Myrtle Rust in Australia

A draft Action Plan

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CRC PLANT biosecurity

Acknowledgements

This draft Plan has been prepared by Bob Makinson (Australian Network for Plant Conservation), with input from staff at the Plant Biosecurity Cooperative Research Centre and the Australian Government Department of the Environment and Energy.

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Feedback

This draft is open for consultation until 31 August 2018.

It is available online at: **apbsf.org.au**

Email your feedback to: **MRActionPlan@apbsf.org.au**

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Front cover: (Clockwise from top) Spotted Gum (*Corymbia maculata*) infected with Myrtle Rust in glasshouse screening program, Geoff Pegg, *Rhodamnia rubescens* with Myrtle Rust, Angus Carnegie, *Melaleuca quinquenervia* with Myrtle Rust, Geoff Pegg

Back cover: Photo: PBCRC

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Executive Summary

Myrtle Rust, a plant disease caused by the introduced fungal pathogen *Austropuccinia psidii*, poses a serious and urgent threat to Australia's native biodiversity. Myrtle Rust affects plant species in the family Myrtaceae (paperbarks, tea-trees, eucalypts, and lillipillies), which are key and often dominant species in many Australian ecosystems. To date it has proved capable of infecting 358 native species and this number is likely to grow. Serious declines towards extinction are underway in some species, and broader ecological consequences are expected. Myrtle Rust is likely to have a significant impact on matters of national environmental significance protected under national environment law, including listed threatened species and ecological communities, wetlands of international importance, world heritage properties, and national heritage places.

Primary industry and biosecurity agencies provided valuable leadership when the pathogen arrived in Australia in 2010, and have supported some important research since. There is however no nationally coordinated response strategy for the environmental dimensions of this threat. There is an urgent need to establish this response and conduct the necessary research and conservation actions, hence the development of this draft Action Plan. Time is very short for some species that are severely impacted by Myrtle Rust, but there *are* meaningful conservation actions that can be taken.

The Myrtle Rust pathogen is included in the Key Threatening Process '*Novel biota and their impact on biodiversity*' listed in 2013 under the Australian Government's *Environment Protection and Biodiversity Conservation Act* 1999. This Key Threatening Process applies to introduced and invasive species that have a significant detrimental impact on the environment. The associated non-statutory Threat Abatement Guidelines provide general recommendations for environmental responses to exotic invasive biota. Many are relevant for a coordinated environmental response to Myrtle Rust, and are consistent with recommendations in this Action Plan. Some features of this pathogen require management approaches that go beyond those general guidelines.

A vigorous environmental response to Myrtle Rust will raise awareness and preparedness for future environmental pathogen threats. It will also assist a stronger national emphasis on environmental biosecurity as recommended in the review of the Intergovernmental Agreement on Biosecurity (Craik, W, Palmer, D & Sheldrake, R 2017, *Priorities for Australia's biosecurity system*).

Overarching Goals

This draft Action Plan provides the foundation for a coordinated national environmental response to Myrtle Rust research and on-ground actions. Its goals are to minimise declines and extinctions of native species due to Myrtle Rust and to mitigate the decline in the integrity and function of their host ecosystems.

About this Action Plan

This draft Action Plan has been developed in partnership by the Plant Biosecurity Cooperative Research Centre and the Australian Government's National Environmental Science Program. The Plan draws on information gathered for *'Myrtle Rust reviewed: the impacts of the invasive plant pathogen Austropuccinia psidii on the Australian environment'* (Makinson 2018), which provides supporting detail.

The Plan proposes actions under two overarching recommendations and five themes as follows:

OVERARCHING RECOMMENDATION 1

Establish momentum, funding and leadership for a coordinated national environmental response to Myrtle Rust

Theme 1: Enabling the response

Theme 2: Awareness and engagement

OVERARCHING RECOMMENDATION 2

Adopt a coordinated and long-term national environmental response to Myrtle Rust

Theme 3: Impact assessment

Theme 4: Towards recovery

Theme 5: Biosecurity

The actions recommended in the Plan have been developed and prioritised through consultation with Myrtle Rust and plant ecology experts and stakeholders, with a focus on the highest priority actions required in the next 3-5 years. This draft Action Plan is a living document open for public consultation. You can email your feedback to **MRActionPlan@apbsf.org.au**

OVERARCHING RECOMMENDATION 1

Establish momentum, funding and leadership for a coordinated national environmental response to Myrtle Rust

THEME 1: ENABLING THE RESPONSE

Objective 1.1: Establish and resource leadership

Action 1.1.1: Establish and resource an Interim Steering Committee

HIGH priority, Year 1

An effective and coordinated response to the environmental threat posed by Myrtle Rust requires leadership from across government environmental agencies. It requires a whole-of-government commitment to enable coordination with, and expertise to be drawn from, other agencies. It also requires consistent outreach to all stakeholders.

