For country

Respects to the Traditional Owners and custodians across the country, past and continuing.

Country currently at risk from Myrtle Rust:

East coast heaths, rainforests, Wet Sclerophyll Forest, Paperbark wetlands.

Safe Custody of Native Guava (*Rhodomyrtus psidioides*)

Part 1: What is Myrtle Rust, and why Native Guava?

R.O. (Bob) Makinson bobmakinson2073@gmail.com

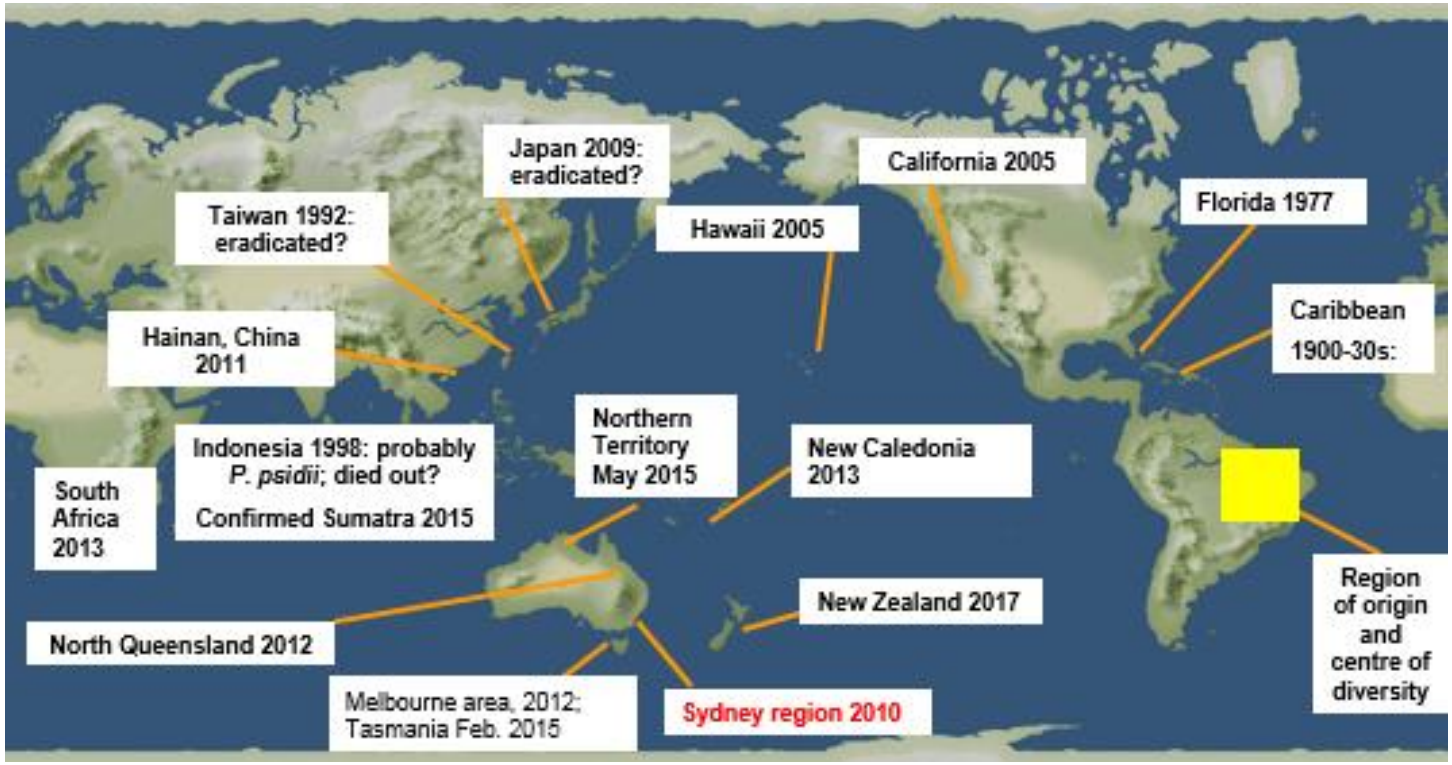
The Australian Network for Plant Conservation Inc.
https://www.anpc.asn.au/myrtle-rust/

Rhodomyrtus psidoides, normal summer sucker growth hit for first time by Myrtle Rust in Dec. 2010 (Central Coast NSW; B. Makinson)

Big tree death, June 2013. (Ewingsdale, NE NSW; K. Kupsch)

Fallen and standing dead trunks, and annual suckers from surviving root systems, Aug. 2019. (Lansdowne NSW; B. Makinson)

Global spread of Eucalypt/Guava/Myrtle Rust (*Austropuccinia psidii*)



Disease caused by *Austropuccinia psidii* is recognised as a global biosecurity and biodiversity conservation problem.

