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# Strings Attached: Managing *ex situ* plants highly susceptible to pathogens


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Cultivating plants in *ex situ* collections is an important method to support plant conservation. Several recent *ex situ* projects at Auckland Botanic Gardens (ABG) have highlighted some complexities of this approach when a plant is threatened by an invasive pathogen. For managers of wild sites, where threatened plants are declining due to pathogens, removing plants and/or germplasm to the safety of an *ex situ* provider such as a nursery or a botanic garden is a well-established response in threatened plant recovery management. For a recipient nursery, the opportunity to participate in threatened plant recovery is a tangible way to demonstrate a clear role in plant conservation and a rewarding way for staff to contribute to a recovery project. However if the subject plant is host to a devastating environmental pathogen which may infect other crops on site, put collections at risk or adversely affect other projects undertaken on site (including those with other stakeholders), thought must be given to how to manage these issues. When Myrtle Rust (*Austropuccinia psidii*) surfaced as a threat to Myrtaceae, many practices at our nursery were reviewed.

## Nursery Biosecurity

Nursery biosecurity is an increasing focus for nurseries and botanic gardens worldwide (Hayden 2020) to prevent the proliferation and movement of invasive pathogens which have the potential to adversely affect wild ecosystems and increase the risk of extinction of highly susceptible plant species. Nurseries provide pathogens with opportunities to infect a range of susceptible hosts or habitats (such as pots), in one location. Biosecurity accreditation schemes in both New Zealand (NZPPI) and Australia (Greenlife Industry Australia) assist nurseries to mitigate the risk through a systems approach to minimise the arrival and proliferation of pests in the nursery setting and mitigate the risk of introducing pathogens into new wild sites through infested nursery raised stock in revegetation programmes (Frankel *et al.* 2020). At its core, nursery biosecurity is based on the principle of preventing the arrival and establishment of a pathogen as the most effective way to maintain nursery hygiene.

## Growing susceptible species

Accepting material into an *ex situ* facility which is highly susceptible, for example to Myrtle Rust, from an area where Myrtle Rust is established, runs somewhat counter to biosecurity principles. Acquiring species susceptible to a specific invasive pathogen must be managed on a case by case basis depending on the nature of the pathogen, including its life cycle and mode of spread. Not all options for germplasm collection may be equally risky in terms of pathogen spread and this should be the key consideration before supplying material to an *ex situ* provider. For research purposes, including determining resistance, maintaining infected and uninfected plants is useful but should only be considered when this does not endanger other collections.

Relevant legislation must also be considered as, at least for a new incursion to a country or region, the pathogen may be subject to biosecurity laws which prevent movement of material (and may include all plants in a susceptible family, not just infected plants) and which may prescribe treatments (or require host destruction). Myrtle Rust, for example, remains an 'unwanted organism' under the New Zealand Biosecurity Act (1993) to prevent new strains arriving in New Zealand. As such, it is prohibited to knowingly move infested plants or spread Myrtle Rust to new locations. Discussions between *in situ* managers and *ex situ* providers should identify the best location for the *ex situ* collection, the management required to acquire and grow the species safely and produce an incursion response plan.

## Choosing an *ex situ* provider

This is arguably the most important decision in the conservation management of an *ex situ* population for a highly susceptible plant. There are two primary considerations: the services required and the geographic range of the invasive pathogen. Not all *ex situ* providers have the same facilities and an *ex situ* provider should be chosen based on whether they can hold the material for the purpose required. Most can propagate material from cuttings or seed to produce plants for display, seed orchards or production for translocation to the wild. Not all *ex situ* providers have seed banks or the ability to hold tissue cultures (and often this may be the least risky method of *ex situ* cultivation of a highly susceptible plant).

For a highly susceptible species, seed orchards or plant production for restoration is ideally undertaken by a provider outside of the climatic range of the pathogen. In most cases, a range of *ex situ* providers will be required to conserve a highly susceptible species. Botanic Gardens Australia New Zealand (BGANZ) is a network of *ex situ* providers who can facilitate discussions on the best providers to suit the needs of *in situ* managers. A network can also be used to find suitable locations for duplicate collections, that are essential as insurance against losses.

There is a role for many providers to contribute to the conservation of a highly susceptible plant species, for example, regional botanic gardens may be suitable for seed orchards outside of the range of the pathogen. Advice from relevant biosecurity agencies should be sought before moving potentially infected material to a location outside of the current range of the pathogen.

Three years prior to the arrival of Myrtle Rust ABG identified *Lophomyrtus* as a target for wild seed collection based on the susceptibility of similar species in Australia (*Rhodamnia* and *Rhodomyrtus*). The project revealed poor seed set on local wild plants. We planted seed-raised individuals with the intention of forming seed orchards to maximise seed production. Since the arrival of Myrtle Rust, all plants have died and while only a few had confirmed infections of Myrtle Rust, we realise that because our Garden is in the range of Myrtle Rust, that without fungicide treatments we are not the best location for a seed orchard. *Lophomyrtus* species (*Lophomyrtus bullata* and *L. obcordata*) and their cultivars (including natural hybrids) have more confirmed infections of Myrtle Rust (Figure 1) in New Zealand than any other species (Black *et al.* 2019). This genus is also emerging as the most affected New Zealand native species in the wild and both species are regarded as threatened (Nationally Critical; de Lange *et al.* 2017). No resistance has been detected to Myrtle Rust in *Lophomyrtus bullata* (Smith *et al.* 2020).

When Myrtle Rust arrived in New Zealand, we duplicated a collection of the highly threatened *Metrosideros bartlettii* to botanic gardens outside the expected climatic envelope of the rust. Long term, if a plant is highly susceptible to a pathogen then this is its most realistic chance for survival, and potentially only chance without intensive ongoing management.

