



Myrtle rust operational response plan

for *Rhodamnia rubescens*, *Rhodomyrtus psidioides* and *Lenwebbia* sp. Main Range

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images, or names of deceased persons in photographs or historical content.

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Introduction

Target species

Scrub turpentine (*Rhodamnia rubescens*) and native guava (*Rhodomyrtus psidioides*) are shrubs or small-to-medium trees of moist forest environments in New South Wales and south-east Queensland. Prior to the arrival of myrtle rust in Australia in 2010, these species were common and abundant, and dominated the mid-storey at some locations. Due to the impacts of myrtle rust, both species were listed as critically endangered in New South Wales under the NSW *Biodiversity Conservation Act 2016* in February 2019 and have been allocated to the 'Landscape' management stream in the NSW Saving our Species program. *Rhodamnia rubescens* is rated by Pegg et al. (2014a) as highly susceptible to extremely susceptible to infection by the myrtle rust pathogen; and *Rhodomyrtus psidioides* is rated as extremely susceptible (see below). Both species had few substantive threats prior to myrtle rust, but are now in very steep decline as a direct result of the disease (Carnegie et al. 2016; NSW TSSC 2019a, 2019b).

Lenwebbia sp. Main Range (PR Sharpe+ 4877) is a shrub or small tree of cloud-forest and cloudy cliff environments in the extreme north-east of New South Wales (Border Ranges) and south-east Queensland. It was a naturally rare species prior to the arrival of myrtle rust. It was provisionally listed as a critically endangered species on an emergency basis in New South Wales under the Biodiversity Conservation Act in January 2019, and a final determination to list in that category was made in October 2020 (NSW TSSC 2019c). It has been allocated to the 'Site-managed' management stream in the Saving our Species program. *Lenwebbia* sp. Main Range was not rated by Pegg et al. (2014), but field observations detailed in the provisional listing (NSW TSSC 2018) and observations since have determined it to be extremely susceptible.

What is myrtle rust

Myrtle rust disease is caused by the introduced fungal pathogen *Austropuccinia psidii*, which was first detected in Australia in 2010 (see Makinson 2018 for review of myrtle rust impacts in Australia). The pathogen prefers moister vegetation types and is currently distributed along the entire east coast of Australia with detections in Tasmania and the Northern Territory.

Myrtle rust only affects plants of the Myrtaceae family, which includes eucalypts, tea-trees, lilly pillies, paperbarks and bottlebrushes. This family is of fundamental importance in many Australian ecosystems and contains many species of economic importance. Several strains of *A. psidii* exist, although the 'pandemic' strain is the only one to have established in Australia so far. Eradication of the pathogen is no longer possible in eastern mainland Australia. Several other strains of the same pathogen remain confined to the Americas, where 2 are known to significantly affect plantation eucalypts. One distinct strain has also been identified in South Africa.



Image 1 **Field assessments of *Rhodamnia rubescens* (Craig Stehn/DCCEEW)**

Myrtle rust mainly attacks new growth (seasonal, seedling or resprout), without which plants cannot grow and renew their foliage. In highly susceptible species, severe repeated infection and defoliation causes death. The prolific spores are dispersed by wind, but animals may act as vectors over short or intermediate distances, and human movement and activity is a demonstrated vector over large distances.

Close to **400 Australian native species** and subspecies are known hosts of the myrtle rust pathogen already. **About 10% of these are seriously affected.** More than half of Australia's Myrtaceae species are yet to be exposed to, or tested against, the disease.



Image 2 Myrtle rust infection on the underside of a *Rhodamnia rubescens* leaf
(Craig Stehn/DCCEEW)

Resistance, susceptibility and tolerance

Different species of Myrtaceae exhibit different levels of susceptibility to the myrtle rust pathogen. Some Myrtaceae are not recorded as exhibiting any overt symptoms of infection – even under inoculation screening conditions that are optimal for the pathogen – and these species may be fully resistant. Such symptom-less species are not considered to be host species for the *A. psidii* pathogen.

A **host species** of the *A. psidii* pathogen is defined as one which is recorded as being infected and sustaining the life cycle of the pathogen (whether sexual or asexual) on one or more occasions. Australian and global host lists can be found on the Australian Network for Plant Conservation website (see link in ‘More information’ section).

A **susceptible** species is one capable of being infected, that is, becoming a host species, at any level of disease frequency or severity. Susceptibility ratings have been applied to many of the Australian host species where data are sufficient to indicate a consistent level or range of responses to the pathogen. The categories applied (Pegg et al. 2014a) are ‘relatively tolerant’, ‘moderately susceptible’, ‘highly susceptible’ and ‘extremely susceptible’. Individuals and populations within a species may exhibit a range of susceptibility and sometimes ‘full resistance’ as well.

The term **resistant** is also often used in a less absolute sense to indicate a variant of the host that is more tolerant of the pathogen than other members of the species or than close relatives. This usage of ‘resistant’ does not necessarily equate to ‘full resistance’ (immunity), although it may do so in some contexts. While this usage of the term resistance is applied at some points in this plan, all 3 species of concern are known host species with high to extreme susceptibility, and no known fully resistant genotypes. Part of the vision for eventual recovery of these species is the identification of genotypes or traits which may confer either greater rust tolerance (more resistance), or optimally full rust resistance – either condition is at this stage a possibility, and both offer potential for species recovery.

Features of decline in ‘extremely susceptible’ host species

There are no pathogen-free refugia:

- The entire ranges of the 3 target species are within the distribution of the pathogen.

There are no known ‘rust-resistant’ or significantly rust-tolerant genotypes within these species:

- Individuals showing genetically based resistance to the disease have not yet been identified, although it is possible that rare alleles for tolerance may exist.

Whole-of-range decline:

- All 3 species are declining across their entire ranges with many subpopulations lost and others greatly reduced in plant health and density.

Loss of large adults:

- Most large plants are now dead.
 - *Rhodamnia rubescens* survives mainly as mid-sized shrubs (3–4 m). These are subject to seasonal attack by myrtle rust, with reduced growth rates, very little fruit and seed production, and continuing mortality
 - *Rhodomyrtus psidioides* survives mainly as small suckers (20–60 cm) arising from surviving root systems of now-dead adults. Suckers may attain heights of 30–150 cm before being attacked and usually killed by new cycles of myrtle rust infection
 - *Lenwebbia* sp. Main Range, a shrubby species, survives mainly as defoliated individuals, with occasional fruit and seed produced (one known occurrence since 2016).

Reproductive failure:

- All 3 species have largely stopped producing flowers and fruits, and hence seed, in most years over most of their range. The leaves of any seedlings that do germinate are ideal new growth for infection by myrtle rust and fail to establish.