Australia has only one strain of *Austropuccinia psidii*, the 'pandemic strain'.

Keeping the other variants out of the Australia is a national biosecurity priority (see https://www.agriculture.gov.au/biosecurity-trade/policy/environmental/priority-list).

Distribution in Australia (so far)

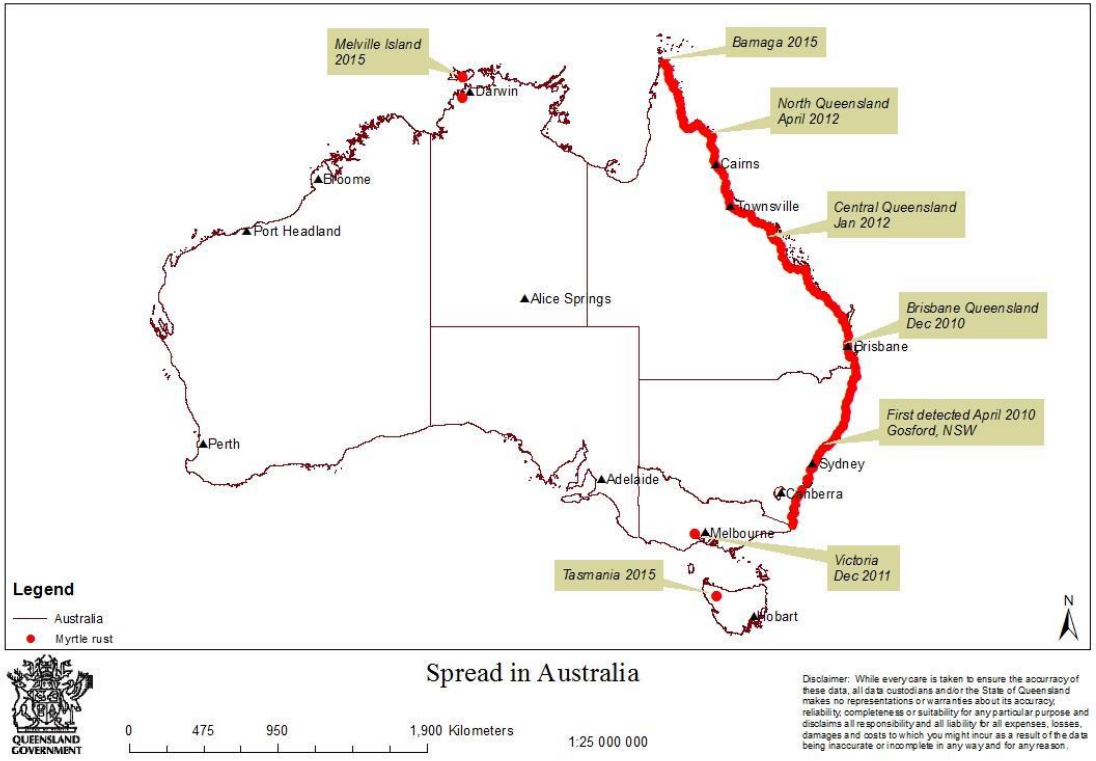
Current distribution :

- East coast inland to the Great Escarpment (rarely on tablelands and W slopes);
- NT (scattered reports);
- **now also just over the WA border near Kununurra**.
- Vic and Tas: in cultivation only.

World Heritage Areas:

- 4, possibly 5 WHA affected so far:
  - Gondwana Rainforests
  - Wet Tropics
  - K'gari (Fraser Is.)
  - Lord Howe Is
  - Kakadu?

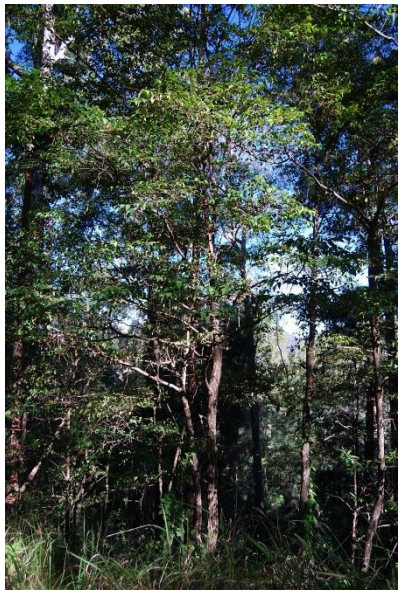
SW of WA in danger - >1,000 Myrtaceae in high-risk area.