Arrangements will undoubtedly evolve as a response takes shape. An essential first step is the establishment of an interim coordination body with lines of reporting and liaison with government environment agencies, and with involvement of key non-government stakeholders.

Objective 1.2: Establish a collaborative response

Action 1.2.1: Secure engagement and commitment from key stakeholders to the response

HIGH priority, ongoing

An effective response to the environmental threat posed by Myrtle Rust requires engagement and commitment of expertise by key stakeholders. These include government environmental agencies, natural resource management bodies, the non-government environmental sector, research institutions, Indigenous stakeholders, participants in the national biosecurity system, primary industry agencies and corporate bodies. Much of Australia's plant pathogen expertise resides among the primary industry agencies and corporate bodies. They have led much of the initial response to Myrtle Rust since 2010 and have generated most of the limited research on its environmental impacts. Their continued engagement in development of an environmental response is crucial.

Objective 1.3: Establish funding arrangements

Action 1.3.1: Identify funding needs and options

HIGH priority, Year 1-3

A coordinated and comprehensive environmental response to Myrtle Rust will require dedicated and discretionary funding to accelerate priority research and actions. A variety of funding sources could be accessed, including competitive funding. While industry levies have funded some Myrtle Rust research, those levies are necessarily focussed on responses to invasive pathogens in agriculture. The environment does not have an equivalent levy which could fund Myrtle Rust research and action. Attention should therefore be directed toward innovative funding mechanisms, particularly as public awareness grows of the threat Myrtle Rust poses to Australia's natural and cultural heritage. This includes the possibility of establishing a joint government-private-public foundation or trust and campaigns such as crowd sourcing of funds to support aspects of the response not easily covered by other funding sources.

Objective 1.4: Expedite legislative mechanisms

Action 1.4.1: Expedite listing of species and ecological communities at serious risk from Myrtle Rust

HIGH – MEDIUM priority, ongoing

The rapid environmental impacts of Myrtle Rust have outrun Australia's legislative extinction-risk assessment systems. Some of the species that are now in severe decline are unlisted or were considered non-threatened until now. In the absence of coordinated monitoring, many species at risk remain 'data deficient' for formal extinction-risk assessment, even though the Myrtle Rust impact and decline are known or strongly suspected.

Identification, prioritisation, and funding of impact assessment and conservation actions for species most affected by Myrtle Rust should not be based on or limited to pre-existing listing status, although it is a factor for consideration. Nevertheless, formal extinction-risk assessment and listing, on a precautionary ('projected decline') basis, remain important instruments. The assessment and listing of species at severe risk from Myrtle Rust will assist in tracking impact, mobilise the gathering of data, raise awareness, and mandate research and conservation actions and external (non-government) fundraising to support them.

Action 1.4.2: Consider expedited instruments to focus on the threat of Myrtle Rust

HIGH priority, ongoing

The legislative recognition of 'key threatening processes' is provided for in some but not all jurisdictions. Policy and strategy statement alternatives are available in others. This Plan recommends consideration of expedited adoption of instruments of this sort to recognise the Myrtle Rust threat. These instruments contribute to raising the level of public and sectoral vigilance and monitoring, and to priority setting for research and its funding bodies. They also provide an additional mandate for conservation actions and assist in raising external (non-government) funding to support them. Such instruments also improve public awareness of environmental biosecurity.

THEME 2: AWARENESS AND ENGAGEMENT

Objective 2.1: Maximise social commitment to and participation in response

Action 2.1.1: Raise awareness of Myrtle Rust and the environmental response

HIGH – MEDIUM priority, ongoing

Increased awareness of Myrtle Rust amongst the public and within key sectors will aid vigilance, reporting and monitoring efforts, and the pursuit of wider funding sources for essential research and conservation actions. It will potentially reduce the accidental spread of Myrtle Rust. It will also complement and support the stronger national emphasis on environmental biosecurity awareness recommended in the review of the Intergovernmental Agreement on Biosecurity (Craik, W, Palmer, D & Sheldrake, R 2017, *Priorities for Australia's biosecurity system*). There are rare 'good news' stories which can be used to raise awareness and support for a whole of government/community response, for example, the early detection and eradication of Myrtle Rust from Lord Howe Island in 2017.

