Threatened plant translocation case study:

Zieria baeuerlenii (Bomaderry Zieria), Rutaceae

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The species

- Many-branched to somewhat straggly, long-lived perennial shrub (average height ~80 cm).
- First collected in 1883 in the "lower Shoalhaven", and in 1943 from "Bombaderry Creek".
- Endemic to the Shoalhaven, with a single known population; restricted to ~50 ha on the plateau either side of Bomaderry Creek, north of Nowra, NSW.
- Listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the NSW *Biodiversity Conservation Act 2016*.
- Fruit or seed set has never been observed.

***Zieria baeuerlenii*. Photo: Kylie Coutts-McClelland**

Threatening Processes

- Small population size (stochastic events, genetics).
- Inappropriate fire regime.
- Lack of sexual reproduction (genetic implications).
- Browsing (from native and exotic species).
- Disturbance (human recreation, utility maintenance).
- Drought/climate change.

Deciding to translocate

First collected in 1883, the Bomaderry Zieria (*Zieria baeuerlenii* J.A. Armstrong) has had a single known population, despite detailed surveys, with no evidence to suggest its distribution ever extended outside the Bomaderry Creek locality (DECCW 2010). No fruit or seed set has ever been observed. Vegetative material was collected in 2007 to create an *ex situ* insurance collection of all known genets. An ongoing population decline, and a preference to use *ex situ* individuals rather than discard the ageing stock triggered the decision to undertake an enhancement planting (trial translocation). It was also a learning opportunity to inform future translocations, particularly any implications for augmentation/ reintroductions to the *in situ* population.

Aim of the translocation

The short-term aims of the enhancement trial were to:

1. Achieve survival of translocants at Bomaderry Creek at a site additional to the extant *in situ* population.
2. Investigate factors critical to successful translocation for the species.
3. Develop a method for the planting of *Z. baeuerlenii* for future translocations.
4. Increase our understanding of the potential reasons for the decline of the natural *in situ* population.

Translocant survival rates for two primary treatments were tested:

- Manual watering (additional to natural rainfall), and no watering. Best watering horticultural practice was implemented as per the protocols/recommendations of the partner Botanic Gardens.
- Fenced and unfenced, to investigate the effect of browser impacts.

Overall, the project sought to increase the number of *Z. baeuerlenii* plants in the wild and increase knowledge on the species more broadly. Knowledge gained from the trial will assist any future enhancement/augmentation proposals, if deemed necessary for the Bomaderry Creek population.

Translocation working group and key stakeholders

- NSW Department of Planning, Industry and Environment (DPIE): Biodiversity and Conservation and National Parks and Wildlife Service Divisions (formerly the NSW Office of Environment and Heritage).
- Wollongong Botanic Gardens, Booderee Botanic Gardens, Australian National Botanic Gardens.
- Shoalhaven City Council.
- Bomaderry Creek Landcare Group Inc.
- South East NSW Bioregion Partnership.

Biology and Ecology

- Trifoliate leaves covered in velvety hairs. Each leaflet is rounded and blunt, to 12 mm long and 9 mm wide, with curled-under edges.
- Produce masses of small pinkish-white flowers between July/August and October, arranged in clusters of three to seven.
- No fruit set or seeds have ever been observed/ recorded.
- Fire-induced re-sprouting; layering, suckering observed (clonal reproduction).
- 20 known genets (Barratt 1999; Sharma 2001), plus five additional probable distinct genets (Barratt 2014 2019). Genetic work suggests it is a distinct species that once reproduced sexually; it is extremely unlikely the species arose as a single hybridisation event followed by vegetative propagation (DECCW 2010).
- Most sites have well-drained, shallow, sandy soils derived from Nowra Sandstone and contain many sandstone outcrops or skeletal soil amongst sandstone boulders (Barratt 1997; PlantNET 2019) across a range of eucalypt open forest, woodlands with shrub understoreys and closed scrub (DECCW 2010).

Site selection

The single recipient site for the enhancement planting trial was ~120 m from the nearest known *in situ* parent *Z. baeuerlenii* plant, mapped as Grey Gum – Blue-leaved Stringybark open forest on gorge slopes southern Sydney Basin Bioregion and north east South Eastern Highlands Bioregion (Plant Community Type 858) (using the NSW Bionet Vegetation Classification application). The habitat was similar to the portion of the natural population in deeper soils. The option to plant in the commonly-inhabited skeletal soils was considered too risky for this first enhancement planting, in terms of *ex situ* stock availability and likelihood of success. The site was considered far enough from the extant population to prevent *in situ* population modification, including minimising potentially negative hygiene impacts. It was large enough for this (and any future) translocation, and had easy access for site preparation, planting, maintenance (specifically water delivery) and monitoring activities.