How Myrtle Rust kills: Scrub Turpentine (*Rhodamnia rubescens*)

Widespread, Narooma NSW to SE Qld
Common and not threatened prior to 2010.
Now in severe decline over entire range, Critically Endangered.
No known rust-resistant genotypes.

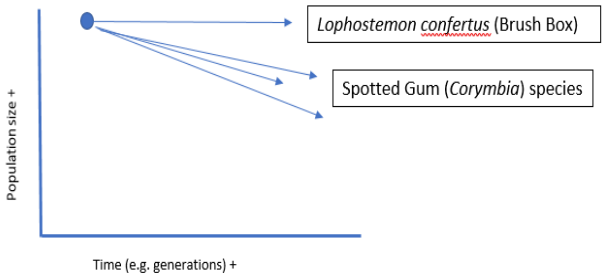
Mostly survives as shrub-sized plants. Most big adults dead.
No reproduction from seed now.



Images: ANBG; AJ Carnegie; C. Stehn; G. Errington; P. Entwistle.

Species scenarios and management options

1, 2: No decline, or low to moderate decline

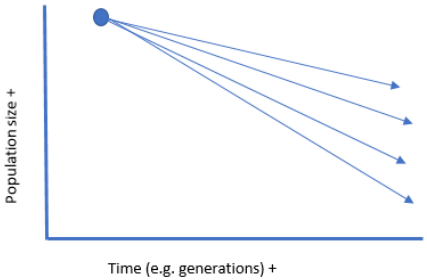


Resistance (R) is widespread. Natural selection for resistance, and eventual recovery, is likely in some populations (transitional damage may still occur).

Management options:

- Germplasm capture
- Track R genetics, ecol trends
- Monitor; maybe translocate (augment) with resistant natural genotypes in worse cases.

3: Moderate to severe decline, resistance variable between or within pop'ns



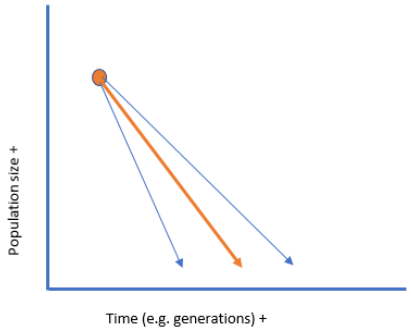
Variable susceptibility & rates of decline: some tolerant genotypes,

- *Melaleuca quinquenervia*

Management options:

- Germplasm capture
- Track declines & natural selection
- Reinforce with natural genotypes AND/OR
- Rely on natural selection.

4: Steep uniform decline (no resistance)



Extreme susceptibility, no tolerant genotypes, rapid decline:

- ***Rhodomyrtus psidioides***
- *Rhodamnia rubescens, et al.*

Management options:

- Germplasm salvage, ex situ conservation
- Rare resistance traits?
- Breed (or engineer?) for resistance traits; reintroduction.

Why has Native Guava gone from common to Critically Endangered in 12 years?

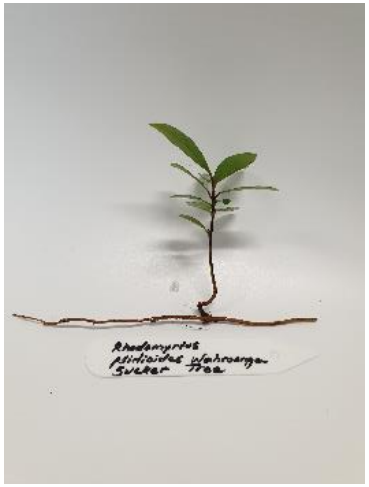
Year 1, Dec. 2010: Wamberal NSW, first exposure.
Top: Damage to sucker growth.
Bottom: infection on late flowers.