Action 2.1.2: Engage other key non-government stakeholders in the response

HIGH priority, ongoing

To raise awareness of Myrtle Rust effectively, it will be important to pay close attention to key stakeholder sectors as well as the broader public. The environmental response should take full advantage of the existence of strongly motivated and appropriately skilled interests in the non-government sector, who have a strong stake in an effective environmental response to Myrtle Rust. These include conservation non-governmental organisations, expert native plant growers, foresters, natural resource management bodies, World Heritage Area management and stakeholders, parts of the scientific community, the environmental and ecological consultancy sector, and other commercial and community sectors (e.g. bush regeneration bodies) with relevant expertise and interests.

Action 2.1.3: Seek Indigenous stakeholder input and participation

HIGH priority, Year 1 and ongoing

Myrtle Rust impacts are highly relevant to Indigenous people and communities. Decline due to Myrtle Rust can affect cultural heritage values, traditional practices, and Indigenous enterprises, particularly those based on bush products and ecotourism. Myrtaceae species continue to be used by Indigenous peoples in most parts of Australia for food, medicine, and other social uses – they are part of the cultural life of those communities. Natural landscapes and native vegetation are important to Indigenous custodianship. Many Aboriginal-run enterprises are based on native-plant products or incorporate them in their tourism and educational activities. Indigenous owned or controlled lands are a major part of the landscapes that have current and projected Myrtle Rust impacts.

Engagement with relevant Aboriginal and Torres Strait Islander organisations, researchers, and environmental managers is recommended, to hear their perspectives and integrate Indigenous views into the recommendations. It is an opportunity to brief Indigenous stakeholders on the known and potential environmental impacts of Myrtle Rust, to seek their views on the cultural implications and proposed response elements and seek their guidance and involvement for monitoring programs. Research and conservation projects need to be conceptually consistent with cultural and land-access protocols for the areas and species concerned. It is recommended that the cultural engagement processes developed in Hawaii and New Zealand for the *A. psidii* pathogen be drawn on as helpful case studies..

OVERARCHING RECOMMENDATION 2

Adopt a coordinated and long term national environmental response to Myrtle Rust

THEME 3: IMPACT ASSESSMENT

Objective 3.1: Establish information hub and data validation protocols

Action 3.1.1: Establish Myrtle Rust data hub and information repository

HIGH priority, Year 1 & 2

Myrtle Rust information is fragmented between specialist journals, government agencies, individual researchers, botanic gardens and ecological field managers. No information repository is currently mandated or equipped to manage the range of information which needs to be gathered to assist in a fully-informed, coordinated environmental response to Myrtle Rust. An effective and integrated impact survey and monitoring program needs a clear line of reporting and consistent standards (see next Action). A dedicated information repository or information management system should be established which is capable of receiving, validating, storing and publishing the full range of incoming data and images resulting from Myrtle Rust impact monitoring and new host reporting. Information would include disease incidence and severity data, and host species ecological and demographic data and images. The information repository will need to interact with related and complementary biodiversity and pest data systems.

Objective 3.2: Assessment of Myrtle Rust impact on priority species

Action 3.2.1: Standardise impact assessment methods and monitoring protocols

HIGH priority, Year 1

Protocols for recording Myrtle Rust incidence, severity and symptomology are well established but not yet widely promulgated outside specialist circles. The additional host plant demographic and ecological data requirements are likewise straightforward but not yet codified. A synthesised set of protocols, adaptable for both professional and skilled non-professional use, is a prerequisite for effective impact monitoring and assessment.

This action is considered 'low-hanging fruit'. It could be easily completed in a short period of time under the guidance of key stakeholder groups.

Action 3.2.2: Identify most effective potential monitoring sites

MEDIUM priority, Year 1-3

Assessment and monitoring of Myrtle Rust impact and declines, and surveys for resistant plants, require a combination of a systematic approach and 'opportunity knocks' observations. Assessment of decline requires a pre-rust or present-day baseline. The most time-effective monitoring will also, where possible, use sites where multiple target species are closely co-located.

It is recommended that information on optimal monitoring sites be made available through collation and analysis of pre-existing permanent plot/transect data and other species occurrence records, currently held in environment and forestry agencies, World Heritage and NRM organisations, herbaria, CSIRO, and some local government bodies. Integration of selected sites into existing agency and citizen science monitoring programs, is recommended where feasible, to extend the reach of the monitoring effort.