Translocation proposal

The proposal for enhancement planting was prepared in accordance with Vallee *et al.* (2004). A revised proposal addressing written feedback from internal reviewers was submitted to, and subsequently approved by, the (then) NSW Office of Environment and Heritage as Scientific Licence SL101894.


Left to right: Enhancement planting site (planting day) and enhancement planting site (post-fire). Photos: Kylie Coutts-McClelland

Pre-translocation preparation, design, implementation and ongoing maintenance

Source material (vegetative cuttings) collected from the likely/known different genets in 2007 was propagated by the Wollongong Botanic Gardens, the Australian National Botanic Gardens, and the Booderee Botanic Gardens. Seedlings for the trial were grown to tubestock or pots up to 250 mm under strict hygiene protocols, sourced primarily from the Wollongong Botanic Gardens' collection (from stock re-propagated in 2016). For experimental rigour, only genets with at least 21 individuals were included: nine 'insurance' individuals to keep the insurance population secure as per the Botanic Gardens' recommendations, and 12 plants for translocation. Twelve genets qualified, with 12-60 individuals from each genet, maximising genetic diversity of the stock available at the time of planting. As such, the maximum number of translocants (316) were planted in mid-May 2017.

Individual translocants within each genet were numbered sequentially, regardless of pot size. To investigate the effect of fencing and/or supplementary watering, translocants were then randomly assigned to one of the four treatment groups: nil treatment; watered; fenced; watered and fenced. Based on a randomly assigned temporary number, translocants were planted in sequential order within a 1 m^2 grid cell plot. Tree bases or large shrubs voided 15 cells, and the next available (sequential) cell was used. Each plant was tagged with a metal tag with a code identifying the genet, the numbered individual of that specific genet, pot size, treatment, and the year of planting. An additional orange horticultural tag was attached to translocants within the watered treatment to aid identification during the watering visits.

Corner star pickets and side plot pegs were installed, mapping out the 1x1 m grid cells. Planting was undertaken in mid-May 2017 to align with milder temperatures and allow sufficient establishment time prior to summer. Holes were dug on the day of planting and each of the 316 translocants was watered in with 1 L within a 10 cm radius of the plant base. Translocants in the fenced treatment were immediately individually fenced with a cylindrical open top cage (40 mm wire mesh, 1.4 mm gauge, 60 cm high), secured around the base with tent pegs.

Timing of the supplementary watering for translocants in the watered treatment used modelled landscape actual evapotranspiration and precipitation values from BOM (2019) to determine daily moisture loss/gain. Plants were watered when the cumulative moisture loss exceeded -40 mm. Each of the 158 'water treatment' translocants were watered with 1 L water, within a 10 cm radius of the plant base. Plants were watered on 21 August 2017, 22 September 2017, 6 December 2017, 29 January 2018, 17 April 2018, 25 September 2018, 26 November 2018, 24 January 2019, 11 March 2019, and 2 May 2019.

Plants were monitored with a full survey (assessing a range of plant health indicators) on planting day, and one, two, three, six, nine, 12, 15, and 21 months post-planting, and a part survey (assessing flower status and survivorship only) 25 months post-planting. Translocants were assigned a health score using a sliding scale where three is the highest score and zero is assumed dead. Fixed photo points also monitored changes in the habitat. Site integrity was monitored during surveys and opportunistically (e.g. fencing intact, pest or weed impacts, signs of vandalism).

Subsequent actions

A bushfire on 15 August 2018 burnt the whole translocation site and the whole natural population excluding three genets. This introduced an additional 'treatment' to the design. The original experimental design was maintained, with monitoring and watering continuing until the end of Year Three. An additional metal in-ground peg was installed for each translocant post-fire (including all plants assumed to be dead) to aid identification of plant location. Melted orange horticultural tags were also replaced, as needed.

The translocants will continue to be monitored for a minimum of three years post-planting, after which a review will decide on further monitoring/management/experimental design arrangements and timeframes.

Outcomes/Outputs

Preliminary results are presented; they exclude statistical and multivariate analyses.

The *a priori* short-term target of 10% survival at Year 1 was met (75% survivorship, Figure 1). Thirteen months post-planting, 70% of translocants were alive. Twenty-five months post-planting, and 10 months post-fire, no translocants presumed dead pre-fire had re-sprouted. An additional 50% of the translocants died after the fire. Twenty per cent of the original translocants survived 10 months post-fire.