Year 4, 2014: Adult death, Bongil Bongil NP NSW – and most other populations. (P. Entwistle)

Year 5: A very rare larger (late juvenile) survivor, 2015. Finding these possibly resistant genotypes is critical. (G. Errington)

Year 9, 2019: Lansdowne NSW. Dead sub-adults (distinctive bark) fallen and standing, and annually emergent sucker fields from surviving root systems. (Makinson)

Putting germplasm to use – vegetative and seed propagation



Green fruit

a—d: Propagation from excavated sucker units and sucker-shoot cuttings.
e: Precocious (year 2) flowering and fruiting in pots.
f: Ripe fruit in open cultivation, ABG Mount Annan; g: successful germination of seed.
(Images V. Viler, B. Makinson).

Long-term vision for recovery of crash-decline species

Sampling near-complete for NSW; just beginning in Qld. Search for any R-genotypes in wild is ongoing.

Not yet – working on it!

R-trait identification is in early stages for two other species (may provide a template)

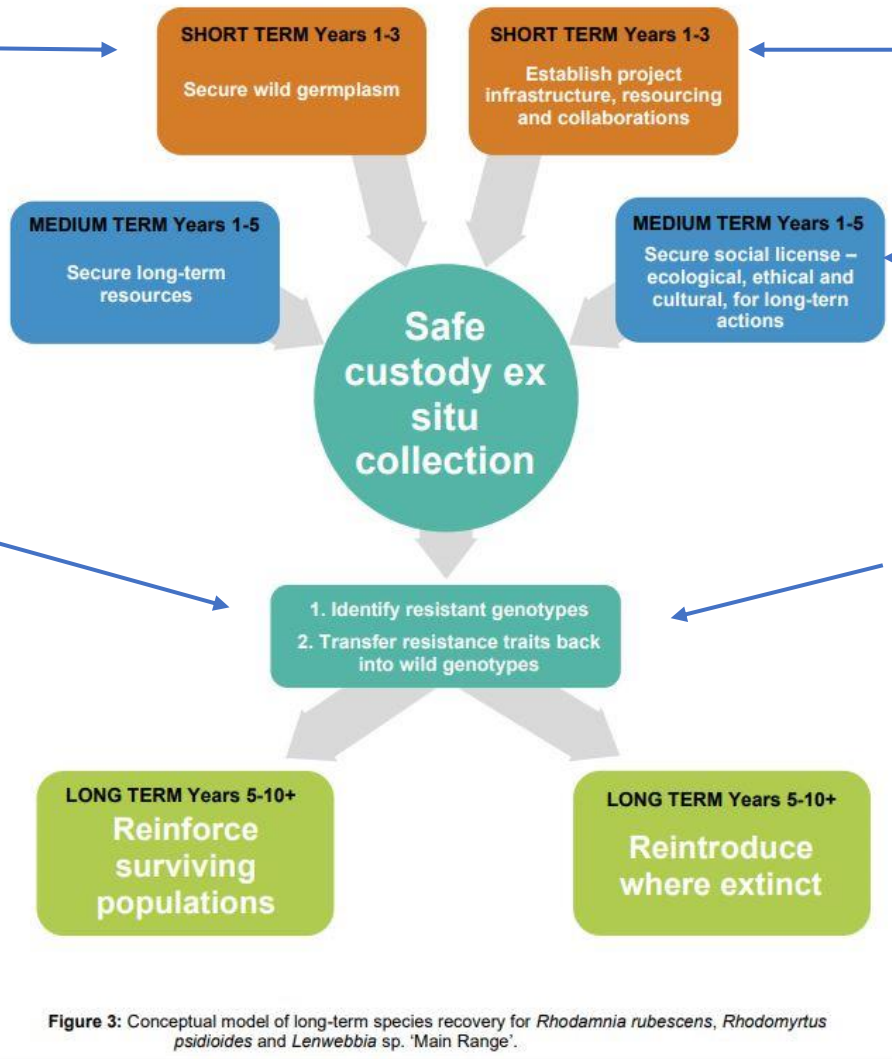


Figure 3: Conceptual model of long-term species recovery for *Rhodamnia rubescens*, *Rhodomyrtus psidioides* and *Lenwebbia* sp. 'Main Range'.

This project (pilot)

Very early stages

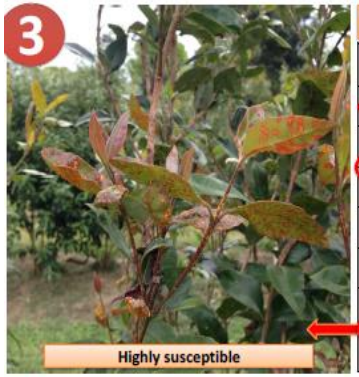
Critical question: how feasible is resistance breeding?

