people may be surprised at which species top the list. "Rabbits, a plant root disease and feral pigs are the top three pest species impacting Australia's threatened species," Mr Kearney said.
http://www.nespthreatenedspecies.edu.au/news/australia-s-10-worst-invasive-species-study

National Recovery Plan for the Littoral Rainforest and Coastal Vine Thickets of Eastern Australia Ecological Community

The Littoral Rainforest and Coastal Vine Thickets of Eastern Australia Ecological Community occurs along the east coast of Australia, from near Cooktown in Queensland to Gippsland Lakes in Victoria. It is listed as Critically Endangered under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), as its distribution has been reduced and severely fragmented due to land clearing from coastal development, sand mining and agriculture. The ecological community continues to be threatened by land clearance and development, weed invasion, recreational disturbance, animal browsing/grazing and fire. The recovery plan establishes a national framework to guide and coordinate the implementation of research and management actions to assist the recovery of the ecological community throughout its range.
http://www.environment.gov.au/biodiversity/threatened/publications/recovery/littoral-rainforest-coastal-vine-thickets

The amazing intelligence of plants

Tally up all the things that plants provide us with and it's a mighty long list. But despite the food, oxygen, fossil fuels, pharmaceuticals, stress reduction, pollution amelioration, climate moderation and more, provided by the plant world, it has never been on an equal footing with the human one. For thousands of years we have been conditioned to think of plants as being less evolved than ourselves.
https://www.smh.com.au/entertainment/the-amazing-intelligence-of-plants-20190215-h1baqv.html

Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*

The Minister for the Environment, the Hon Melissa Price MP, has made the 'Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi' under the Environment Protection and Biodiversity Conservation Act 1999. The new plan, developed with input from Phytophthora experts and on-ground practitioners from around Australia, addresses the key threatening process 'Dieback caused by the root-rot fungus *Phytophthora cinnamomi*'. It identifies actions to ensure the long-term survival of native species and ecological communities affected by Phytophthora dieback and guides investment and effort by government, researchers, land managers and other stakeholders.
http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018

Gamba grass threatens Tropical North

The cane toad continues its inexorable march westwards across our tropical north, but some scientists think there could be an even worse pest emerging in The Top End – and they say we need to get onto it quick smart. This pest grows up to 4 metres tall, and it's called Gamba grass. Unlike the cane toad it pushes out everything; other plants and the insects and animals that rely on them. Gamba grass is so tall and thick when it burns that it makes what would be a simple grass fire into a towering inferno that also destroys larger trees.
https://www.abc.net.au/radionational/programs/latenightlive/gamba-grass/10858528

Georgia Garrard – Connecting people with biodiversity

After undergraduate majors in Geography, Environmental Science and Botany, I did my PhD on native grasslands. I was struck by how these Critically Endangered ecosystems existing right on the edge of my city were being lost without most people even knowing about them – or understanding what amazing, superdiverse ecosystems they are. They are not the brown, dead, snake-infested paddocks of popular imagination but rather home to an abundance of incredible plants and animals.
http://www.nespthreatenedspecies.edu.au/news/georgia-garrard-connecting-people-with-biodiversity

Droughts, heatwaves, floods and fires – Threatened species in a changing world

The world is changing. Some of this change is planned and desirable. But much else is an unwanted consequence of the expansion of the human species. Those unwanted impacts will affect our lives and those of our descendants. But they are also affecting – and will increasingly threaten – many of the world's endangered species, including many Australian plants, animals and ecosystems.
http://www.nespthreatenedspecies.edu.au/news/droughts-heatwaves-floods-and-fires-threatened-species-in-a-changing-world

How smart technology is helping to save a Kimberley river from devastating rubber vine

An invasive species devastating fragile ecosystems across northern Australia is on the back foot in one of the Top End's most untouched rivers. Rubber vine kills native flora and fauna, damages pastoral land and chokes waterways from Queensland to Western Australia's far north.