Action 3.2.3: Rapid field surveys

VERY HIGH priority, Year 1-3

Few of the species known or suspected of being at serious short-term risk of decline from Myrtle Rust have been surveyed fully and systematically for rust impact, possible resistant populations, and germplasm collection. Forty-five species are recommended as priorities for systematic field assessment, to enable more informed conservation actions and adjustment of priorities: four on an emergency basis, twelve on an urgent (Year 1) basis, and 29 on a medium priority basis (years 1-3). See Priority Species section on page 10 for species lists.

Action 3.2.4: Undertake quantified field impact studies

HIGH priority, ongoing

Detailed research on Myrtle Rust's progressive impact on individual species is valuable but is unlikely to be feasible given the large number of species involved. However, selected species studies should be supported, targeting exemplar species in several groups. For example, these could shed light on differential resistance to disease at sub-specific levels, gauge the risk to keystone ecological species (such as Broad-leaved Paperbarks), or provide generalisable models in other groups.

Objective 3.3: Assessment of Myrtle Rust impact on ecological communities and function

Action 3.3.1: Continue and expand research programs in priority ecosystems

HIGH – MEDIUM priority, Year 1-2 and ongoing

Ecological communities with high proportions of affected Myrtaceae have the highest potential for loss of ecological function due to Myrtle Rust impacts. Three ecological communities are recommended as the basis for dedicated research programs. Ecological research in these communities will help to anticipate the effects that rust-mediated decline of host species may have on other flora and fauna. It will also provide a broad evidence base for ecosystem-level planning for Myrtle Rust impacts.

Priority ecological communities as at 2018 are east coast rainforests, coastal heath/woodlands, and *Melaleuca* wetlands.

It is recommended that discretionary and directed funding be made available for the implementation of these programs and for overall coordination within and between the programs. A multidisciplinary approach is recommended, encompassing plant health, plant ecology, Myrtaceae-associated or dependent flora and fauna, and broader ecological considerations such as hydrology or niche closure. Interdisciplinary scoping will be necessary to identify optimal collaborations and critical elements.

THEME 4: TOWARDS RECOVERY

Objective 4.1: Germplasm capture

Action 4.1.1: Secure future options for species in current or projected decline through germplasm capture

VERY HIGH – HIGH priority, Year 1-2

Decline of species means loss of genetic variation, including distinct genotypes that may be significant for ecological reasons or as future genetic resources. Preservation of genetic variation is a conservation goal; where this cannot be done in the wild, it can be approximated by germplasm capture.

For some species in severe and uniform decline due to Myrtle Rust, germplasm capture is now the only option to avoid the likelihood of complete extinction. Without germplasm capture, there are no future options for species preservation or recovery. The Priority Species section below recommends four species for emergency priority germplasm capture and 12 as a very high priority (Year 1-2).

For species with more patchy but still regionally severe declines, germplasm capture from both high- and low-resistance populations is desirable to maintain genetic variability, enable research into resistance, and be able to augment or replace extinct populations. The Priority Species section below recommends 29 species for medium priority germplasm capture.

Seed is the easiest and most efficient form of germplasm to gather and store. Many Myrtle Rust affected species have storage tolerant seeds, and capture of representative samples from the wild requires only extra resourcing of the seed banking effort. However, many others, particularly rainforest species, have storage intolerant seeds, and prior research is needed to enable seed storage (see next Action).

Among the species undergoing the most drastic declines due to Myrtle Rust, we know that several are no longer producing seed due to foliage and stem damage and stress. For these species, we have missed the window for seed collection, and we must capture and grow vegetative material from which protected seed production areas can be established later.

In South Australia, Western Australia, Lord Howe Island and parts of the Northern Territory, proactive germplasm capture before Myrtle Rust arrives is recommended as a high priority for the species considered most at risk. The Priority Species section below recommends six species from Lord Howe Island and Kakadu for precautionary germplasm capture. Enough germplasm should be collected and stored to allow for screening, future resistance research, conservation translocation and a long-term seed bank reserve. This action is considered 'low-hanging fruit'. It could be easily completed in a short period of time under the guidance of key stakeholder groups.