Diagram from **NSW Saving Our Species *Rhodomyrtus psidioides* Operational Plan 2020**, after Makinson 2019.

Myrtle Rust National Action Plan 2020. Download from www.anpc.asn.au/myrtle-rust/

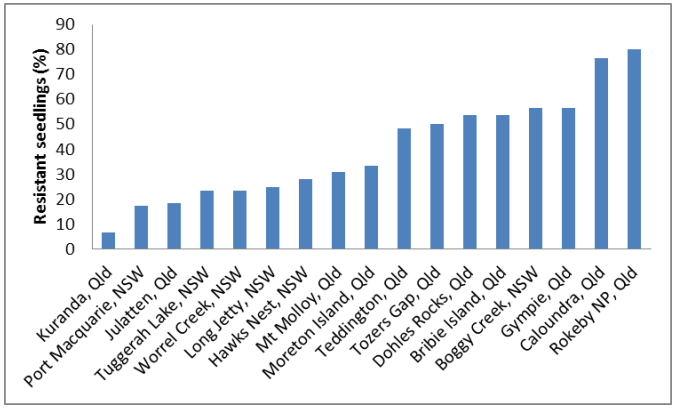
Myrtle Rust resistance selection and breeding: eucalypts (Brazil), Lemon Myrtle (Qld)

Carnegie AJ (2012) 'The impact and management of Eucalyptus/Guava Rust in commercial forestry and native environments in Brazil and the USA: lessons for Australia.' 2012 Gottstein Fellowship Report.



RESULTS OF FIELD ASSESSMENTS	
Disease rating	Clones (%)
0	0
1	3
2	18
3	25
4	28
5	25
6	1

Lancaster *et al.* (2017) Myrtle Rust in Lemon Myrtle plantations (conf. poster)

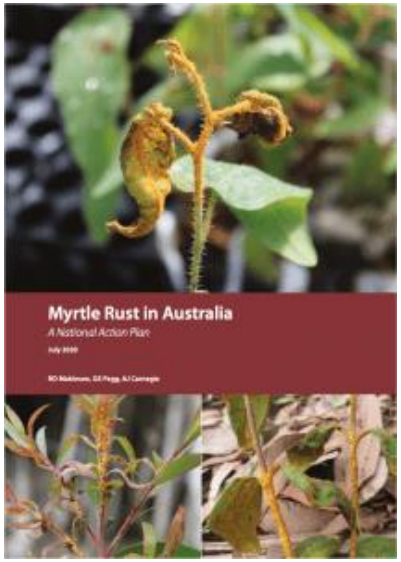


Melaleuca quinquenervia – known variation in resistance of seedlings means good basis for selection for resistance. (G. Pegg, workshop presentation 2018)

Resistance breeding for re-wilding faces extra challenges:

- no commercial imperatives and investment.
- Must avoid genetic bottlenecking (infuse R-traits into wide range of wild genotypes); needs broad germplasm sampling.
- Ecological, ethical, and cultural issues.
- Few global models (but cf. American Chestnut, White Pine).

National Action Plan (NAP) provides a framework for conservation action



- A viable framework for national action in short and medium term, and a basis for long-term recovery.
- Explicit endorsement of the NAP by Governments would provide a mandate for action and resource allocation, and support funding applications.
- NAP implementation needs to dovetail with evolving State and Commonwealth programs, and with new research.
- Commonwealth (DCCEEW) is considering a Threat Abatement Plan under EPBC Act.
- Download from https://www.apbsf.org.au/ or https://www.anpc.asn.au/myrtle-rust/

New Zealand Myrtle Rust response – check it out at https://www.myrtlerust.org.nz
30+ species, c. $40M allocated to response (conservation, industry, & social aspects)

Remaining slides: Take home information
See PDF version, or contact bobmakinson2073@gmail.com

- Myrtle Rust – Key facts
- Host numbers and Myrtle Rust distribution
- Myrtle Rust potential in Western Australia
- Control options and recovery strategies
- Infection process
- ANPC's response to Myrtle Rust 2010—2022
- Some references and resources

Take-home info: Myrtle Rust – Key facts

- An exotic (introduced) pathogenic fungal disease, originating in South America.
- Attacks only plants in Myrtaceae family ('mur-**tay**-see').
- Moister habitats only (inland mostly unaffected).
- 'Host' plant species vary in their susceptibility.
- The pathogen spreads very easily – airborne spores.
- Rapid life cycle: 10-12 days to produce 1,000s of spores.
- Attacks new growth – highly susceptible plants can't renew foliage.
- Loss of growth, reduced (or no) flowering and fruiting.
- Multiple 'strains' known overseas; different host ranges.
- Australia currently has one strain, the 'pandemic strain'.
- One South American strain is strongly eucalypt-associated ('Eucalyptus Rust').