A group of people in WA's remote Kimberley region are using innovative technology to fight back, and they're winning. For the past eight years, John Szymanski has led the battle against the plant in the Fitzroy River, one of the country's last pristine river systems.
https://www.abc.net.au/news/2019-03-16/winning-the-war-against-rubber-vine-australias-worst-pest/10893766

Native grasses create urban oases

Nature in our cities is important for biodiversity conservation and human health. We have a considerable amount of urban green space in Australian cities (outside sporting fields and manicured parks) where the predominant management regime is plant grass and regularly mow it. And would you believe it, mown grass is the worst for biodiversity, it is a net emitter of carbon, costs heaps to maintain, is under-utilised by people and is a poor vehicle for engaging local communities with the management of their local green spaces. Phillip Gibbons takes you to the root of the grass debate.
https://www.abc.net.au/radionational/programs/blueprintforliving/native-grasses-create-urban-oases/10878896

Everything you need to know about our iconic Illawarra flame trees

The Illawarra flame tree is a native beauty that rivals the jacaranda in spring and summer. You may have heard the song Flame Trees by Cold Chisel a number of times, but do you know what it's really about? Well, it's an ode to the Illawarra flame tree (*Brachychiton acerifolius*). A bright red flowering tree that easily "blinds the weary driver". These trees have an ancient history in Australia. According to Russell Barrett, a systematic botanist at the Royal Botanic Garden Sydney, the inner bark of flame trees was used by Aboriginal Australians for making string, fishing nets and traps, as well as being a food resource. "The large seeds are rich in protein and taste rather like raw peanuts," Russell says. "They were commonly cooked before they were eaten to ensure that all the irritating hairs were burnt off."
https://www.australiangeographic.com.au/topics/science-environment/2019/03/everything-you-need-to-know-about-our-iconic-illawarra-flame-trees/

Savage Garden

Josh visits the home garden of restoration ecologist Dr Adam Cross to look at his fantastic native garden, and amazing collection of carnivorous plants. In his backyard, Dr Cross has planted in excess of 200 native plant species, the majority of which are indigenous to the area in which he lives. While Adam adores his natives, it is carnivorous plants that are his true passion, particularly those that are native to the south west area of Western Australia.
https://www.abc.net.au/gardening/savage-garden/10928682

Young custodians of our plant life

Motivated young students are involved in the SEEDS project, finding threatened, endangered and rare South Australian plant species, pollinating them, "propagating" them and planting them out. ABC Radio Adelaide's Deb Tribe speaks with Seed Biologist Dan Duval and volunteer Michael Yeo from the South Australian Seed Conservation Centre at the Botanic Gardens of South Australia, and students from Kildare College, who how the project works.
https://www.abc.net.au/radio/adelaide/programs/saturdaybreakfast/seeds-project/10932534

Can trees talk and think?

Can plants think, learn and communicate? We used to believe that only humans and other animals had that ability. But science is showing that plants are smarter than you think. Plant scientists describe how plants talk to each other, respond to sound and share resources.
https://www.abc.net.au/radionational/programs/bigideas/can-trees-talk-and-think/10924624

Urban biodiversity to lower chronic disease

Replanting urban environments with native flora could be a cost effective way to improve public health because it will help 'rewild' the environmental and human microbiota, University of Adelaide researchers say. In a new paper, published in Frontiers in Microbiology, researchers say that humans – thought of as 'holobionts', a symbiosis of host and microorganisms reliant on ecosystem health and biodiversity for optimal health outcomes – and more specifically, urban populations, are in dire need of more natural habitat to address chronic disease rates.
https://www.scimex.org/newsfeed/urban-biodiversity-to-lower-chronic-disease

Feral goats no match for Riley family and their trusty kelpie companions

Clint and Brooke Riley are known as the goat chasers, trekking through the New South Wales high country with their eight kelpie dogs and two young kids Chloe and Jack to muster feral goats. The family from Bredbo help remove goats from properties in the Snowy Mountains and Monaro region. Clint and Brooke Riley said farmers considered wild goats as pests because of the destruction they caused to native vegetation and the environment.
https://www.abc.net.au/news/2019-03-28/feral-goats-no-match-for-this-family-and-their-kelpies/10940338

Smut to the rescue

Deep inside our quarantine facility in Canberra, our scientists have been testing a leaf smut fungus for the last few years. Why? It could control an invasive weed called wandering trad. Wandering trad (*Tradescantia fluminensis*) is native to South America, but it's a major weed in Australia. Here, it forms a dense cover on the forest floor, reduces native vegetation and clogs waterways.
https://blog.csiro.au/smut-to-the-rescue/

