Threatened Species Recovery Hub

National Environmental Science Programme

Fire and rust – impact of myrtle rust on post-fire regeneration

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We would like to thank the Butchulla Land and Sea Rangers for access to sites and assistance in assessing fire damaged sites on K'gari. We would like to thank QPWS staff in Queensland and NSW NPWS for access to sites used in this study. We would particularly like to thank Harry Hines for helping identify sites and assist with fire damage mapping for Queensland. Thank you to Craig Stehn and Ryan Sims for access to data from Central Coast NSW study sites.

Cover images all credited to: Geoff Pegg, Department of Agriculture & Fisheries, Queensland
Top left – Post fire damage along the banks of the Esk River, Bundjalung National Park
Bottom Left – Impact of myrtle rust on Melaleuca quinquenervia post fire regeneration
Bottom middle – Myrtle rust on Melaleuca nodosa
Right – Fire damage on Eucalyptus pilularis in Double Duke State Forest

Contents

Executive Summary

Recent extreme fire events have resulted in significant impacts on a range of different ecosystems, with widespread epicormic and seedling regeneration creating ideal conditions for spread and impact of myrtle rust. This project aimed to determine the susceptibility to and impact of myrtle rust on Myrtaceae species regenerating after bushfire. Locations across fire affected regions in New South Wales and Queensland, including reserves in the Gondwana Rainforests of Australia and Fraser Island World Heritage Areas, were targeted with general surveys capturing data across a range of sites and species. Surveys were conducted from May to October 2020 across a wide range of vegetation types and ecosystems capturing information on species susceptibility and impacts.

Austropuccinia psidii symptoms and damage were found in all survey sites in fire-affected areas of south-east Queensland and NSW south to the Central coast region. This included coastal heath, woodland and swamp environments, littoral and notophyll vine forests along the coast, inland paper bark swamp ecosystems, inland eucalypt woodlands, wet sclerophyll and rainforest ecosystems as far west as the Great Dividing Range. However, no evidence of *A. psidii* was identified in surveys of fire-affected areas south from Ulladulla in southern NSW. Areas in Victoria were not assessed due to Covid 19 restriction. Surveys identified new host species for Australia including *L. speciosum, E. pyrocarpa and E. amplifolia subsp. amplifolia*. Significant impacts were identified on *Rhodamnia rubescens*, listed as Critically Endangered in NSW, with populations affected in all Gondwana World Heritage Areas assessed. The range of restricted and endangered *Uromyrtus australis*, confined to Nightcap National Park, was also identified as being impacted upon. *Melaleuca nodosa* and *M. quinquenervia* were affected in all sites, with dieback caused by *A. psidii* on *M. nodosa* appearing to directly impact on flowering.

While the data from this study gives us an insight into the role fire severity has on disease development and severity of impact, there is still a need to better understand this. It also provides an insight into the impacts of *A. psidii* on the post-fire recovery of individual Myrtaceae species, but it does not look at the more detailed and long-term ecological effects. There is a clear need to expand the current research network to include broader knowledge beyond just the disease experts currently driving much of the research.

Introduction

While fire is considered an important selection agent in the development of Australia's native flora (Gill 1975), the development of new epicormic and young seedlings en-masse are ideal for the development and spread of *Austropuccinia psidii* because juvenile leaf and stem tissues are much more susceptible to the rust than older suberized tissues. Recent extreme fire events have resulted in significant impacts on a range of different ecosystems, with widespread epicormic and seedling regeneration now occurring or about to commence, creating ideal conditions for spread and impact of rust.

Fires

The 2019-20 bushfires in New South Wales (NSW) have been unprecedented in their extent and severity (Table 1). Fires affecting native forest systems commenced in September 2019 and as of 28 January 2020, the fires had burnt large areas of bushland including World Heritage Listed National Parks. In New South Wales 5.3 million hectares (6.7% of the State) were fire affected, including 2.7 million hectares in national parks (37% of the State's national park estate) (ABARES). More than 50% of the Gondwana Rainforests of Australia World Heritage property was affected by fire.

Individual fires burnt large areas of land with Myall Creek Road fire in the Richmond Valley burning more than 121,000 ha, impacting a range of ecosystems including coastal heath and woodland in Bundjalung National Park.

Table 1: Fire extent area during 2019–20 summer bushfire season in southern and eastern Australia, and the area of forest in this extent, by jurisdiction - Source: Fire extent derived from the Department of Agriculture, Water and the Environment National Indicative Aggregated Fire Extent Dataset (v20200428) current to 28 April 2020.