Very unusual among rusts:

- Huge host range: 480 species globally and rising, in 69 genera.
- Short asexual life cycle on any host species. Does not need an 'alternate host'.
- Largest fungal genome sequenced to date.

Above: Broad-leaved Paperbark (*Melaleuca quinquenervia*), north-east NSW 2011.

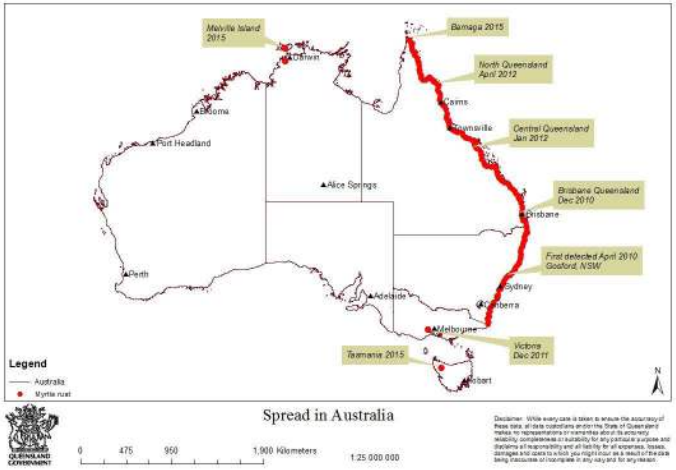
Below: *Eucalyptus tindaliae*, coppice growth, Bungawalbin NSW, 2012.
Images: Peter Entwistle

Take home info: Host species numbers, and Myrtle Rust distribution

Australian hosts: In 2018, 378 native species (in 52 genera)

- 38% from inoculation trials only
- 48% from field observations (wild or cult.)
- 13% from both.
- 3% of screened species seem 'immune'.

Of 163 Queensland hosts, 48 (29%) fall wholly or partly in the High or Extreme susceptibilty classes (Pegg et al. 2014).



165+ native host taxa have natural distributions totally or near-totally within the zone of full Myrtle Rust naturalisation in eastern Australia

32 of these are rated partly or wholly in the 'Highly' or 'Extremely' Susceptible categories (Pegg et al., 2014) . This number may rise.

A further 15 have natural distributions predominantly within the current Myrtle Rust east-Australian envelope.

4, possibly 5 World Heritage Areas affected so far:
Gondwana Rainforests, Wet Tropics, K'gari (Fraser Is.), Lord Howe Is; Kakadu?

Myrtaceae in Western Australia

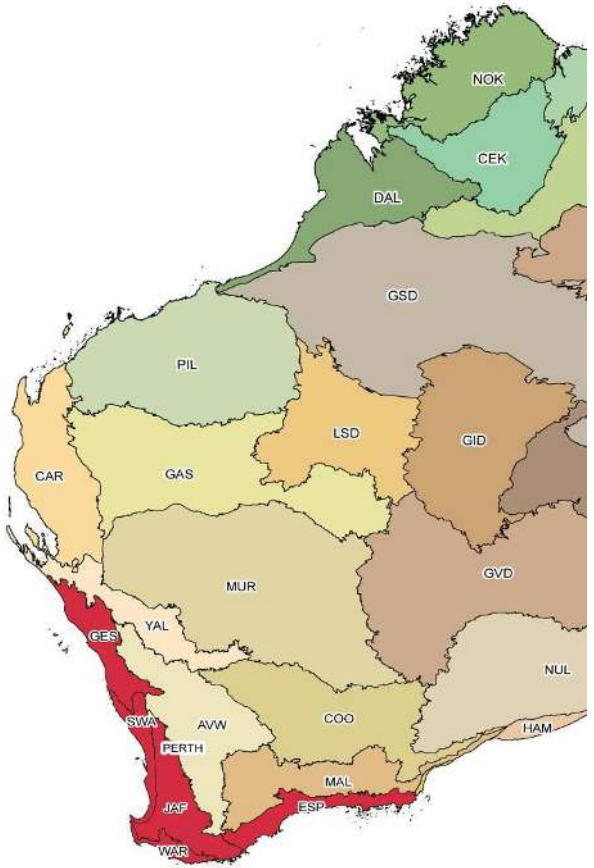
2253 native Myrtacae species in Australia.