Action 4.1.2: Seed storage-enablement research; determine alternative germplasm storage options for storage intolerant species

VERY HIGH priority, Year 1 and ongoing

Many affected species, particularly of rainforests, have seeds known or suspected not to be amenable to normal seed bank storage (storage intolerant). Species by species testing is needed to determine whether storage can be enabled by modified treatment, or to determine alternative germplasm storage options for fully storage intolerant species. This is a prerequisite for germplasm storage for these species.

Action 4.1.3: Inventory of priority Myrtaceae species in botanic gardens and other collections

HIGH priority, Year 1

Some species in severe decline no longer produce fruit and seed in the wild in collectable quantities. For these species, cultivated specimens that can be protected by periodical fungicidal treatment may represent the only source of seed for storage research and for long-term preservation of the species. In extreme cases, these specimens may be the last of their kind in years to come. A national inventory of specimens of priority species in botanical gardens and other public or private collections should be undertaken. This action is considered 'low-hanging fruit'. It could be easily completed in a short period of time under the guidance of key stakeholder groups. See the Priority Species section below for a species list.

Action 4.1.4: Scope potential locations for ex-situ and inter-situ live plant collections and/or seed production areas

MEDIUM priority, Year 1–5

For species where little or no seed is available or which are not amenable to seed storage, seed production programs may be required. For some other species, standing collections of live plants will be useful for resistance research and breeding programs. In both of these cases, host sites with suitable horticultural conditions will be needed. These should be amenable to fungicide control of rust as necessary. Some regional and metropolitan botanic gardens, universities, and arboreta, if resourced, are among the candidate sites.

Objective 4.2: Improve understanding of affected species

Action 4.2.1: Assemble host life history profiles for priority species

MEDIUM priority, Year 2+

Substantial botanical and ecological knowledge exists for many of the species at risk, including forestry species. However, this knowledge is fragmented and has not been indexed or assembled. Assembling relevant host-species literature, data references and links will facilitate and expedite research, conservation planning and rapid surveys for Myrtle Rust-affected species. It will also ensure conservation planners have the fullest possible information to base their decisions on. This information should be stored in the repository recommended in Action 3.1.1.

This action is considered 'low-hanging fruit'. It could be easily completed in a short period of time under the guidance of key stakeholder groups.

Action 4.2.2: Develop online atlas of authenticated Myrtaceae seedling images

MEDIUM priority, Year 2+

In many species, very young seedlings may be particularly vulnerable to *A. psidii* infection (and are known to be so for some species). Host plant identification normally relies on features of the adult plant. An authenticated image bank of seedling images, coupled with lists of species known to occur in particular areas, would assist field impact surveys, particularly during recruitment after fire. This will also help to predict the mode and timeframe of Myrtle Rust impact on host species and ecosystems. These images should be stored in the repository recommended in Action 3.1.1.

Objective 4.3: Explore resistance and control

Action 4.3.1: Assessment of selected species for variation in levels of resistance/tolerance

HIGH priority, ongoing

Some significantly affected species are known to have varied levels of tolerance to the disease within or between populations, and other species may also exhibit this variation. An understanding of this variability and its heritability, through screening tests and molecular techniques, will shed light on resistance genetics and physiology. It will also enable an estimation of natural versus assisted regeneration potential, and inform potential selective breeding strategies.

Action 4.3.2: Augment knowledge of phylogenetic relationships within Myrtaceae

MEDIUM priority, Year 2-4

Susceptibility to Myrtle Rust does not have a straightforward relationship with phylogeny (the evolutionary lineages in the Myrtaceae family), but there is partial correlation. Some lines of research also suggest the possibility of phylogenetically correlated resistance gene-complexes, not always expressed, which may inform resistance studies and breeding. Completion and integration of phylogeny for the family in Australia and New Zealand would facilitate targeted research on resistance and its management implications.

Action 4.3.3: Review and identify priorities for resistance research

HIGH priority, ongoing

The wide host range of *A. psidii* and the search for a better understanding of rust resistance traits and their potential deployment, dictate a spread of the research effort across affected species. Some of the most severely affected species show no patterns of resistance, but close relatives may, and cross breeding or trait transfer may prove to be an option. Other species that are severely but less uniformly affected, and play a key ecological role (e.g. wetland *Melaleuca* species), require resistance research to shed light on whether populations have a natural capacity to reverse decline over time, or require assisted reinforcement with resistant genotypes. There is strong potential for crossover of this research with production sector efforts, but environmental species need their own priority. Specialist scoping is needed to determine priorities and the best lines of investigation.

