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**Figure 1.** John Taylor and his dog Wink during surveillance operations for *Spartina* in the Avon – Heathcote Estuary. (Photo: ECan photo library).

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## **Ex situ threatened calcicoles of Canterbury: developing a limestone collection in the Christchurch Botanic Gardens**

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Christchurch Botanic Gardens

While often seen as only a pretty amenity park, the Christchurch Botanic Gardens has always grown a range of threatened plants for conservation purposes and for display to the public. Many curators and managers of the Christchurch Botanic Gardens, and earlier of the Christchurch Domain, have been committed to conserving rare and endangered species within its plant collections. These priorities were formally laid out by David Given in the *Christchurch Botanic Gardens Management Plan 2007*, including the objective “To grow a wide range of New Zealand subalpine and montane plants, including those that are rare and endangered, with an emphasis on plants of the Canterbury region”. A sub-Policy adds that “A New Zealand limestone garden shall be developed in the New Zealand section... *Comment:* New Zealand limestone plants contain a number of rare and attractive species, many of which are at threat in the wild”. Lawrie Metcalf had already imported limestone rocks into the subalpine area of the Cockayne Memorial Garden with this very intention.

Canterbury is home to a number of endangered species with 17.5% of Canterbury’s threatened flora existing in limestone ecosystems. The effects of browsing and the excluding effect of exotic pasture grasses and weeds have pushed many plants to their limits. Tiny populations of some of the country’s most critically endangered species occur in Canterbury and a number of these species only occur at one location. Multiple *Ranunculus* spp. (including the Castle Hill buttercup), *Gentianella* spp. and *Geranium* spp. are all extremely vulnerable to

extinction. Others such as *Lepidium solandri* and *Myosotis colensoi* represent unique limestone populations that need protection. The book *Conserving the plants of eastern South Island limestone Ngā tipu ō te pākeho* by Peter Heenan and Geoffrey Rogers and published by the Canterbury Botanical Society outlines the what, where and whys of limestone plants in the eastern South island. It expresses the urgent need for further research into habitat requirements, reproductive restraints, and the development of an appropriate methodology for ex situ conservation and potential translocation of species. I am the Collection Curator of the New Zealand plant collection in the Botanic Gardens, and have previously worked for the Department of Conservation in a range of positions including one at the Department of Conservation nursery at Motukarara, and have a strong interest in cultivating the threatened plants of the eastern South Island.

### **Ex situ conservation in the Christchurch Botanic Gardens**

It is recognised that botanical gardens throughout the world provide great opportunities to contribute to plant conservation. The Christchurch Botanic Gardens can contribute to the protection of these threatened plants in several ways:

- Public education. With over a million visitors a year the Botanic Gardens provides a great platform for the education of the public about these plants and their tenuous lives.
- The establishment of an ex situ population safe from herbivore predation.
- Propagation of plants for return to the wild. This can be from the ex situ populations, or by continuing to be done from wild-sourced seed to supplement the ex situ population and contribute to replanting or translocation.
- Seed farming and banking. There is opportunity to grow and produce seed in quantities that are suitable for broad scale sowing trials and seed banking protection.
- Study of the plants themselves, and their pests and diseases. The Botanic Gardens provide an isolated environment where a number of the variables facing the plants growing in the wild could be controlled. This would allow a systematic study of the effects of each variable.

### **Ex situ limestone gardens**

Two comparative limestone gardens have been developed and refurbished within the New Zealand plant collection:

1. A new limestone area has been developed on the edge of the *Veronica (Hebe)* garden by the Water Garden (Fig. 1, p. 69). It is positioned at the top of a north-facing bank and receives sun almost all of the day. This garden was prepared by digging in 3 m<sup>3</sup> of fine Springfield limestone to the existing soil, arranging Springfield limestone rocks to create micro habitats, and then covering the ground with fine Springfield Limestone chip and larger Ahuriri Limestone chip to a depth of 5 cm. Weed growth has been minimal in the limestone substrate and over the last two years it has been naturally colonised by mosses. In the peak of summer this garden is occasionally watered to support surrounding vegetation.
2. Within the Alpine Garden of the New Zealand plant collection, the former Limestone Bed has been cleared and redeveloped to provide a second area for limestone plants. This area was created by Laurie Metcalf in the 1960s and contains a limestone blend soil with large limestone boulders. This once open area has been over-shadowed by surrounding trees and its now shady nature has allowed it to be completely colonised by the limestone fern *Asplenium lyallii*, with natural regeneration of *Astelia fragrans*, *Melicytus ramiflorus* and *Macropiper excelsum*. The soils have developed over time due to the natural accumulation of organic leaf litter and the soil-mixing and building qualities of earthworms. Work to thin the woody vegetation and ferns followed by a replenishment of the limestone substrate has redeveloped the space for new plantings. The conditions in this area will allow us to investigate the former microclimates and niches created within or alongside woody vegetation. As stated by Heenan and Rogers (2019, p. 34):

*Today much of the woody tree and shrub vegetation has been cleared or burnt from around limestone bluffs and outcrops...these forests and shrublands would have provided suitable conditions for indigenous grasses and lower-statured herbaceous species growing directly on the limestone outcrops and crevices, edges and solution hollows and on associated talus and rock debris...Currently, many of*

*the limestone specialists are growing in suboptimal sites where they are exposed to low and fluctuating humidity, desiccating effects of sun and wind, and skeletal dry soils.*



**Figure 1.** The new limestone area developed on the edge of the *Veronica (Hebe)* garden.

### **Propagation of calcicole plants**

*Seeds of various limestone species sown in August 2019*

Seeds of multiple limestone species were provided by Daniel Kimber of the Department of Conservation. Under current management by DOC, the plants are already grown at the DOC nursery at Motukarara and by Danny at the Waimakariri Area Office. Herman Frank, under the advice of Nick Head, also provided seed from multiple species of limestone plants from South Canterbury. Seeds were kept under refrigeration for the winter and were sown in August 2019.

A germination condition experiment was trialled by sowing the seeds on one of two different substrates: either a blend of 70% Springfield limestone to 30% potting mix, or a straight potting mix. A layer of Springfield limestone chip was used to cover the seeds on both of these seed beds to a depth of 5-10 mm.

Seeds were treated in the same manner for all seed sowing trials. Seed trays were kept on a raised bench within a covered but unheated nursery shade house. Seed trays were watered by hand when observed to be dry in a covered nursery environment where they received no natural rainfall.

All species germinated in the first season on the limestone substrate, but only a few on the potting mix. This was seen as an obvious example of their limestone specialisation. During subsequent seasons germination continued to occur in both treatments including seeds that had not initially germinated on the potting mix. This debunked any previous assumption that the potting mix had caused the seed to spoil or rot.

Seedlings rapidly grew deep roots to the bottom of the pot, showing their adaptations for surviving in drought-prone sites. Plant growth in the potting mix far exceeded that in the limestone blend with plants germinated in the potting mix growing far larger and with greener leaves. *Ranunculus paucifolius* showed the least difference between the two treatments.

Seedlings were grown on under the same nursery conditions and “Threatened Plant intern”, Ashlin Freear, and I pricked them out into the 70% limestone mix. All plants of *Ranunculus* spp. and *Lepidium solandri* were potted, but due to high germination rates only a limited number of *Gentianella* were potted and many remain in seed trays.

Plants grew well under nursery conditions, unnaturally better than they would have done in the wild. Plants grew tall, upright and open in form, and large in size. A number of plants were planted outside into a range of micro-habitats within the new limestone area in the autumn of 2020. Plants planted out in the open garden quickly transformed from their upright, leggy form in the nursery into squat flat rosettes more typical of their natural appearance.

*Seed sown on a conventional seedbed of sand in July 2020*

A second sowing of seed, and of three additional species, were sown at the end of July 2020. These were sown along with other alpine plants using conventional nursery methods. Seed was sown onto bedding sand with a layer of 5 mm stone chip over top. Sand is good at maintaining suitable levels of moisture but remains aerated, and the layer of chip ensures good seedbed contact and does not harbour fungal pathogens. Germination rates did not seem affected by this treatment.