Lost and Found – Trees

From the Giant Sequoia and the Cathedral-like Mountain Ash forest, to modern timber skyscrapers, we explore the world of trees. We take a tour of the world's most spectacular trees, learn why cross laminated timber might revolutionise the building industry, mourn the loss of Darwin's magnificent Milkwood tree and discover an ambitious urban project that's transforming Melbourne's western suburbs.
https://www.abc.net.au/radionational/programs/lost-and-found/lost-and-found-%E2%80%94-trees/10928146

The 39 endangered species in Melbourne, Sydney, Adelaide and other Australian cities

The phrase "urban jungle" gets thrown around a lot, but we don't usually think of cities as places where rare or threatened species live. Our research, published today in Frontiers in Ecology and the Environment, shows some of Australia's most endangered plants and animals live entirely within cities and towns. Australia is home to 39 urban-restricted threatened species, from giant gum trees, to ornate orchids, wonderful wattles, and even a tortoise. Many of these species are critically endangered, right on the brink of extinction. And cities are our last chance to preserve them within their natural range.
https://theconversation.com/the-39-endangered-species-in-melbourne-sydney-adelaide-and-other-australian-cities-114741

Forest canopy the final frontier as scientists discover tiny bats and hundreds of plant species

A team of scientists and artists discover a tiny fruit bat and 90 plant species around just one tree in a vertical BioBlitz of Mary Cairncross Scenic Reserve on the Sunshine Coast. The team took turns being suspended up to 50 metres above the ground to survey the top crowns of five giant strangler fig trees as part of the only vertical BioBlitz undertaken in Australia. The scientists and artists from across a range of disciplines spent four days in the rainforest surveying each strangler fig from the tree's drip line on the ground to the tree's crown to see what was living on each tree, and the relationships formed between plants, animals and insects.
https://www.abc.net.au/news/2019-04-02/mary-cairncross-rainforest-bioblitz/10959264

A detailed eucalypt family tree helps us see how they came to dominate Australia

Eucalypts dominate Australia's landscape like no other plant group in the world. Europe's pine forests consist of many different types of trees. North America's forests change over the width of the continent, from redwood, to pine and oak, to deserts and grassland. Africa is a mixture of savannah, rainforest and desert. South America has rainforests that contain the most diversity of trees in one place. Antarctica has tree fossils. But in Australia we have the eucalypts, an informal name for three plant genera: *Angophora*, *Corymbia* and *Eucalyptus*. They are the dominant tree in great diversity just about everywhere, except for a small region of mulga, rainforest and some deserts. My research, published today, has sequenced the DNA of more than 700 eucalypt species to map how they came to dominate the continent. We found eucalypts have been in Australia for at least 60 million years, but a comparatively recent explosion in diversity 2 million years ago is the secret to their spread across southern Australia.
https://theconversation.com/a-detailed-eucalypt-family-tree-helps-us-see-how-they-came-to-dominate-australia-113371?fbclid=IwAR1YFwO9aANxw-UXbFD5wBXuah53swKStJktkUhemEhs0OBXGAU-lNZ0wC8

Creating a counterpoint to urban sprawl

You can't take the politics out of a political cartoonist, even one who has retired and spends most days gardening. Peter Nicholson says all his horticultural pursuits – his propagating, his planting and his intense scrutiny of the 43 indigenous species listed under the Ecological Vegetation Class relevant to his cliff-top property in Mornington – have a political edge.
https://www.theage.com.au/entertainment/creating-a-counterpoint-to-urban-sprawl-20190401-h1d16r.html

Scientists launch plant rescue mission on far north Queensland mountain

A mountaintop rescue mission is being launched in far north Queensland to collect plant species believed to be at risk from climate change. The five-year project, led by James Cook University professor Darren Crayn, hopes to save a host of species in Queensland's Wet Tropics World Heritage Area, from tiny orchids to huge trees. Professor Crayn said climate modelling predicted "severe to catastrophic impacts" on about 70 plant species that are restricted to a mountaintop habitat in Australia's wet tropics. "These plants, which rely on the cool tropical mountaintops more than 1000 metres above sea level, are losing their habitat," he said.
https://www.smh.com.au/national/queensland/scientists-launch-plant-rescue-mission-on-far-north-queensland-mountain-20190414-p51dy5.html