No soil-stored seed bank:

- All 3 species have seed that has evolved to germinate rapidly when mature. As such, there is no reservoir of older seed stored in the soil.

Pollination system decline:

- Declining density of adult plants means that pollen is less likely to be transferred between individuals, decreasing the rate of out-crossing (a mechanism that maintains a genetically healthy and fit population) and increasing the rate of selfing and in-breeding.

Management options

Vision for species recovery

The steep decline of all 3 target species since 2010 is directly attributable to the effects of myrtle rust disease operating across their entire geographic range. The mobility of *A. psidii* spores means that no refugia for susceptible host species are likely to occur within the east coast zone. Given documented declines since 2010, effective extinction in the wild (decline to negligible levels of occurrence, or a total lack of recruitment) is likely within the next 5–10 years. No feasible in situ management techniques for myrtle rust infection currently exist and ex situ germplasm holdings of all 3 species were at low levels prior to the commencement of this project.

Species recovery will require 3 key operational stages covering wild germplasm collection, the establishment of safe ex situ collections and the identification and transfer of resistance traits to wild populations. Concurrent with these operational requirements will be the establishment of project infrastructure and support systems and the securing of social licence to undertake these actions. Figure 1 provides a conceptual model of long-term species recovery for *Rhodamnia rubescens*, *Rhodomyrtus psidioides* and *Lenwebbia* sp. Main Range.



Figure 1 Conceptual model of long-term species recovery for *Rhodamnia rubescens*, *Rhodomyrtus psidioides* and *Lenwebbia* sp. Main Range

Priority management actions

The conservation of these species and their genetic diversity and any eventual reintroduction of rust-resistant genotypes into the wild rests on the implementation of short-term emergency action and targeted research and development over the medium and long terms. The short-term, medium-term and long-term priorities are summarised in Table 1.

Table 1 **Short-term, medium-term and long-term management action priorities**

Action type	Action description	Short	Medium	Long
Field surveys and monitoring	Active field survey for plants or populations exhibiting unusual levels of tolerance of the rust and monitoring of myrtle rust impacts on target species.	Yes	Yes	Yes
Germplasm collections and management	Capture and ex situ storage of genetically representative germplasm material (of all 3 species).	Yes	–	–
	Establish dispersed collection framework.	Yes	Yes	–
	Develop and maintain documented collections of genetically diverse live plants suitable for research and breeding purposes, preserving the full range of adaptive potential.	–	Yes	Yes
Resourcing	Establish ongoing support and resourcing for medium- and long-term actions.	Yes	Yes	–
Research	Undertake genetic research to inform collection management and project delivery.	Yes	–	–
	Utilise seed production areas to support research to identify rust-tolerant lineages, genetic and physiological bases of resistance and susceptibility, and heritability of resistance-related traits.	–	Yes	–
	Continue research on seed storage requirements of target species.	–	Yes	–
Reinforce and reintroduce	Selective breeding for rust resistance, and/or resistance-trait transfer.	–	Yes	–
	Deployment of reinforced wild-types for augmentation or reintroduction in the wild.	–	–	Yes
Communications	Develop an education and engagement strategy about the distribution and management requirements of the species.	Yes	Yes	Yes

Management challenges

Feasibility of identifying rust-tolerant genotypes and breeding them into wild-types

Many species of Myrtaceae are fully or strongly resistant to myrtle rust infection, and many more are affected at a moderate to severe level varying within the species. This response reflects the existence of variable genotypes and traits that confer some level of passive or active tolerance or resistance to the pathogen.

Rust-resistant and rust-tolerant genotypes are best understood in the eucalypt genera, and breeding for resistance to this pathogen in the eucalypt plantation context has been successfully developed in South America for some decades (Carnegie 2012). The existence of infraspecific variation in susceptibility is demonstrated in a range of wild-type eucalypts in Australia (Pegg et al. 2014b; Potts et al. 2016) and in the broad-leaved paperbark (*Melaleuca quinquenervia*) (Pegg et al. 2018). More tolerant genotypes are also known in lemon myrtle (*Backhousia citriodora*) (E Lancaster, University of Queensland, work in progress). Rust-tolerant genotypes may also exist in other host species as well. These genotypes may, however, be rare and unlikely to be detected without active survey.

The 3 host species in this plan are not yet known to have rust-resistant or rust-tolerant genotypes, although they exhibit somewhat different types of response to the pathogen, and *Rhodamnia rubescens* has some ability to maintain a new growth flush beyond an infection cycle if conditions are right. The survey work proposed for the short-term phase of this plan includes searches for consistently healthier plants or populations in the wild. The medium-term phase will allow for structured experimental testing for resistance or tolerance in an ex situ context.

If significant resistance-related genetic traits in these species do prove to be absent, the possibility of trait transfer from related species that do possess such genotypes is technically feasible.

Social, ecological and technical considerations for the long-term aim of species recovery

The 3 target species present an unusual case for conservation action in that even active management measures in situ are unlikely to ensure their survival in the wild. This situation is comparable to that of some frog species which are severely threatened in the wild by amphibian chytrid disease. The most likely path towards species recovery involves an extended process of ex situ storage and propagation/breeding, followed by reintroduction of modified genotypes to the wild.

This long-term goal presents a range of ecological, ethical and social/cultural issues, as well as technical and logistical challenges. Ecological issues include the impact of modified genotypes on the adaptive potential of the species, how to deal with niche

closure and the impacts of reintroduction activity. Ethical and cultural issues include the degree to which stakeholders and partners, including Indigenous custodians, are comfortable with this approach as an alternative to extinction. Consideration of these issues must be initiated early in the project in the expectation that resolution will be gradual and will involve extended liaison and dialogue, as well as technical work, that may modify project aims and practise.

Project partners and external collaborators

Several work units in the NSW Department of Climate Change, Energy, the Environment and Water (the department) are direct partners in the project, including Conservation Programs, Heritage and Regulation and the National Parks and Wildlife Service (NPWS). A closely related research project examining rust-resistance genetics in *Rhodamnia rubescens* and other species is also running through the Research Centre for Ecosystem Resilience at the Botanic Gardens of Sydney.

Most of the recovery actions currently funded in New South Wales are managed under the NSW Saving our Species program and are delivered by staff from the department (in particular Conservation Programs, Heritage and Regulation and NPWS). Links to the conservation strategies for each of the 3 species are provided in the 'More information' section of this plan.