Action 4.3.4: Review and identify priorities for silvicultural selection and breeding for resistance

HIGH – MEDIUM priority, ongoing

The selection and breeding of eucalypt genotypes resistant to the *A. psidii* pathogen for plantation timber species is well established in South America. The identification and deployment of such genotypes in other genera, and for conservation purposes in natural environments, raises more complex issues (e.g. avoidance of genetic bottlenecking, and ecological considerations) but is feasible in principle and for some species may be the best option. Specialist evaluation of the options for silvicultural selection and resistance breeding in the context in the context of the Australian natural environment is recommended as the first stage.

Action 4.3.5: Explore novel Myrtle Rust controls through reviews and scoping studies

MEDIUM priority, ongoing

While no quick fix is to be expected, especially for wild plant populations, some lines of potential biocontrol have been identified in the scientific literature, and others under development for other rust diseases may have application. These include bacterial, viral, and fungal hyperparasite biocontrols, RNA interference vaccines, and novel fungicides. Some of these, if developed, may be deployable for Myrtaceae in production systems, including in ex-situ conservation seed production areas.

Objective 4.4: Explore reinforcement/reintroduction strategies for affected species

Action 4.4.1: Explore species recovery options for species and ecosystems in decline

MEDIUM priority, Year 2-5

For some species in acute decline due to Myrtle Rust, the only likely path back from the brink of extinction will be through translocation or introduction/reintroduction of rust-resistant genotypes, whether these are wild-origin or modified. Translocation is a well-established conservation tool, although success is not guaranteed. There are fewer global precedents for modification of genotypes of wild species as a response to pathogens (e.g. by selection or cross-breeding followed by 're-wilding'), but there are some models and much potential.

Stakeholder consultations and production of an initial issues paper on the ecological, genetic, social and ethical factors of deployment of rust-resistant wild and modified genotypes, is recommended.

THEME 5: BIOSECURITY

Objective 5.1: Prevention of arrival of new strains of *A. psidii*

Action 5.1.1: Continue pre-border and border vigilance for all strains of *A. psidii*

VERY HIGH priority, ongoing

Australia currently has only one strain of the *A. psidii* pathogen. Other strains have the potential to infect a still wider range of hosts, show wider climatic tolerances, and add to the adaptive potential of the pathogen. Two further strains in South America show a strong affinity for eucalypt species grown there, and have caused serious damage to them in plantation. The continued exclusion of any further strains of *A. psidii* from the Australasian region is a national imperative, requiring both a national and a regional approach for biosecurity vigilance and response.

Action 5.1.2: Review potential pathways of entry of different strains of *A. psidii* into Australia

HIGH priority, Year 1-2

The progressive establishment of the pandemic strain of Myrtle Rust in the Asia-Pacific region, a different strain in South Africa, and the potential for future emergence of yet other strains from the Americas, necessitate continued reappraisal of potential arrival pathways and measures for prevention and early detection.

Action 5.1.3: Establish an Asia-Pacific Myrtle Rust network

MEDIUM priority, Year 2 and ongoing

We know that *A. psidii* can spread by human, animal and wind vectors within the Asia-Pacific region. Given this, the regional exclusion of new strains, and early warning of new recombinant or mutational genotypes within the region, should be a priority for environmental biosecurity and for Myrtaceae production systems.

Action 5.1.4: Promote and contribute to coordinated international Myrtle Rust collaborative biosecurity and biological research network

HIGH priority, ongoing

Screening of more Australian plants against *A. psidii* and against different strains of the pathogen overseas provides valuable data on susceptibility and resistance. This information can inform risk appraisal, predictive threat models, resistance studies, and breeding trials. A greater emphasis on screening environmental (non-commercial) species will help to refine our understanding of conservation threats and priorities.

Objective 5.2: Maintain domestic quarantine

Action 5.2.1: Vigorously maintain current quarantine arrangements for Western Australia and South Australia

VERY HIGH priority, ongoing

Predictive bioclimatic models differ but show some areas of Western Australia and South Australia are potentially suitable for Myrtle Rust establishment. More than half of Australia's Myrtaceae species occur in Western Australia, over 1000 of them in the south-west, which is the region most likely to be favourable for Myrtle Rust. Current domestic biosecurity arrangements for human vectors, coupled with bioclimatic separation, have so far successfully prevented spread of the pathogen to these states. It is critical to maintain domestic biosecurity arrangements to continue to exclude *A. psidii* from these states.