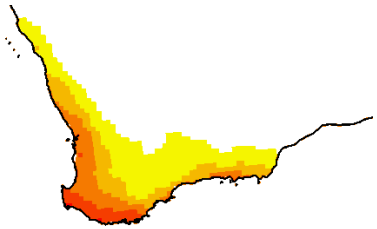
1568 native Myrtaceae species in W.A.

1043 of the WA species are in just 5 south-west IBRA Bioregions:

502	Geraldton Sandplain
378	Swan Coastal Plain
449	Jarrah Forest
154	Warren
548	Esperance Plain

First Myrtle Rust record in WA: June 2022, at a remote site between Kununurra and the NT border, in a coastal paperbark community.





Top: IBRA v7 Bioregions (red = 1043 species of Myrtaceae).

Lower: SW WA detail from Kriticos *et al*. (2013): Ecoclimatic area suitable for Myrtle Rust.

Flora statistics courtesy K. Thiele, WA Herbarium, May 2013.

Take-home info: What controls and biocontrols are possible for affected species?

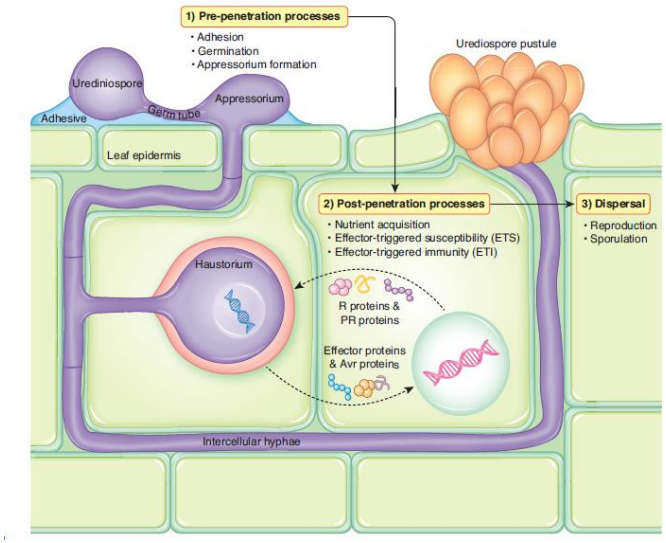
- Fungicides (rotational regime) adequately understood, but enviro-toxic.
- Can we mask or disrupt the physical and chemical 'dialogue' between spore and plant surface to inhibit spore germination and/or infection? Polymer and particulate sprays trialled. Need to investigate wax and leaf chemistry.
- RNAi vaccines for plant, or RNAi disruptor treatments direct to fungus? Yes (under study) but short-duration and difficult at scale.
- Biocontrols: Bacteria; endobiotal reinforcement; fungal and viral hyperparasites. Some such exist, but none likely to be effective to deploy at scale.

None of the above are likely to be deployable at scale in the wild.

Some/all may be useful in ex situ conservation & during reintroduction to the wild

MORE LIKELY STRATEGIES FOR USE IN THE WILD:

- Constitutive traits (e.g. leaf cuticle features) that may confer resistance. Selection & breeding; gene-pool reinforcement.
- Infection and response processes and interactions: Resistance genes and metabolites. Selection & breeding; Gene-pool reinforcement.
- Translocation to 'permanent' sites in areas unsuitable for Myrtle Rust. Not a viable conservation response except *en route* to something better.



From Chock (2020 – Fig. 1, Infection pathway):

The global threat of Myrtle rust (*Austropuccinia psidii*): Future prospects for control and breeding resistance in susceptible hosts. *Crop Protection* 136: 105176. DOI: 10.1016/j.cropro.2020.105176

ANPC's response to Myrtle Rust 2010-2022

Awareness/training workshops 2011-16:
NSW: 2011 (x11) Gosford Newcastle Ballina Lismore Coffs Harbour Springwood Hornsby Nowra Sutherland Narooma Mudgee
Lord Howe Island: 2013 (x3)
Qld: 2011 Mossman
WA: 2013 Perth x2, Bunbury, Albany
NT: 2015, 2016: Darwin x3
Seminar & conference versions include: ANBG Canberra; BGANZ Albury; AMR2011 Adelaide; TNRM Darwin 2014; ANPC Hobart; Lae PNG 2013; Bogor Indonesia 2013. APCC12 Canberra 2019.