The broad distribution of 2 of these species (*Rhodamnia rubescens* and *Rhodomyrtus psidioides*), and the need for a widespread search for rust-tolerant genotypes, imposes a large field component in the short- and medium-terms that would be hard to meet from departmental resources alone. For this reason, the plan proposes the use of skilled external collaborators to assist with the location of surviving plants, monitoring and, in some instances, the collection of germplasm material. Over 300 potential skilled collaborators have been identified, and extension materials prepared for their use. A phased involvement of these project supporters is envisaged as the project develops.

Given the 3 species also occur in Queensland, where some monitoring and recovery actions are underway, the development of partnerships with Queensland agencies and researchers is an early priority. An integrated approach to location, monitoring, germplasm capture and research on all 3 species is desirable, for these species and for others at risk from this pathogen and which may be listed as threatened in the future. Future administrative and resourcing arrangements relating to the myrtle rust threat may or may not facilitate a common approach, but in the interim, mechanisms for liaison, data interchange and collaboration should be encouraged and centrally developed.

Management of a dispersed conservation collection

The rapid decline of the 3 target species and lack of any current in situ threat management options dictate an extended strategy of capture and ex situ maintenance of large wild plant germplasm collections. The non-storability of seed of 2 of the 3 species (*Rhodomyrtus psidioides* and *Lenwebbia* sp. Main Range), and the expected short life in storage of the third (*Rhodamnia rubescens*), further dictate that a significant proportion of the germplasm must be held in the form of living whole plants.

A living collection would also provide a resource for screening rust susceptibility, testing genetic structure, researching the mechanisms of myrtle rust infection and host response, and as the basis for seed orcharding. A live collection of this scale would require significant resources and careful record keeping over the long term, including ongoing protection from rust and other pests and diseases, auditing of holdings and procedures to ensure the tracing of genetic lineages.

The scale of germplasm capture needed will require the cooperation of several institutions. Within the NSW project, inter-agency and inter-institutional arrangements are expected to develop. These already include germplasm custodial sharing with one Victorian and 2 Commonwealth institutions. Several botanic gardens and some other facilities in eastern Australia have the requisite combination of space, horticultural and record-keeping skills and facilities, labour-time, and climatic conditions to meet a custodial role for this project. Most have policy commitments supportive of conservation, either individually or through peak organisations like the Botanic Gardens Australia and New Zealand Incorporated.

A dispersed, but strongly integrated, plant conservation collection of this sort has few precedents in Australia, although it is more common overseas and with conservation-oriented zoos. International guidelines and experience will be adapted to the Australian context.

Germplasm capture strategies

Sampling strategy

The project's sampling strategy, described for each species in the following sections, is based on current best advice and assumes that most or all plants currently surviving in the wild are likely to be killed by myrtle rust in the relatively near future (5–10 years). Based on this assumption, the impact to wild populations associated with germplasm collection needs to be balanced with the likely conservation gains associated with the establishment of ex situ collections of these critically endangered species. Impacts to wild populations should not be ignored, and local sensitivities need to be considered when sampling, for example, switching from sucker excavation to sucker cuttings in *Rhodomyrtus psidioides*.

Neither the number of germplasm samples required to establish an ex situ collection, nor the extent of sampling in any one subpopulation needed to maximise the likelihood of capturing significant genetic variation are known for any of these species. Population-based genetic sampling and analysis would identify genetic variation and structuring at both between-population and within-population levels to help inform future collections. Also, the degree of decline has been so great that in many cases sampling will be constrained by the limited availability of healthy and right-stage material.



Image 3 Field collection of *Rhodamnia rubescens* cuttings. Craig Stehn/DCCEEW

Scrub turpentine (*Rhodamnia rubescens*)

The widespread distribution of *Rhodamnia rubescens* prior to 2010, as known from collections and survey records, showed some regional and subregional clustering. In the absence of specific knowledge of genetic structure within the species, an interim spatial definition of germplasm sampling zones will be used (see Figure 2).

Rhodamnia rubescens does sometimes coppice and may produce ‘remote’ suckers at some distance from the trunk of the parent plant, but unlike *Rhodomyrtus psidioides*, there are no observations to suggest that the root system survives long after death of the adult trunk or is prone to produce multiple annual suckers. As a working assumption, individuals of *Rhodamnia rubescens* within a patch are more likely to be genets than clonal ramets, although small patches may be selfed progeny from a single parent. Sampling should try to span the dimensions of a patch, if possible, with a minimum 10 m separation between sampled plants.

Sampling in *Rhodamnia rubescens* is generally by cuttings of suitably aged stem material, or less frequently by fruit/seed capture, with the proviso that seed yields from apparently mature wild fruits may be very low. Sucker collection may also be suitable.

An interim goal (years 1–3) is to secure a minimum of 6 individual vegetative lineages from at least 5 subpopulations in each of 9 germplasm sampling zones (a notional 270 maternal lineages in total), plus seed if uninfected full-sized ripe fruits are encountered. Anomalously healthy plants from any zone would be extra.