### **Plants propagated for the limestone beds of the Botanic Gardens**

*Ranunculus callianthus*, Tengawai buttercup (sown 2/9/19)

This species has proved easy to propagate. It is the most tolerant of different soil conditions and grows well in the nursery. It is prone to powdery mildew under cover, but quickly hardens off when planted outdoors. Germination rates are high and this plant will be a prominent feature of the limestone garden. Eight plants were initially planted in the sunny limestone garden and did well. All of these initial plants flowered and three subsequently died. Seedlings have been observed emerging from the limestone chip surrounding the dead plants. In December 2020, 30 more plants were planted into each display garden to compare their performance in different conditions. Plants in the sunny garden quickly took on their flat form, with plants in the shaded garden continuing to grow large and upright. None of these 60 plants has flowered or died as of 2021.

*Ranunculus paucifolius*, Castle Hill buttercup (collected 15/2/19; sown 2/9/19)

The Castle Hill buttercup had lower germination rates, but still seemed to germinate in both limestone mix and potting mix. *Ranunculus paucifolius* continues to germinate in its pot a year after sowing, with seedlings still emerging in the winter of 2020. Growth is much slower than that of *R. callianthus*, and plants remain too small to be planted out into the garden. Work will have to be done to keep these two plants separate during flowering to avoid cross pollination. If seed of *R. paucifolius* is required, the flowers of *R. callianthus* will be removed. Sown onto sand (28/7/20), one plant germinated.

*Lepidium solandri*, Maniototo peppercress, Castle Hill (seed collected 16/2/16; sown 2/9/19)

Few plants germinated in either the potting mix or the limestone treatments and this may be due to the age of the seed provided. Plants that germinated in potting mix grew very well, while plants that germinated in limestone substrate continue to struggle. These have been prone to aphids under nursery conditions. Ten plants were potted up into limestone substrate but many continued to struggle and die. Five plants were planted out in the sunny limestone garden where they remain alive. Their new growth is greatly reduced in size with plants barely noticeable amongst the limestone chip. Sown on sand (28/7/20), there was no germination.

*Gentianella calcis* subsp. *waipara* (sown 2/9/19)

There was limited germination of this species, and in the limestone substrate only. Some of these seedlings appeared to succumb to damping off. Plants that were potted up have done little since potting, and continue to languish in the nursery. They do not seem to like the conditions provided in the nursery environment and only one plant remains potted up, and two later to emerge seedlings remain in seed tray.

*Gentianella calcis* subsp. *taiko* (sown 2/9/19)

Seeds from two separate populations were sown individually under the two treatments. Large numbers of seedlings germinated but only on the limestone substrate. A number of these seedlings were potted up. During the Covid-19 lockdown of 2020 some plants missed out on watering and became extremely desiccated. Upon receiving regular watering again these plants were able to fully recover, although their weakened state caused them to become susceptible to an infestation of whitefly. These plants were treated with “plant soap” and were subsequently planted out into the limestone garden in August 2020. Of the 15 plants in the garden, 12 are

doing well with no subsequent infestations of pests. Three plants have died, two of unknown reasons and the third was smothered by *Geranium socolateum*.

*Gentianella calcis* subsp. *manahune* (sown 2/9/19)

Seeds from three separate populations were sown. Once again large numbers of seedlings germinated but only on the limestone substrate. A number of these seedlings were potted up. During the Covid-19 lockdown of 2020 some plants missed out on watering and became extremely desiccated. Upon receiving regular watering again these plants were able to fully recover, but became susceptible to an infestation of whitefly. These plants were also treated with “plant soap” and the white fly was controlled. These plants have not been planted out into the limestone garden as we need to keep these separate from *G. subsp. taiko*.