There was a post-fire plant health transition. Immediately post-fire, plant health varied (health score 1-3); two months on, all surviving plants were in poor condition (health score 1); 10 months post-fire, all surviving plants were in good condition (health score 3). Translocants that survived 10 months post-fire (25 months post-planting) displayed lush, and often vigorous, new growth re-sprouted from the plant base/rootstock.

The mid- to long-term target of >60% survival was on-track pre-fire, however can no longer be achieved having lost an extra 50% of the original translocants 10 months post-fire, in addition to the pre-fire 30% loss.

Pre-fire, the mid- to long-term target to retain full genet representation was also met. Different genets had different survival rates pre-fire (50-100% 13 months post-planting, Figure 2), and 10 months post-fire (0-42 %

25 months post-planting). Post-fire genet survival of translocants alive two months pre-fire ranged from 0-56 %. Genet 12 was lost, and five other genets had only one or two individuals (2-17% survivorship of the original individuals). Disproportionate numbers of individuals planted from the different genets may have influenced the results; some genets are known to perform better in the *ex situ* collections (J. Beattie, pers. comm. 2017).

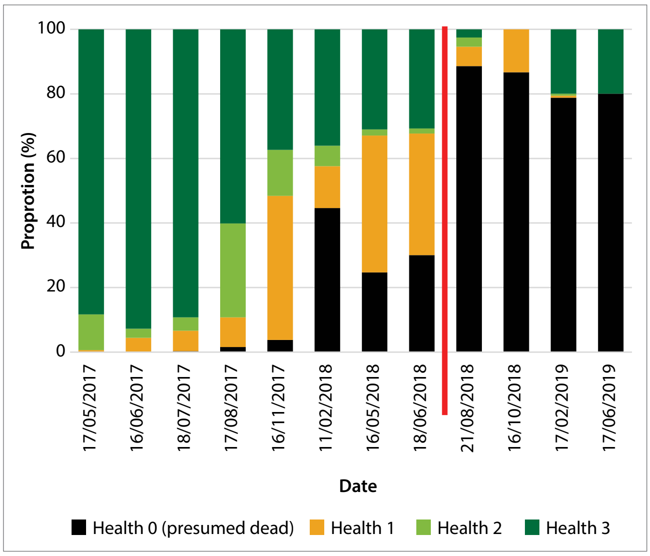

Figure 1. Bomaderry Zieria translocant survival (health score 0-3) timeline. The red line denotes the bushfire.

Using pot size as a surrogate of plant age, younger plants had higher survival rates pre- and post-fire (Table 1). Sixty-one per cent of the younger translocants alive pre-fire survived 10 months post-fire. Post-fire survival of pre-fire survivors was ~20% for all other plant ages.

Watering and/or fencing improved survivorship both pre- and post-fire (Figure 3). Thirteen months post-planting, survivorship was highest for the watered and fenced treatment. Twenty-five months post-planting, survivorship was highest for the watered treatment. Survivorship of pre-fire individuals after the fire was highest for watered individuals (39%), followed by watered and fenced (27%), nil treatment (26%) and fenced (22%). Possible biases from genet and pot size within treatments warrants further investigation in terms of resilience to the fire, and survivorship more broadly, to disentangle their level of influence.