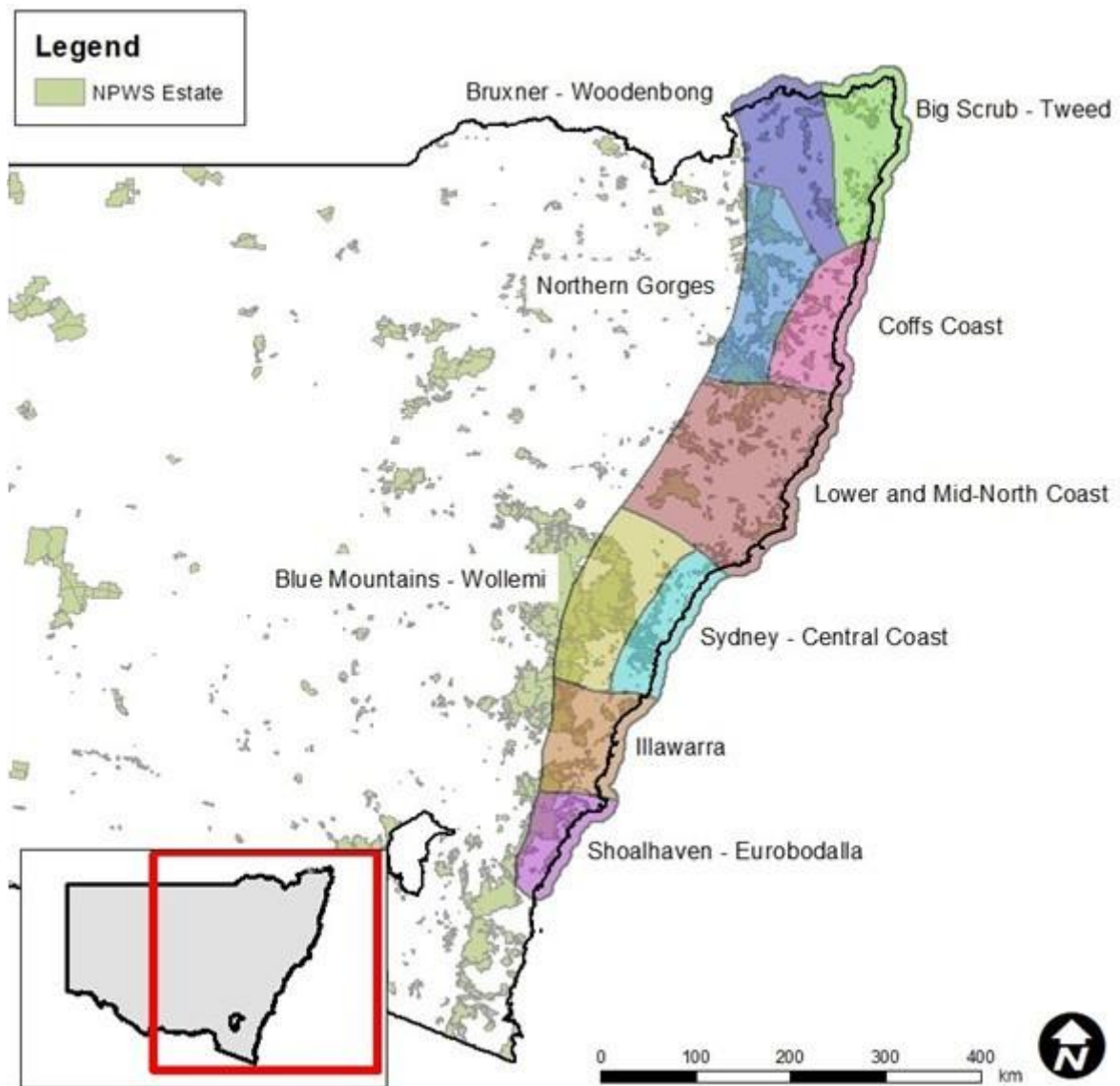


Figure 2 NSW range of *Rhodamnia rubescens* and interim collection zones

Native guava (*Rhodomyrtus psidioides*)

The widespread distribution of *Rhodomyrtus psidioides* prior to 2010, as known from collections and survey records, showed some regional and subregional clustering. In the absence of specific knowledge of genetic structure within the species, an interim spatial definition of germplasm sampling zones will be used (see Figure 3).

Rhodomyrtus psidioides was already known to reproduce by suckering as well as seed prior to the arrival of myrtle rust. It now survives in the wild largely as patches of suckers arising from the roots of dead adult stems, and at distances of up to 5–10 m from the parent plant. Sucker patches can be prolific, with several dozen sometimes inferred to be from a single parent root system. Such sucker patches are known from some sites in 2019 around the dead trunks of adults that were completely defoliated as early as the summer of 2010–11. It is uncertain how long such root systems have before they become exhausted. Emergent sucker survival appears to range from 1 to 3 years, after which they succumb to infection by myrtle rust.

Cuttings taken in spring from semi-firm shoots of both new-season and last-season suckers show good strike rates. However, early suckers may be too small, with too few leaf nodes, for good cuttings. Delayed collection may result in better cutting material but may also result in heavy summer/autumn myrtle rust infection that renders the whole sucker shoot unsuitable. One option to avoid this problem during collection is to excavate whole sucker units in spring prior to heavy infection. Trials have shown excellent survival rates for these whole suckers if handled and transported carefully. The project's 'Germplasm collection guidance sheet' provides information on best technique, although collection by professionals is optimal. Impact on the overall root system is a consideration if this method is used. Both methods (cuttings or suckers) are viable.

An interim goal (years 1–3) is to secure a minimum of 6 individual maternal vegetative lineages from at least 5 subpopulations in each of 6 germplasm sampling zones (a notional 180 maternal lineages in total), plus seed if uninfected and full-sized fruits are encountered. Anomalous healthy plants from any zone would be extra.