Weed detector dog unleashed in Hobart

An alpine weed that was brought to Australia by hydro-electric workers and has spread in New South Wales, Victoria and Tasmania is being attacked by specially trained dogs. The dogs are sniffing out the orange Hawkweed, and their handlers will then poison the plant they hope to eradicate.
https://www.abc.net.au/radio/programs/pm/weed-detector-dog-unleashed-in-hobart/11044218?fbclid=IwAR3o-3CGawnnNHhcUT0FIsFwtMUaWFL2_IBKL1AIgSvVQsaVWewpNweISUg

Native tree seeds sown using drones to restore habitat for birds and bats on cotton farms

Drones with modified air rifles are being used to shoot native tree seeds and fertiliser into cropping country. University of New England researcher Rhiannon Smith is leading the seeding project that's aimed at restoring habitat for birds, bats and beneficials on cotton farms on a large scale. The drones can sow 1 hectare, about the size of a football field, in 18 minutes with "one person sitting in the ute playing on the computer". But the specialised drones can't be used by just anyone. ABC reporter Cara Jeffery speaks with Dr Smith about the trial that's revegetating agricultural land.
https://www.abc.net.au/radio/programs/nsw-country-hour/drone-used-sowing-native-tree-seed-revegate-cotton-farms/11049700

Other conferences, courses and events

Updates available at:
http://anpc.asn.au/other_conferences_and_events

20th NSW Weeds Conference – Newcastle NSW, 26-29 August 2019

Are you working to manage and eradicate weeds in Australia? The 20th NSW Weeds Conference is a premier event for NSW weeds officers, researchers, market and industry analysts, government officials and policymakers working towards better weed management across the country. The conference will unite more than 250 weeds management experts in the beautiful beach-side city of Newcastle, Australia. Weeds are a serious threat to Australia's native flora and fauna and add pressure to our economy. Recent technologies, policies and innovations are helping us manage weeds more effectively – but more work is needed. This conference provides an opportunity for the NSW weeds management community to showcase new research and ideas for controlling and eradicating weeds. It's a chance to network and build strategic partnerships and invest in a shared vision for our industry's future.
https://www.nswweedsconf.org.au/

WA State NRM and Coastal Conference – Perth WA, 1-4 October 2019

The 2019 State Natural Resource Management (NRM) and Coastal Conference will be held amongst the beautiful natural gardens of Edith Cowan University, Joondalup. A highly regarded WA event that has been held regularly since the 1990s, the Conference will focus on maximising networking opportunities with an interactive program including workshops, tours, engaging conference sessions and open space sessions. The theme for the conference is 'Our Coast | Our Land – Striving Together'. The theme aims to inspire delegates to make transformational changes together that improves and protects our natural environments and creates healthier communities.
https://www.nrmandcoastalconference.org.au/

BGANZ Congress 2019 – Wellington NZ, 20-23 October 2019

'Plants from the past: plants for the future'. Plants have brought Australasian Botanic Gardens together though BGANZ every 2 years since 2003. They have canvassed a range of roles and perceived roles for botanic gardens. They have been about education, conservation, their roles in communities and any number of shades of these themes. 2019 returns to basics – it is all about the plants. Science, education, recreation, conservation, community outreach – they are all dependent on plants.
https://www.confer.nz/bganz2019/

NSW Landcare and Local Land Services Conference 2019 – Broken Hill NSW, 22-24 October 2019

For the first time in its 20 year history, the NSW Landcare and Local Land Services Conference is heading to the far west! Set aside 22-24 October and make your way to Broken Hill where you will join some of the most passionate, innovative and engaging people from around Australia. Book your tickets today and start making travel plans to ensure you don't miss out on what promises to be an informative and truly inspiring event. Delegates will also have the opportunity to kick up dust in the outback, party the night away at the Silverton Hotel and experience many more unique and wonderful events.
http://nswlandcareconference.com.au/