Journal paper: *Gardens Bulletin Singapore* 2015

ANPC Website (www.anpc.asn.au):
- Australian & global host lists
- Myrtle Rust bibliography
- APBSF National Action Plan
- PBCRC Review of Environmental Impa

Briefings to:
- WHA Advisory Committees (Gondwana Rainforests; K'gari/Fraser Island)
- Commonwealth TSSC
- Lord Howe Island Board
- Territory NRM (NT)
- Ecological Society of Australia 2019 conference – Pathogens symposium

Training manual (150pp): two editions 2011-16, State updates.

Listing nominations:

NSW BC Act – successful: *Rhodomyrtus psidioides, Rhodamnia rubescens*

Commonwealth EPBC Act: (2014) 'Exotic rusts on Myrtaceae' Key Threatening Process nomination.

Strategy and policy inputs to:
- NSW *Saving Our Species* Myrtle Rust KTP Strategy
- NSW SOS species actions and CAM assessments
- WA DBCA Myrtle Rust Preparedness Strategy
- Lord Howe Is. Preparedness Strategy

Recovery project leadership
'Saving Native Guava' Dispersed ex situ collections (pilot project), 2022-3.

Some of our Myrtle Rust partners 2011-22
Royal Botanic Gardens & Domain Trust, Sydney
Rural Industries Research & Development Corp'n
NSW Office of Environment & Heritage
NSW *Saving Our Species* Program
Commonwealth Dept of Agriculture (NAQS)
NSW Dept of Primary Industry
Qld Dept of Agriculture, Forestry & Fisheries
Qld Dept of Environment & Science
Bjarne K Dahl Trust
Biosecurity Queensland
Cairns City Council
Lord Howe Island Board
Central West CMA (NSW)
Meat Industry Training Advisory Council
(ex) Dept of Environment & Conservation (WA)
WA Forest Products Commission
WA Dept of Agriculture & Food
Territory NRM (NT)
NT Dept of Natural Resource Management
Charles Darwin University
National Meat Industry Training Advisory Council
Invasive Species Council
Plant Biosecurity CRC / APBSF

Australian Network for Plant Conservation Inc. www.anpc.asn.au

Take-home info: Some references and resources

- Fensham RJ & Radford-Smith J (2020) Unprecedented extinction of tree species by fungal disease. *Biological Conservation* 261: 109276. https://doi.org/10.1016/j.biocon.2021.109276
- Makinson RO, Pegg GS, Carnegie AJ, (2020) Myrtle Rust in Australia – a National Action Plan, Australian Plant Biosecurity Science Foundation, Canberra, Australia. Download from either https://www.apbsf.org.au/ or https://www.anpc.asn.au/myrtle-rust/
- Makinson RO (2018) Myrtle Rust reviewed: the impacts of the invasive pathogen *Austropuccinia psidii* on the Australian environment. Plant Biosecurity Cooperative Research Centre, Canberra. Download from either https://www.apbsf.org.au/ or https://www.anpc.asn.au/myrtle-rust/
- Pegg GS *et al*. (2018) Predicting impact of *Austropuccinia psidii* on populations of broad leaved *Melaleuca* species in Australia. *Australasian Plant Pathology* 47:421–430. https://doi.org/10.1007/s13313-018-0574-8
- Pegg GS, *et al*. (2021) Fire and rust – impact of myrtle rust on post-fire regeneration. (plus Update report, also 2021). Threatened Species Recovery Hub. https://www.anpc.asn.au/fire-and-rust/
- Soewarto J, Giblin F, & Carnegie AJ (2019) *Austropuccinia psidii* (myrtle rust) global host list. Version 4. https://www.anpc.asn.au/myrtle-rust/
- 'Myrtle Rust – The silent killer'. Awareness video, at https://www.anpc.asn.au/myrtle-rust/
- Other Myrtle Rust videos (ANPC YouTube channel): https://www.youtube.com/playlist?list=PLuPMH5OJZz0Efq2fJ-y2knJPv528nLTCu