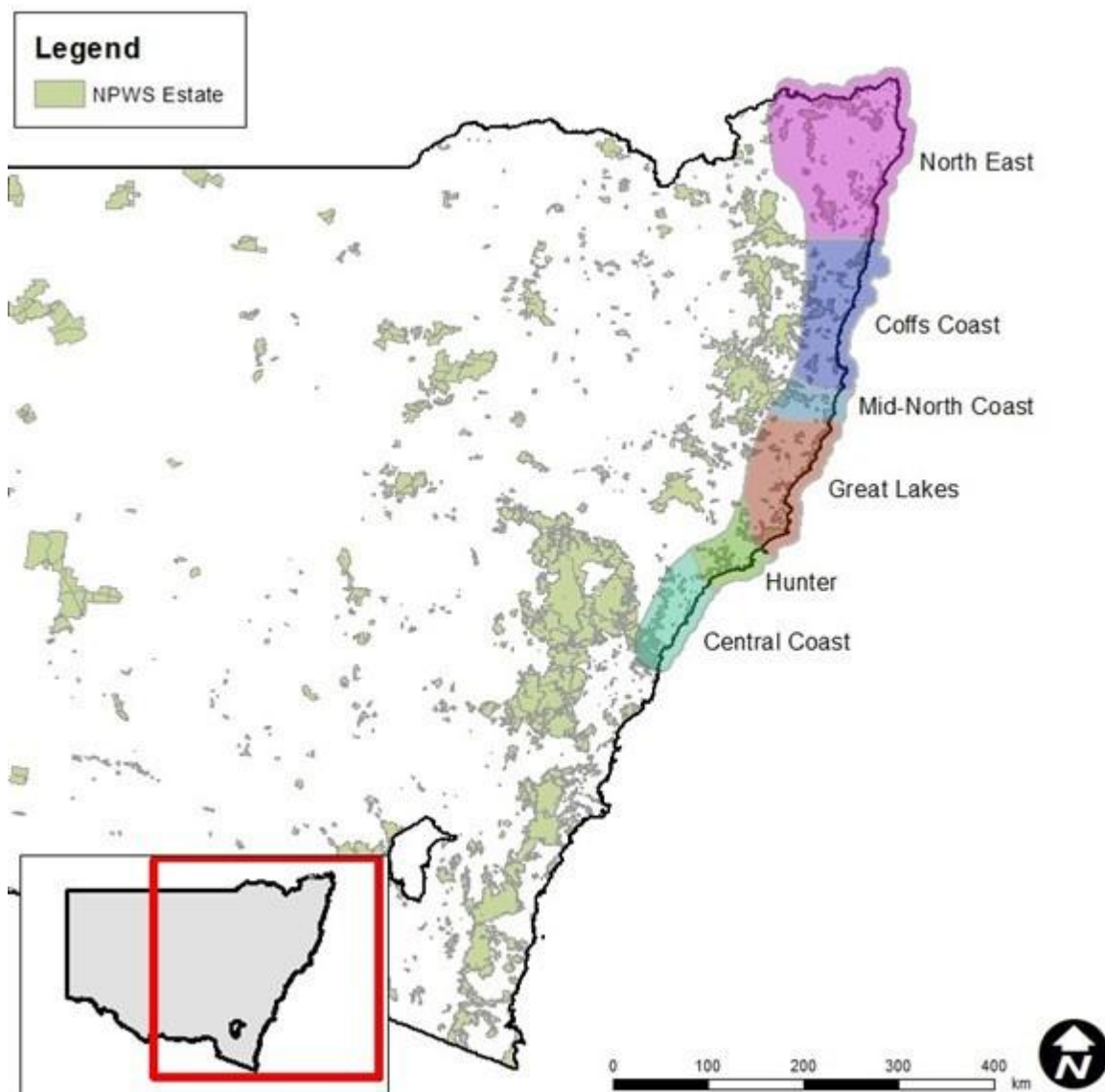


Figure 3 NSW range of *Rhodomyrtus psidioides* and interim collection zones

Lenwebbia sp. Main Range

The natural distribution of *Lenwebbia* sp. Main Range consists of several disjunct 'island' populations corresponding to suitable cloud-prone habitat. Up to 9 subpopulations are known on the New South Wales side of the border (as of December 2019) (see Figure 4 and Figure 5). Improved knowledge of the species distribution on the Queensland side may modify this.

A precautionary assumption is to collect germplasm as cuttings from as many genotypes as possible from each NSW subpopulation for propagation, and to treat each subpopulation as potentially genetically distinct until the genetic structure of the species is determined.

Lenwebbia sp. Main Range has been collected and successfully propagated using semi-hardwood cuttings from several subpopulations. The species produces weak coppice shoots from mature trunks on rare occasions, more commonly on fire-impacted individuals. No root suckering has been observed. Mature fruit has been collected from one individual from one site since 2016.

An interim goal (years 1–2) is to secure a minimum of 6 individual vegetative lineages from each subpopulation where the number of surviving and accessible plants permits, plus seed if fruits are encountered.

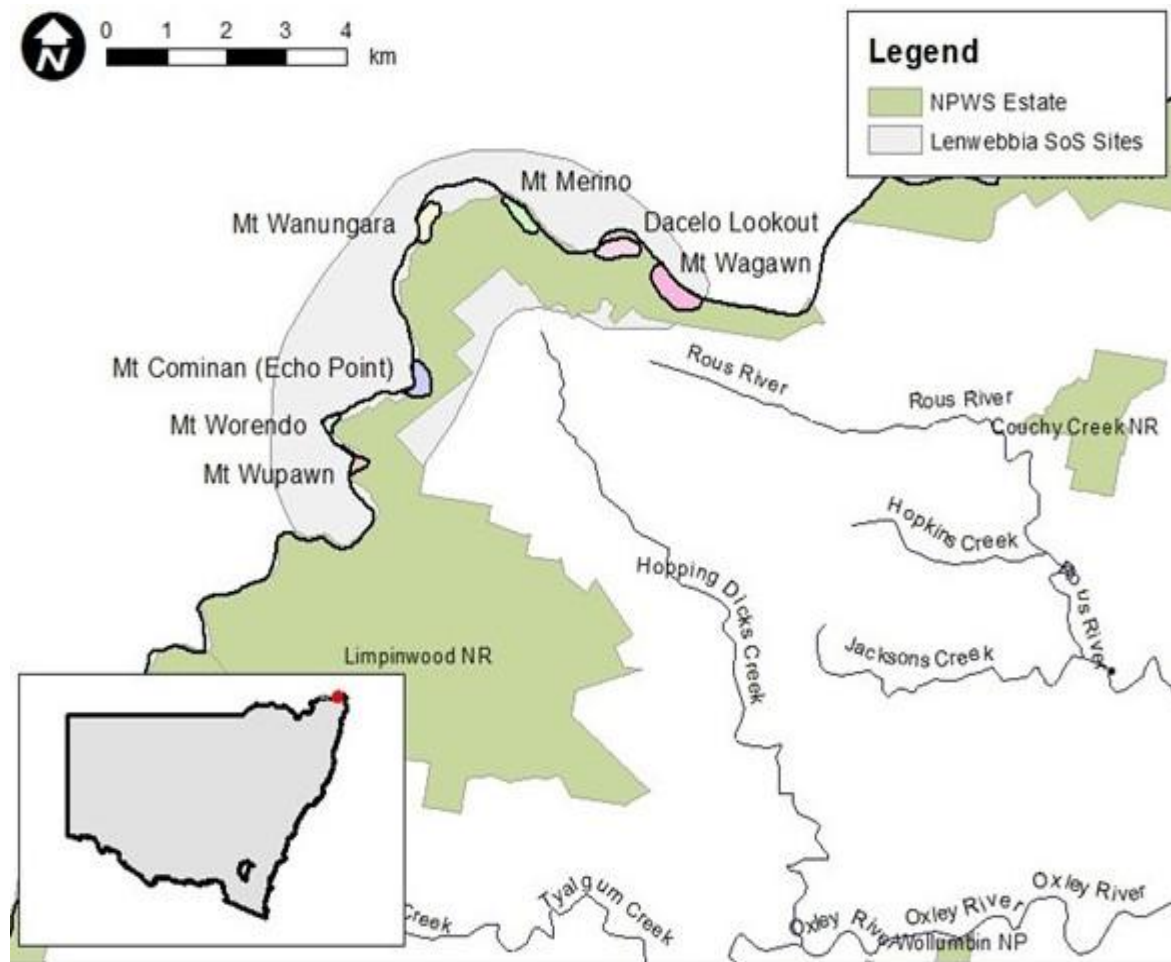


Figure 4 *Lenwebbia* sp. Main Range subpopulations within the eastern Saving our Species site