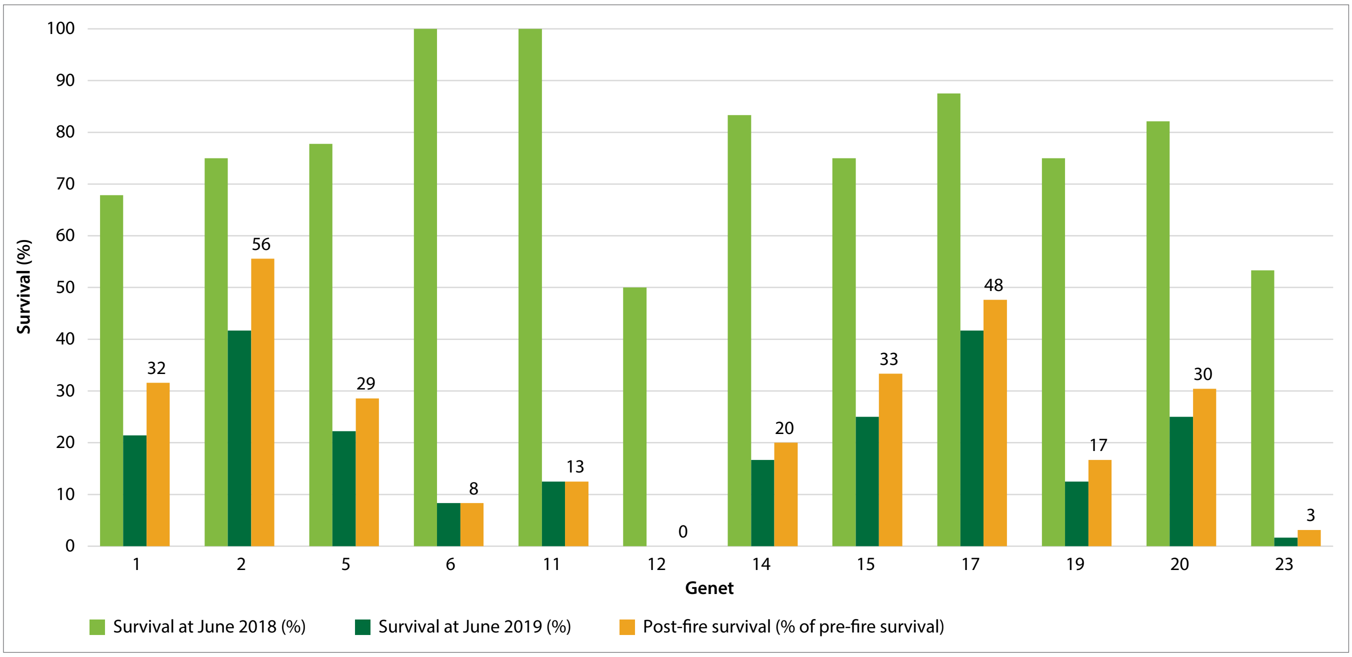

Figure 2. Bomaderry Zieria translocant survival across genets.

Table 1. Bomaderry Zieria translocant survival for different pot sizes (where pot size is a surrogate for plant age).

Pot size (mm)	Sample size (n)	Survival (%) 13 months post-planting; 2 months pre-fire (June 2018)	Survival (%) 25 months post-planting; 10 months post-fire (June 2019)	Survival (%) of individuals alive 2 months pre-fire, 10 months post-fire
50-100	48	85	52	61
120-125	158	61	13	21
140-175	91	76	16	22
200-250	19	79	16	20

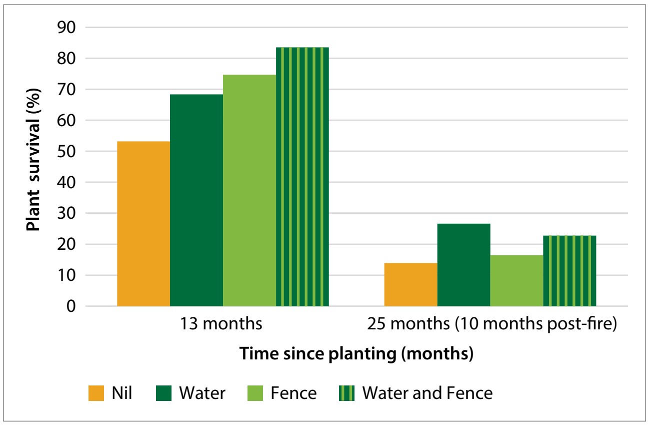

Figure 3. Bomaderry Zieria translocant survival across treatment groups.

As at June 2019: 54 plants had insect damage (86% of the surviving translocants); and seven plants had browsing damage. Insect and browser (native and exotic) damage were also reported in the natural population, post-fire-recovery.

The interrelationships between, and determinant strengths of, the variables of treatment, genet and pot size with survivorship needs further analysis. They may help to explain some of the currently unexpected trends; for example, why plants in the watered treatment have higher survival rates than plants in the watered and fenced treatment.

What we learned

- Plant sufficient numbers of translocants to maximise the likelihood of success, allowing for natural loss and for stochastic events (e.g. fire), as per Silcock *et al.* (2019).
- Ensure there are sufficient resources, human in-kind and financial, for the longer-term monitoring and management of any translocation/ augmentation attempt.
- Propagated Bomaderry Zieria *ex situ* seedlings can survive transplantation back into the natural environment.
- Watering and/or fencing improves *Z. baeuerlenii* survivorship generally (and may offer added resilience to surviving a bushfire, thus far at least). The *in situ* population appears to support these findings, in terms of improved survivorship when manually watered during times of low rainfall, and when fenced.
- Certain *Z. baeuerlenii* genets, and younger plants, appear 'stronger' in terms of their survivorship both pre- and post-fire.
- Fire may induce re-sprouting of healthy, new stems of increased vigour, provided the rootstock is sufficiently protected and hydrated at the time of the fire, and that sufficient follow-up rain falls post-fire.

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