Jurisdiction	Fire area ('000 hectares)	Forest area in fire area ('000 hectares)	Proportion of fire area that is forested (%)
Australian Capital Territory	90	83	93
New South Wales	5,682	5,123	90
Northern Territory	0	0	0
Queensland	574	514	90
South Australia	313	137	44
Tasmania	45	30	65
Victoria	1,583	1,457	92
Western Australia	2,044	1,143	56
Total	10,331	8,486	82

Austropuccinia psidii – Myrtle rust

Austropuccinia psidii, commonly known as myrtle, eucalyptus and guava rust, has long been considered a significant threat to Australian plant industries and ecosystems. In April 2010, A. psidii was detected for the first time in Australia on the central coast of New South Wales. The impact *A. psidii* would have on plant industries reliant on Myrtaceae and native species was unknown. The geographic distribution of *A. psidii* in Australia continues to expand with detections now extending from Tasmania, along the entire east coast of Australia as far north as Bamaga at the tip of Cape York Peninsula and most recently in the Tiwi Islands and Darwin in the Northern Territory. Reports from west of the Great Dividing Range remain low and restricted to nurseries and urban gardens.

Austropuccinia psidii affects plants in the Myrtaceae family, which includes many Australian natives including eucalypt, paperbark, bottlebrush, tea tree and lilly pilly. The fungus spread rapidly along the east coast and in December 2010 was found in Queensland followed by Victoria a year later. More recently (January 2015) myrtle rust was detected in Tasmania and the Northern Territory. The impact of *A. psidii* on individual trees and shrubs has ranged from minor leaf spots, foliage, stem and branch dieback to reduced fecundity. Tree death, because of repeated infection, has been recorded for *Rhodomyrtus psidioides*. Rust infection has also been recorded on flower buds, flowers and fruits of a range of species (Pegg *et al.* 2014a).

The perceived threat to Australian biodiversity and industry is now being realised. Severe damage to key species has been observed in native environments, including rainforest understorey species such as *Rhodamnia rubescens* and *Rhodomyrtus psidioides* and the keystone wetland species *Melaleuca quinquenervia* (Carnegie *et al.* 2016; Pegg *et al.* 2017, Pegg *et al.* 2020). The essential oil industry is being impacted, particularly lemon myrtle (*Backhousia citriodora*), and although *A. psidii* has been found in eucalypt plantations, the forest industry has not yet seen significant damage (Carnegie 2014). The disease has seen an increase in reliance on regular chemical applications in the nursery industry and in some cases resulted in a removal of the more susceptible species from production and on-sale.

The current host range in Australia exceeds 350 species from 57 different genera. In just the short time that *A. psidii* has been established in Australian natural ecosystems, we have observed significant damage and tree mortality. There are few exotic diseases in Australia that threaten such a wide range of Australian flora. Our studies, while currently limited, have shown that *A. psidii* is severely affecting key species in natural ecosystems, and likely to be significantly affecting a much wider range of species. We have identified significant impacts caused by *A. psidii* on threatened species with restricted natural ranges as well as those with a broad native range and considered widespread. Outcomes from this study have resulted in applications to have *Rhodomyrtus psidioides* and *Rhodamnia rubescens* listed as Critically Endangered species.

Austropuccinia psidii is now identified from a range of native forest ecosystems including coastal heath (*Austromyrtus dulcis, Homoranthus* spp.), coastal and river wetlands (*Melaleuca quinquenervia, M. viridiflora*), sand island ecosystems of Moreton, Stradbroke and Fraser Islands, and littoral, montane, subtropical and tropical rainforests (*Syzygium* spp., *Rhodamnia* spp., *Rhodomyrtus* spp.) (Pegg *et al.* 2014a). The disease is prevalent in urban and peri-urban environments around major cities and towns, commonly reported from botanic gardens and nature reserves with disease impacts ranging from minor leaf spots to severe dieback and infection, and premature senescence of flowers and fruits (Pegg *et al.* 2014a).

Impacts on plant communities have now become more apparent with changes in host density due to myrtle rust related dieback within species rich environments likely to impact on the long-term survival of species. *Austropuccinia psidii* has caused significant disturbance in wet sclerophyll environments where Myrtaceae dominate the rainforest understorey. Significant dieback caused by repeated *A. psidii* infection has seen once dominant species in severe decline with little evidence of potential for regeneration. Impacts on keystone species such as *Melaleuca quinquenervia* include tree death, decline in tree vigour and reduced flowering rates with additional decline found to be associated with interactions with insect damage. Using glasshouse screening methods developed in this project we were able to study populations of *M. quinquenervia* and other broad-leaved *Melaleuca* spp. providing a better understanding of resistance patterns as well as identifying populations at greatest risk of significant impact.