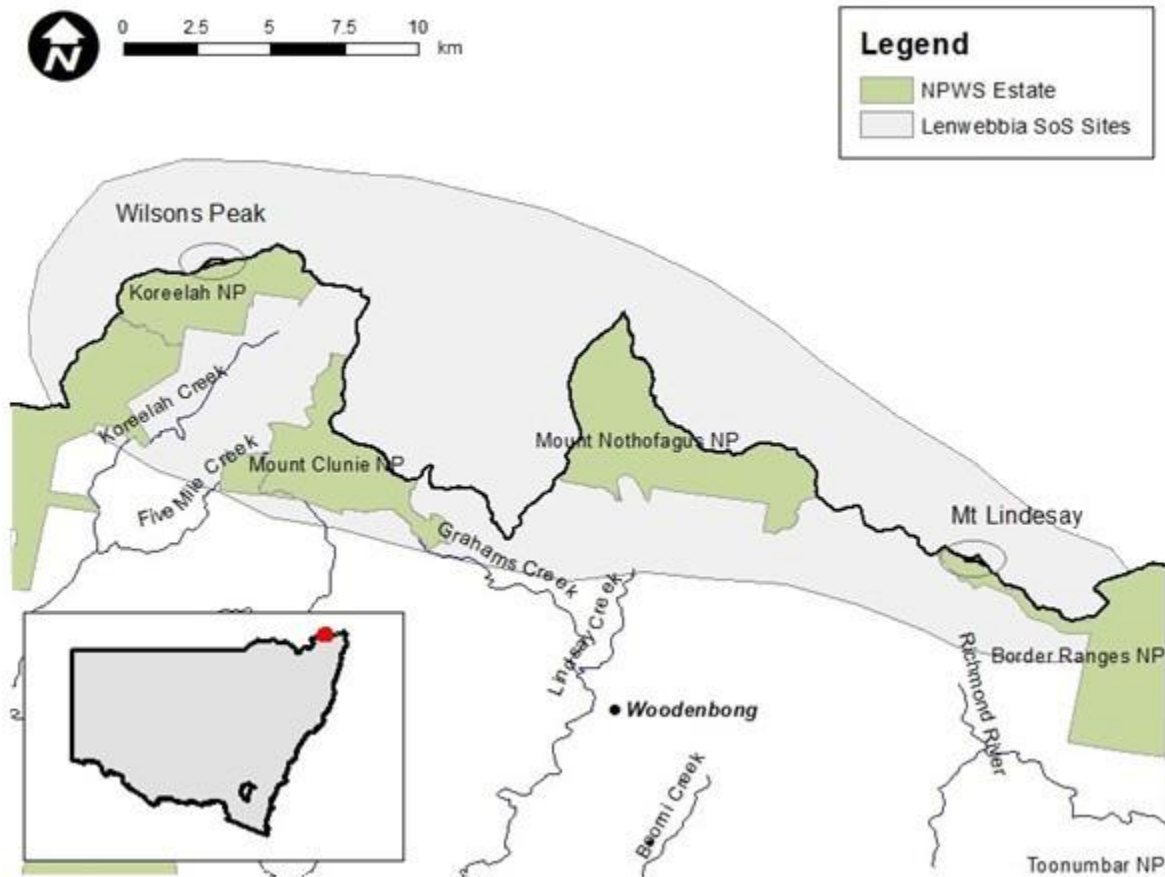


Figure 5 *Lenwebbia* sp. Main Range subpopulations (circled) within the western Saving our Species site

Seed collection and production

The seeds of *Rhodamnia rubescens* are tolerant of seed bank storage but are likely to be short-lived, limiting storage options to relatively short periods (Sommerville et al. 2019). Trial field collections in spring 2019 showed small yields of fruit and seed, with high rates of myrtle rust infection on maturing fruits, resulting in abortion or destruction of the seed. Wild collection of healthy fruits will remain important, but is likely to be secondary to seed production from protected cutting-grown plants of known provenance.

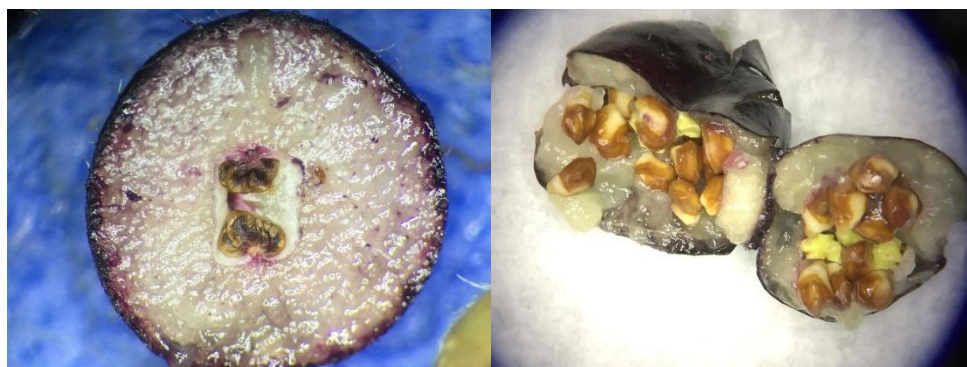


Image 4 Fruit from *Rhodamnia rubescens*. Left: fruit from a wild tree affected by myrtle rust. Right: fruit from a managed tree not affected by myrtle rust (Graeme Errington, Botanic Gardens of Sydney)

The seeds of *Rhodomyrtus psidioides* and *Lenwebbia* sp. Main Range are thought to be intolerant of seed bank conditions (Sommerville et al. 2019), although further research is needed if adequate quantities of seed become available. The setting and maturation of collectable quantities of seed in the wild is now very unlikely due to myrtle rust damage. Production from protected cutting-grown plants of known provenance in cultivation will be the main source of seed.

The response of seed of all 3 species to the expensive option of cryogenic storage is yet to be determined.

All 3 species mature quickly in cultivation and will flower and set fruit precociously (within 2–3 years). This offers good prospects to produce seed in cultivation when protected from myrtle rust impacts, and for the rapid (years 3–5) accumulation of adequate quantities of seed for storage tolerance testing, rust susceptibility screening, and growth and fitness trials across a range of wild genotypes. Assuming the successful isolation and infusion of rust-tolerance traits into wild-types over the longer term (years 5–10+), there are also good prospects for the rapid production of large quantities of seed for deployment in any approved reintroduction actions.

Species recovery actions

The following tables list the proposed recovery actions for the 3 target species. Actions have been grouped under 6 **action types**:

1. field surveys and monitoring
2. germplasm collections and management
3. resourcing
4. research
5. reinforce and reintroduce
6. communications.

Each action type has one or more **actions** associated with it, and each action has one or more **specific deliverables** described together with the deliverable priority, status, budget and responsibility. Responsible parties are:

- the department's Conservation Programs, Heritage and Regulation (CPHR)
- NSW National Parks and Wildlife (NPWS)
- Australian Botanic Gardens Mt Annan (ABGMA)
- Botanic Gardens of Sydney (BGoS)
- Royal Botanic Gardens Melbourne (RBGM)
- Australian National Botanic Gardens Canberra (ANBG).