Action 5.2.2: Ongoing review and identification of potential risk pathways for entry of Myrtle Rust to Western Australia and South Australia

HIGH priority, ongoing

The establishment of Myrtle Rust in the Northern Territory, and its partial naturalisation in Victoria and Tasmania, are widening the potential area of domestic origin for transmission to as-yet unaffected states and regions. Continual reappraisal is needed of the evolving potential arrival pathways, and measures for prevention and early detection.

Objective 5.3: Monitor for changes in pathogen population

Action 5.3.1: Develop strategies to monitor for changes in the Australian and regional *A. psidii* populations

HIGH priority, ongoing

There is a need for continued monitoring for genetic change in the population of *A. psidii* in Australia and the broader Asia-Pacific region. This will allow us to detect the development of new genotypes and pathotypes through mutation, recombination, or the arrival of new strains not otherwise detected.

Priority Species

The priority species for field surveys and monitoring (Theme 3) and for germplasm capture (Theme 4) are categorised according to their known or suspected level of decline due to Myrtle Rust (either regionally or over their total range). Supporting information for this prioritisation is presented in *'Myrtle Rust reviewed: the impacts of the invasive plant pathogen Austropuccinia psidii on the Australian environment'* (Makinson 2018).

EMERGENCY priority

Four species undergoing extremely strong decline are recommended for emergency-level action to secure germplasm:

- *Lenwebbia* sp. 'Blackall Range' (P.R.Sharpe+ 5387)
- *Lenwebbia* sp. 'Main Range' (P.R.Sharpe+ 4877)
- *Rhodamnia rubescens*
- *Rhodomyrtus psidioides*

VERY HIGH priority

Twelve further species are known or strongly suspected to be in serious decline on a total or regional basis, and are recommended for the most urgent (Year 1-2) conservation action – i.e. impact surveys to establish baselines, assess decline and locate disease-resistant populations or individuals, and urgent germplasm collection to conserve genetically representative material of the declining populations:

- *Archirhodomyrtus beckleri (*Southern Chemotype*)*
- *Decaspermum humile (*Southern Metapopulation*)*
- *Eugenia reinwardtiana*
- *Gossia fragrantissima*
- *Gossia gonoclada*
- *Gossia hillii*
- *Melaleuca nodosa*
- *Rhodamnia angustifolia*
- *Rhodamnia dumicola*
- *Rhodamnia maideniana*
- *Syzygium anisatum*
- *Syzygium hodgkinsoniae*

All except *Melaleuca nodosa* are known or suspected to have storage-intolerant or short-lived seed, and storage enablement research is an urgent prerequisite for larger-scale germplasm capture..

MEDIUM priority

29 species, of known or suspected high susceptibility, and suspected decline but for which there are fewer observations of impact, are recommended for medium priority (pre-end 2020) impact surveys to establish baselines and look for disease-resistant populations or individuals, and in most cases to capture sample germplasm (seed or vegetative) for storage enablement and germination research:

- *Austromyrtus dulcis*
- *Backhousia citriodora* (a germplasm set exists)
- *Backhousia leptopetala*
- *Backhousia oligantha*
- *Eucalyptus curtisii*
- *Eucalyptus andrewsii* (= *E. montivaga*, Mackay region population)
- *Eucalyptus resinifera* subsp. *hemilampra* (Mackay region population)
- *Gossia acmenoides*
- *Gossia inophloia*
- *Gossia lewisensis*
- *Gossia myrsinocarpa*
- *Lenwebbia prominens*
- *Leptospermum trinervium*
- *Lithomyrtus retusa* (NT populations initially)
- *Melaleuca leucadendra*
- *Melaleuca quinquenervia*
- *Melaleuca viridiflora*
- *Melaleuca lophocoracorum*
- *Rhodamnia argentea*
- *Rhodamnia australis*
- *Rhodamnia costata*
- *Rhodamnia longisepala*
- *Rhodamnia sessiliflora*
- *Rhodamnia spongiosa*
- *Rhodamnia whiteana*
- *Rhodomyrtus canescens*
- *Rhodomyrtus pervagata*
- *Stockwellia quadrifida*
- *Syzygium oleosum*

World Heritage Area flagship species MEDIUM priority

Six species are recommended for medium priority (2018-19) precautionary collection of germplasm as flagships of the environmental response in World Heritage Areas. These species are not currently known to be exposed to *A. psidii* but are at risk of exposure in the near future and could then be subject to rapid decline in their narrow geographic ranges. All but one are known hosts of *A. psidii* from inoculation screening. Proactive banking of these species, given their World Heritage context, would be prudent and likely to assist the momentum of the overall national response.