*Geranium socolateum*, limestone geranium

This plant is prolific in cultivation and can quickly become a weed in nursery conditions. Little effort has been made to propagate this species as the two stock plants held in the nursery produce a number of self-sown seedlings. Three plants were planted in each of the limestone gardens and rapidly naturalised. By January 2020 there were over 400 plants present in the sunny limestone bed and it was clear that this species was going to dominate. It was decided to intervene to stop it from interfering with rarer, less vigorous plants. Naturalisation was much restricted in the shaded limestone bed with only 14 seedlings recorded. As with most geraniums this appears to be a species that requires high light environments. Its growth in the shade is very upright whereas in full sun environments it forms a dense mat.

*Veronica maccaskillii*, limestone sunhebe (sown on sand 28/7/20)

Good germination on sand, and potted into 70% limestone chip with 30% potting mix but suffered damping off and mildew in nursery pots. It was decided that although very small the plants would be trialled in the garden. In autumn 2021, five plants were planted into each display garden in a range of habitats. Most of these continued to go backwards in condition with only four plants persisting in the full sun display garden, and none persisting in the shady garden.

*Aciphylla* aff. *ferox* “Mt Cass” (sown on sand 28/7/20)

Good germination on sand. 50 plants were potted into 70% limestone chip with 30% potting mix, and three plants were planted into both display gardens in a range of habitats. All continue to grow well.

*Australopyrum calcis* subsp. *optatum*, Canterbury limestone wheatgrass (sown on sand 28/7/20)

Average germination rate with eight plants potted into 70% limestone chip with 30% potting mix. Plants did well in the nursery and four were planted out in each garden autumn 2021. Plants continue to grow in all locations planted but in the shaded garden they are larger and more lax. The true test of their habitat preference will occur over the summer of 2021/2 when exposed to full sun and dry conditions in the sunny garden.

*Asplenium lyallii*

“*Asplenium lucidum* var. *lyallii*” #446 Lawrie Metcalf Herbarium, Christchurch Botanic Gardens. Wild-collected by Lawrie Metcalf in 1962 at Woodside Creek, Marlborough. “Not uncommon in shady places on rocks etc.” Planted in the New Zealand alpine garden by Lawrie Metcalf and subsequently naturalised on limestone boulders.

During the redevelopment of the old limestone garden hybrid *Asplenium* plants were discovered amongst the naturalised *Asplenium lyallii*. One of these hybrids appears to be of *A. lyallii* x *A. oblongifolium* parentage, which could be a new hybrid record if confirmed, and another may be of *A. lyallii* x *A. flaccidum* parentage. It was suggested that as these were uncommon hybrids these plants should be retained as an “oddity” (Leon Perry, Te Papa, pers. comm.).

## Conclusions

In the Botanic Gardens nursery most species proved relatively easy to germinate. Plants tolerated being potted up into limestone substrate although many did not enjoy being grown on in the cold, shaded, humid nursery environment. Species that require high light and airflow, like the sun hebe (*Veronica maccaskillii*), struggled the most, but *Ranunculus callianthus* and *Australopyrum* coped well in shady environments.

Germination was definitely faster and more consistent on the limestone substrate, but this does pose its own challenges. Limestone substrate is prone to drying out faster and forms into a very hard block when dry. The author believes it is important that any plants grown for translocation are grown in a substrate similar or as close as practicable to their destined soil type. This may impact on speed of growth, but might better prepare them for planting out. Recent restoration plantings of *Ranunculus paucifolius* have been largely unsuccessful (Daniel Kimber pers. comm.) as the plants do not seem to cope through dry conditions.

Seedlings exhibited fast, deep root growth and some investigation should be conducted around this. Pot shape and depth could be explored as a means to encourage deep roots for transplanting. Planting of young plants in the right conditions (probably autumn) where they can get their roots down deep to establish before the summer dry could be important.

There are some ongoing questions and considerations. Comparisons between the performance of plants in high light and semi-shaded environments will need to be observed over coming seasons. However, we are already seeing some difference in seedling recruitment and plant growth. Hygiene will be an important factor to consider in translocation. *Lepidium solandri* is infected with white rust throughout much of its range. The Castle Hill population does not currently seem to be affected, and care must be taken not to introduce this pathogen to the environment.

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### References

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[<http://www.ccc.govt.nz/Parks/HagleyParkBotanicGardens/ChChBotanicGardensMngtPlan/>]
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