All actions have also been assigned to an implementation timeframe: short-term (years 1–2), medium-term (years 3–5) and long-term (years 5–10+). All the following management actions have broad alignment with the national action plan for myrtle rust (Makinson et al. 2020).

1. Action type: Field surveys and monitoring

Table 2 details the specific deliverables for the action:

- Active field survey for plants or populations exhibiting unusual levels of tolerance of the rust and monitoring of myrtle rust impacts on target species.

Table 2 **Field surveys and monitoring action: Active field survey for plants or populations exhibiting unusual levels of tolerance of the rust and monitoring of myrtle rust impacts on target species**

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
All	‘Monitoring proforma’ and ‘Infection scoring guidance sheet’ developed, and field tested.	H	Completed	Nil	CPHR
All	Roll out ‘Recent sightings report form’ to relevant department and BGoS staff and external collaborators as and when required; ensure return data are shared between relevant key project nodes.	H	Completed	Nil	CPHR
All	Roll out ‘Monitoring proforma’ and ‘Infection scoring guidance sheet’ to relevant department and BGoS staff and external collaborators.	H	Completed	Nil	CPHR
All	Develop a multi-species monitoring plan to record long-term myrtle rust impacts on the target species and identify permanent monitoring sites.	H	Yet to be commenced	Contract \$6,000	CPHR, NPWS

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Continue impact assessment by Saving our Species and BGoS staff and external collaborators during germplasm collecting.	H	Ongoing	0.2 FTE	CPHR, NPWS
All	Implement multi-species monitoring plan at established permanent monitoring sites.	H	Ongoing	Contract \$10,000 per year	CPHR, NPWS
All	Establish permanent (non-project) repository for incoming monitoring and germplasm data.	H	Yet to be commenced	To be determined (TBD)	CPHR
Long-term (years 5–10+)					
All	Continue impact assessment by Saving our Species and BGoS staff and external collaborators during germplasm collecting.	H	Ongoing	0.2 FTE	CPHR, BGoS
All	Continue to implement multi-species monitoring plan at established permanent monitoring sites.	H	Ongoing	Contract \$10,000 per year	CPHR, NPWS
All	Data analysis at 5-year and 10-year milestone.	H	Yet to be commenced	TBD	CPHR

2. Action type: Germplasm collection and management

Table 3, Table 4 and Table 5, respectively, detail the specific deliverables for the following actions:

- Capture and ex situ storage of genetically representative germplasm material.
- Establish dispersed collection framework.
- Develop and maintain documented collections of genetically diverse live plants suitable for research and breeding purposes, preserving the full range of adaptive potential.

Table 3 Germplasm collection and management: Capture and ex situ storage of genetically representative germplasm material

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
All	Complete audit of live plant holdings of target species in cooperation with the Council of Heads of Australian Botanic Gardens and Botanic Gardens Australia and New Zealand Incorporated.	M	Yet to be commenced	TBD	ABGMA, CPHR
<i>Lenwebbia</i> sp. Main Range	Complete germplasm collecting for 3 sites not currently represented (Mt Wanungara, Mt Lindesay and Mt Wupawn).	H	Completed	\$12,000	ABGMA, NPWS
All	Finalise germplasm sampling from all populations. Cumulative target of 6 vegetative lineages from 9 subpopulations; combine with monitoring for survival/recruitment after fire.	H	Yet to be commenced	\$20,000	CPHR, NPWS
All	Initiate discussions with Queensland Department of the Environment, Tourism, Science and Innovation (DETSI) re. information exchange, complementarity of projects, and potential germplasm exchange.	M	Yet to be commenced	Nil	CPHR, ABGMA
All	Seek information from Queensland DETSI re. distribution of records in areas contiguous with NSW sites.	M	Yet to be commenced	Nil	CPHR, ABGMA

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Confirm identity of Dacelo Point plants when cuttings reach diagnosable stage.	H	Yet to be commenced	Nil	ABGMA
All	Seek cutting samples of pre-listing plant held by Limpinwood Gardens Nursery, for incorporation into ex situ collection.	H	Yet to be commenced	Nil	ABGMA, NPWS
<i>Rhodamnia rubescens</i>	Complete targeted germplasm collections within a subset of the 9 germplasm collection zones. Aim to secure a minimum of 6 individual vegetative lineages from at least 5 subpopulations in each of 9 germplasm sampling zones (a notional 270 maternal lineages in total) by 2021.	H	Commenced	\$20,000	CPHR, ABGMA
All	Continue trials of late-season cuttings to determine best collection time.	H	Commenced	Nil	ABGMA
<i>Rhodomyrtus psidioides</i>	Complete targeted germplasm collections within a subset of the 6 germplasm collection zones. Aim to secure a minimum of 6 individual vegetative lineages from at least 5 subpopulations in each of 6 germplasm sampling zones (a notional 180 maternal lineages in total) by 2021.	H	Commenced	\$20,000	CPHR, ABGMA
All	Establish interim seed production area at the Australian Botanic Gardens Mt Annan (ABGMA).	H	Yet to be commenced	TBD	ABGMA

Table 4 Germplasm collection and management: Establish dispersed collection framework

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
All	Develop standards and protocols for the establishment and management of dispersed collections and identify potential partner institutions.	H	Commenced	TBD	CPHR, ABGMA
Medium-term (years 3–5)					
All	Establish trial ex situ collections in ground at the Australian National Botanic Gardens Canberra (ANBG).	H	Yet to be commenced	Nil	CPHR, ANBG
All	Establish trial ex situ collections in ground at the Royal Botanic Gardens Melbourne (RBGM).	H	Yet to be commenced	Nil	CPHR, RBGM

Table 5 Germplasm collection and management: Develop and maintain documented collections of genetically diverse live plants suitable for research and breeding purposes, preserving the full range of adaptive potential

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Complete remaining germplasm collections (if required)	M	As required	TBD	CPHR, NPWS
All	Continue dispersal of propagants to collaborating custodial institutions in line with bilateral/multilateral agreements and risk-management design.	M	As required	TBD	CPHR, ABGMA

All	Continue and maintain seed production areas at ABGMA (multi-lineage).	M	As required	TBD	CPHR, ABGMA
Medium-term (years 3–5)					
All	Develop additional seed production areas at collaborating custodial institutions.	M	As required	TBD	CPHR, ABGMA
Long-term (years 5–10+)					
All	Ongoing management of multi-lineage ex situ collections and seed production areas across all locations	M	As required	TBD	CPHR, ABGMA, ANBG, RBGM
All	Assess outcomes of genetics study by the BGoS and incorporate into ex situ management plan.	M	As required	TBD	CPHR, ABGMA, ANBG, RBGM
All	Assess initial outcomes of seed production area(s) and modify project plan as required.	M	As required	TBD	CPHR, ABGMA and participating institutions

3. Action type: Resourcing

Table 6 details the specific deliverables for the action:

- Establish ongoing support and resourcing for medium- and long-term actions.