Kakadu WHA and adjacent area:

- *Allosyncarpia ternata*

Lord Howe Island WHA endemics:

- *Leptospermum polygalifolium* subsp. *howense*
- *Melaleuca howeana*
- *Metrosideros nervulosa*
- *Metrosideros sclerocarpa*
- *Syzygium fullargarii*

Background

The exotic plant disease Myrtle Rust, caused by the microfungus *Austropuccinia psidii,* threatens to cause declines and extinctions of native Australian plant species across large areas of Australia. The pathogen attacks new growth on species in the plant family Myrtaceae (eucalypts, tea-trees, paperbarks, lillypillies, and many other well-known groups). Seedlings are particularly vulnerable, and repeated infection of adult plants of highly susceptible species can lead to defoliation, loss of reproductive capacity, and death. *A. psidii* favours moist habitats and is under current climate conditions is unlikely to be a threat in drier areas.

A. psidii is not a direct threat to human or animal health, although loss of Myrtaceae species habitat may affect some animal species, human economic, social and cultural values and amenity, as well as ecosystem integrity.

First detected in Australia in 2010, *A. psidii* is very invasive and is now fully naturalised along most of the east coast and in parts of the Northern Territory, and is marginally established in Victoria and Tasmania. The most serious species declines are in New South Wales and southeast Queensland. Declines are suspected but not well documented in the Wet Tropics and adjacent areas of North Queensland. *A. psidii* has an uncertain potential for damage to native flora in the monsoon tropics, and for very serious damage in the south-west of Western Australia. It has also been found in recent years in New Zealand and other neighbours in the region, some of whom are mounting their own conservation responses.

To date (2018), *A. psidii* has proved capable of infecting 358 native Australian plant species or subspecies (16% of the 2,253 known native Myrtaceae). This 'host range' is expected to expand further, especially if the geographical range of Myrtle Rust in Australia increases. Only about three per cent of native species screened for susceptibility so far have failed to develop infection.

Of these, 45 species (12% of the known hosts) are known or suspected to be severely affected and require urgent assessment to determine decline. The pre-existing listing status of species as 'threatened' or 'not threatened' is not a safe guide to prioritisation of species at risk of decline from Myrtle Rust.

Sixteen species are recommended for most urgent conservation action (2018-19), four of them on an 'emergency' basis. Necessary actions include field survey for impact and resistance, and germplasm capture (seed if still available).

A further 29 species are recommended for similar medium-priority (pre-end 2020) actions, and a further six, in two World Heritage Areas not yet affected but at near-term risk, for medium-priority germplasm collection (but recommended for 2018-19 for best advantage to the overall program).

Myrtle Rust is amenable to management by hygiene and fungicidal treatments in cultivated situations (horticulture). It has inflicted economic damage and expense on some so-far limited areas of native plant commercial production (notably the Lemon Myrtle industry). Longer-term effects on plantation and native forestry species in climatically vulnerable areas are uncertain, but appear mild at this stage. Research and development funded from government and industry levies in this domain is ongoing on economically significant species, and forms an important partner area to the proposed environmental response; cross-over in research and communication should be encouraged. However, the environmental response should establish and fund its own priorities, based on biodiversity, cultural and ecological criteria.

Myrtle Rust is not amenable to direct management in the wild, except by its continued exclusion from regions isolated from current infection (South Australia, Western Australia, Lord Howe Island). A biological control agent deployable in the wild is highly unlikely, although some options are worth investigation for use in controlled situations. This intractability to direct management has been one of the main challenges in the Australian environmental response to date – if it cannot be managed, why invest in conservation actions? The thesis behind this Action Plan is that minimisation of declines and extinctions are in fact possible in some cases, and at least partial species and ecosystem recovery possible for some, if options are secured now.

Decline of some species is occurring and cannot be directly stopped at this point, although prompt action may allow the assisted recovery of some affected species over the longer term. Extinctions in the wild are likely in the short term, but again prompt action can secure plant material for possible resistance breeding and reintroduction. More host species are likely to decline over coming decades, especially if the disease spreads.

All recommendations in this plan should be read in the context that the Myrtle Rust pathogen is now a globally recognised problem, and that international collaborations, particularly with New Zealand, South African, and South American partner researchers and institutions, constitute a good investment for Australia.

Australian Government

National Environmental Science Programme

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