2019 SA Community Landcare Conference – Bordertown SA, 27-30 October 2019

We are pleased to announce the next biennial State Community Landcare Conference will be held in Bordertown from 27 to 30 October 2019. The Landcare Association of SA will also celebrate 20 years in 2019 and hopes that you will celebrate this milestone with us. The theme of the Conference is: 'Landcare Unearthed – Celebrating Diversity, Managing Landscapes'. Register now to take advantage of a great price and secure your seat at a conference that cannot be missed.
https://landcaresa.asn.au/event/2019-sa-community-landcare-conference/

ESA19: the 2019 Conference of the Ecological Society of Australia – Launceston TAS, 24-29 November 2019

'Ecology: science for practical solutions'. Ecology is the science of interactions among all forms of life and the abiotic environment they inhabit, and in turn, change and shape. Applications of ecology are all around us everyday, in natural resource management, forestry, fisheries, agriculture, water production and conservation biology. These applications demonstrate the importance of ecology in seeking to understand and explain our Earth, and how humans can better co-exist with nature in an increasingly anthropogenically-modified environment. This provides the theme for this conference: how the science of ecology can contribute to developing and implementing solutions for our planet in the throes of a biodiversity crisis and a changing climate. Ecological science is fundamental to informing policy but the next generation of practising ecologists will need to work more closely with economists, political scientists, historians, human geographers and social scientists to develop ecologically sustainable practices.
https://www.esa2019.org.au/

ASBS–NZPCN 2019 – Wellington NZ, 24-28 November 2019

'Taxonomy for Plant Conservation'. We invite you to a joint conference of the Australasian Systematic Botany Society and the New Zealand Plant Conservation Network—an exciting opportunity to connect with people who are passionate about science and conservation of native plants in New Zealand and Australia. The conference will be held at Wellington's premier conference venue, the Museum of New Zealand Te Papa Tongarewa. Get up to date information from our stimulating and comprehensive range of speaker presentations. Explore Wellington's forests and rugged coastlines on our field trips. Network with people involved in a wide variety of plant conservation work. Discuss and learn at our workshops. Take a tour of the Te Papa Herbarium (WELT) and Otari Native Botanic Gardens.
https://systematics.ourplants.org/

Research round up

COMPILED BY KIRSTEN COWLEY
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Centre of Excellence for Environmental Decisions (CEED) legacy website:

CEED operated from July 2011 to May 2018, on Australian Research Council funding. Its focus of work was on defining and analysing environmental management problems and developing modelling, monitoring and evaluation tools for environmental actions. The CEED legacy website at http://www.ceed.edu.au/ contains many resources, including links to over 1,000 publications and the full run of the bulletin *Decision Point*.

NSW BioNet Atlas user manual 2019. NSW Office of Environment and Heritage. Free download (442 pp) from https://www.environment.nsw.gov.au/research-and-publications/publications-search/bionet-atlas-user-manual-2019

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SAVE THE DATE!

Tuesday 8 October 2019

Seeds for the Future: a one day Forum

Teachers Federation Conference Centre, Sydney

Tickets will go on sale soon. See **https://www.anpc.asn.au/seeds-for-the-future/** for updates.

Where will the seeds for the future come from?

Planners, managers, practitioners, seed collectors and nursery operators are familiar with the need to collect seed from widely spaced parents to optimise genetic integrity in replanted areas – but do we have a similar problem of inbreeding with small remnants subjected to bush regeneration alone?

Given development pressures and declining space for connectivity, there is an increasing need for restorationists, plant producers and landscape architects to collaborate on ensuring natives of the correct provenance and genetics are conserved as well as planted within urban spaces.

Planning for the Seeds for the Future, a one-day forum is underway to address these issues. This forum brings together people from the bush regeneration, revegetation, nursery and landscape architecture and planning sectors to set the scene for future collaborations and introduces the innovative project 'Healthy Seeds' that is poised to offer practical solutions for all.

The day will be structured around nine morning presentations to provide the background and context and an afternoon panel discussion on the implications for practitioners and need for leadership strategies which span agency boundaries.

This event is being co-hosted by the ANPC and the Australian Association of Bush Regenerators (AABR) and is assisted by the NSW Government through its Environmental Trust.

Australian Network for Plant Conservation Inc

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