Table 6 Resourcing: Establish ongoing support and resourcing for medium- and long-term actions

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
All	Project team and external partners to workshop options for securing external funding resources.	H	Yet to be commenced	Nil	CPHR, ABGMA
All	Seek and secure support funding to support establishment and operational maintenance of dispersed whole-plant collection, including grants to core facilities and collaborating custodians.	H	Yet to be commenced	TBD	CPHR, ABGMA and participating institutions
Medium-term (years 3–5)					
All	Seek and secure support funding for part-time position to anchor dispersed collection and other project functions, including mating system experiments ex situ.	M	Yet to be commenced	0.2–0.4 FTE	CPHR, ABGMA

4. Action type: Research

Table 7, Table 8 and Table 9, respectively, detail the specific deliverable for the following actions:

- Undertake genetic research to inform collection management and project delivery.
- Utilise seed production areas to support research to identify rust-tolerant lineages, genetic and physiological bases of resistance and susceptibility, and heritability of resistance-related traits.
- Continue research on seed storage requirements of target species.

Table 7 Research: Undertake genetic research to inform collection management and project delivery

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
<i>Lenwebbia</i> sp. Main Range	Complete a genetic study with the following specific aims: • characterise genetic variation across the range, including population ‘structure’ • characterise genetic diversity within sites, clonality and kinship of neighbour plants. Perform further analyses to inform aspects of germplasm management. Specifically: • design an optimally diverse collection, of a size limited by propagation constraints • use field impact surveys to selectively incorporate potentially resistant material.	H	Commenced	Contract \$28,000	CPHR, ABGMA, BGoS, NPWS
<i>Rhodomyrtus psidioides</i>	As above.	H	Commenced	Contract \$28,000	CPHR, ABGMA, BGoS
<i>Rhodamnia rubescens</i>	As above.	H	Commenced	Contract \$28,000	CPHR, ABGMA, BGoS

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
<i>Rhodamnia rubescens</i>	Maintain and strengthen collaboration with BGoS study on resistance genetics in <i>Rhodamnia rubescens</i> , via supply of DNA samples.	H	Commenced	Nil	CPHR, ABGMA, BGoS

Table 8 **Research: Utilise seed production areas to support research to identify rust-tolerant lineages, genetic and physiological bases of resistance and susceptibility, and heritability of resistance-related traits**

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Ensure utilisation of dispersed collection elements in research relating to resistance screening, host resistance systems and traits, variation in the rust pathogen, etc.	M	Yet to be commenced	Nil	CPHR, ABGMA, BGoS
All	Conduct flower bagging experiments on plants ex situ to determine capacity for autogamy (self-fertilisation) and production of viable and fit seed, versus out-crossed mating.	M	Yet to be commenced	TBD	ABGMA
All	Explore potential for screening for differential responses to rust infection and commission scoping study/design for a selective breeding operation (dependent on acquisition of anomalously healthy lineages from field, and outcomes of BGoS resistance genetics study).	M	Yet to be commenced	TBD	ABGMA, BGoS

Table 9 Research: Continue research on seed storage requirements of target species

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Further studies in seed bank and cryogenic storage conditions to determine viability and longevity, details to be discussed with Seed and Horticultural Research Unit at ABGMA.	H	Commenced	TBD	CPHR, ABGMA

5. Action type: Reinforce and reintroduce

Table 10 and Table 11, respectively, detail the specific deliverable for the following actions:

- Selective breeding for rust resistance, and/or resistance-trait transfer.
- Deployment of reinforced wild-types for augmentation or reintroduction in the wild.

Table 10 Reinforce and reintroduce: Selective breeding for rust resistance, and/or resistance-trait transfer

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Commission full conceptual plan for long-term reintroduction/augmentation of wild populations using genetically reinforced genotypes, associated ecological, ethical, and social/cultural issues.	M	Yet to be commenced	~\$20,000	CPHR, ABGMA, BGoS, NPWS
All	Assess concept plan, considering progress on ex situ, research and social support fronts. Commission draft operational plan for recovery in wild and/or translocated populations in climatically protected areas west of the Great Dividing Range.	M	Yet to be commenced	TBD	CPHR, ABGMA, BGoS

Table 11 Reinforce and reintroduce: Deployment of reinforced wild-types for augmentation or reintroduction in the wild

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Long-term (years 5–10+)					
All	Implement actions from the reintroduction/augmentation operational plan. Review annually.	M	Yet to be commenced	TBD	CPHR, ABGMA, BGoS, NPWS

6. Action type: Communications

Table 12 details the specific deliverable for the action:

- Develop an education and engagement strategy about the distribution and management requirements of the species.

Table 12 **Communications: Develop an education and engagement strategy about the distribution and management requirements of the species**

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Short-term (years 1–2)					
All	Develop a communications plan for the project targeting the general community and interest groups.	H	Yet to be commenced	Nil	CPHR
All	Liaise with Gondwana Rainforests of Australia World Heritage property managers regarding management strategies for the species and associated vegetation communities, project publicity and education and fundraising.	H	Yet to be commenced	Nil	CPHR
All	Liaise with Indigenous interest groups including Indigenous protected area managers and Native Title holders, regarding the planned conservation actions; seek agreement of appropriate actions where necessary. Establish ongoing points/personnel for contact and liaison.	H	Commenced	TBD	CPHR
Medium-term (years 3–5)					
All	Seek funding for, and initiate, scoping studies and community engagement/consultation around potential contentious issues of long-term recovery strategy, including use of selective breeding, wild-genotype reinforcement with rust-resistance traits, and augmentation/reintroduction to the wild.	M	Yet to be commenced	Contract \$40,000–60,000	CPHR, ABGMA, BGoS

Timeframe/ Species	Specific deliverables	Priority	Status	Budget	Responsibility
Medium-term (years 3–5)					
All	Implement actions identified in the communications plan.	M	Yet to be commenced	TBD	CPHR
Long-term (years 5–10+)					
All	Continuing community consultation and engagement as above, dependent on prospects for long-term recovery actions.	M	Yet to be commenced	TBD	CPHR, ABGMA, BGoS

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More information

Australian Network for Plant Conservation website – [Myrtle rust resources](#)

Saving our Species strategies:

- [Scrub turpentine \(*Rhodamnia rubescens*\)](#)
- [Native guava \(*Rhodomyrtus psidioides*\)](#)
- [Lenwebbia sp. Main Range](#)