**Figure 1. Myrtle Rust infection on *Lophomyrtus* 'Plum Duff'. Photo: Emma Bodley**

## Pathogen Management

An *ex situ* provider within the range of a pathogen may still be able to contribute to conserving a susceptible species. Each provider will have their own best practice for pathogen management, and this should be discussed to minimise the chance of moving a pathogen to an *ex situ* facility. At ABG, for example, no seeds which have fallen on the ground are collected for our revegetation programme to reduce the potential for soil containing the causal agent of Kauri Dieback (*Phytophthora agathidicida*) arriving.

Susceptible species may be managed by housing them separately to other crops. ABG hold more individuals of *Metrosideros bartlettii* (rāta Moehau) than any other *ex situ* location. This species is regarded as Nationally Critical (de Lange *et al.* 2017) with less than twenty plants known from the wild (Figure 2). We are custodians of this material held on behalf of local Māori communities to assist, eventually, with the return of species to the wild. Material was acquired before Myrtle Rust arrived in New Zealand and subsequent to the arrival of the rust, the rāta were placed in a separate greenhouse to provide a physical barrier to attempt to reduce inoculum reaching the plants. There is no overhead watering to reduce suitable conditions for Myrtle Rust, which prefers high humidity. The plants require hand-watering and a preventative fungicide programme operates in spring to late autumn applied at fortnightly intervals, and monthly in winter. It is important to observe plants regularly post treatment, as in some cases species will respond differently to types of fungicides. These may need to be tested to ensure no negative impact on the plant growth occurs with treatment regimes.

Treatment and control regimes can maintain the health of a crop, but this requires committing to an ongoing, potentially indefinite, programme. *Ex situ* providers must weigh up the costs to ongoing management including time to apply treatments, staff training to use chemicals and extra responsibilities such as surveying and monitoring. Surveying for incursions and monitoring plant health are critical to ensure a treatment regime is effective.

*Ex situ* providers in the range of a pathogen can be useful by providing material that is in high demand by researchers, which commercial nurseries may no longer provide. One of the early effects of the arrival of Myrtle Rust was the loss of *Lophomyrtus* species and cultivars from the trade. During the year-long eradication phase, any detection of Myrtle Rust in a nursery would result in loss of stock, restrictions on trade and reputational risk. *Ex situ* providers can fill this gap, if suitable treatments and controls can be put in place to ensure this does not affect other crops or projects.

The most difficult decisions about acquiring a highly susceptible plant will be those cases where so few wild sites remain after an incursion that any material brought into *ex situ* cultivation is infected. It is normal nursery practice that infested material is rejected or destroyed on arrival. Options for bringing highly susceptible material into cultivation must be discussed to identify the safest methods *e.g.,* collecting at a time when the pathogen may be dormant, cleaning the seed and treating material on arrival. Sommerville *et al.* (2020) outline an example of a treatment programme for producing 'clean plants' even after infection with Myrtle Rust. Pathologists and propagators must work together to establish the cleanest possible propagation strategy that ensures the plant is healthy and no other work is jeopardised.

**Figure 2. Flowers of rāta Moehua, *Metrosideros bartlettii*. Photo: Greg Meylan**

## Incursion Response Plan

For any *ex situ* provider acquiring a plant highly susceptible to an invasive pathogen, it is prudent to consider actions if an incursion occurs. An incursion plan is an agreed response if, or when, a pathogen arrives and infests the conservation collection. Ideally this plan is in place before or very soon after an *ex situ* program begins. All stakeholders must be consulted in its preparation, so there are no surprises or potential losses of valuable research or conservation material. Issue to address include deciding when to cull infected material. Material may still be treatable, depending on the pathogen, or the material may be useful for research. ABG acquired a collection of 13 cultivars of *Lophomyrtus* to test for resistance to Myrtle Rust and when they all became infected the plants were useful for a pathologist working on the rust. They are now planted in a research collection offsite (Beresford *et al.*, 2020).

An incursion plan is also likely required by nursery accreditation programmes and ensures systems have integrity. Plans also allay potential concerns of stakeholders involved in other projects at your facility. ABG grows 65,000 native plants each year for forest restoration (Figure 3). Three early successional species of Myrtaceae including *Metrosideros excelsa*

(pōhutukawa), *Leptospermum scoparium* (mānuka) and *Kunzea robusta* (kānuka) form the bulk of species we grow for revegetation projects. For the site managers where these plants will eventually be taken, a plan provides reassurance that work on highly susceptible Myrtaceae will not infect their plants, or the wild sites where they will be translocated.

## Summary

In the past three years, the incursion of Myrtle Rust has required Auckland Botanic Gardens to reflect on how we acquire plants which may be threatened, but which are also highly susceptible to an invasive pathogen that we do not want established in the nursery. The arrival of Myrtle Rust, a wind-borne pathogen, challenged our thinking about nursery hygiene because the rust had the potential to arrive despite our nursery biosecurity systems. We have deduced that our site may not be the best location for seed orchards of highly susceptible species (*e.g., Lophomyrtus* spp.), that this is an activity that would be better suited to a location outside of the range of Myrtle Rust. Others, such as *Metrosideros bartlettii*, are smaller collections held as insurance, and can be housed in a greenhouse separated from the main collections and treated with fungicide to prevent infection. We have established that if we get infections, we can re-home these plants to researchers. We advocate that managers of wild sites who require *ex situ* providers to support conserving plants highly susceptible to pathogens, that they discuss their requirements with a botanic garden to identify the best location for the *ex situ* collection, the treatments and controls required to manage it and a plan for when incursions occur.

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**Figure 3. Rows of native plants for forest restoration. Photo: Bec Stanley**