Research aim

This project aimed to determine the susceptibility to and impact of myrtle rust on Myrtaceae species regenerating after bushfire. Locations across fire affected regions in New South Wales and Queensland, including reserves in the Gondwana Rainforests of Australia and Fraser Island World Heritage Areas, were targeted with general surveys capturing data across a range of sites and species. The project aimed to identify the species showing susceptibility and the regeneration forms (re-shoots/seedlings) affected by myrtle rust. The effect of repeated infection on species recovery/survival was examined.

Methods

Surveys

Surveys were conducted from May to October 2020 across a wide range of ecosystems to capture information on species susceptibility. Sites incorporated a range of vegetation types including coastal heath, paperbark wetlands, coastal and inland woodland habitats, Eucalyptus forests and subtropical rainforest in the Gondwana Rainforests of Australia World Heritage Area and temperate coastal woodlands. Selection of sites will be based on:

- Fire severity maps (Figure 1, 2, 3)
- Information on flora – i.e. presence of Myrtaceae and species of Myrtaceae
- Local landowner/manager information

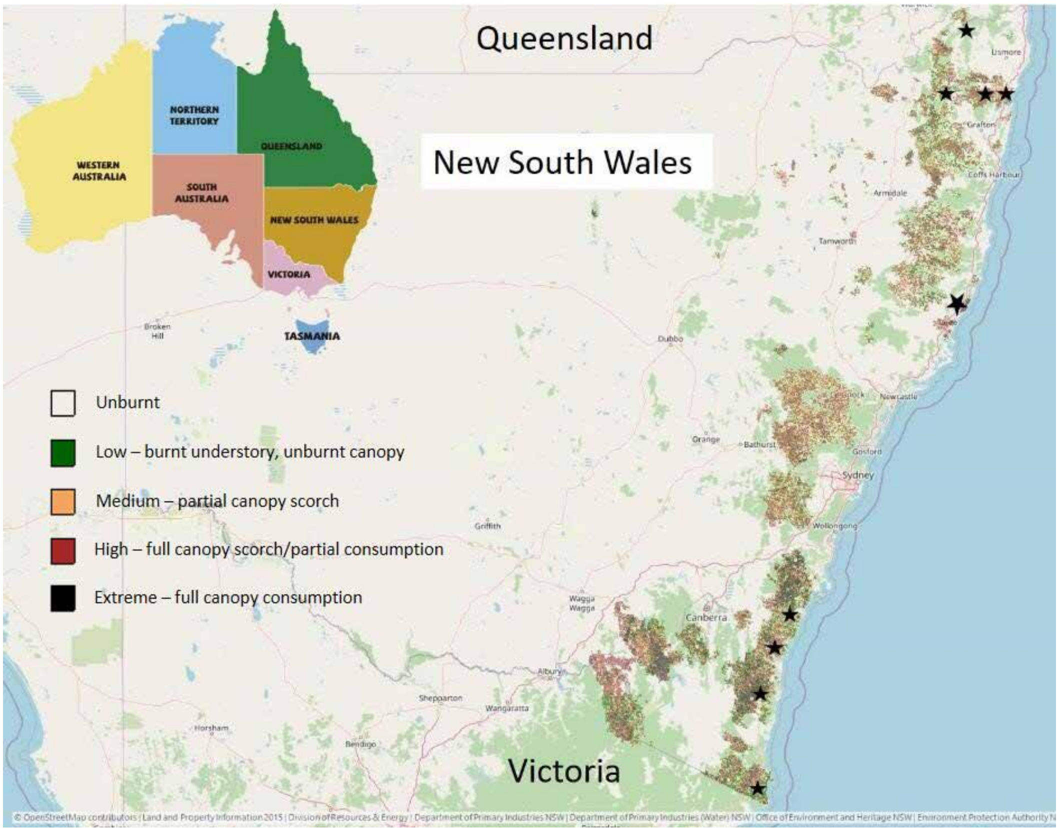

*Figure 1: New South Wales fire affected native forests and post-fire myrtle rust survey areas. Maps from Department of Primary Industries NSW. * Indicate locations surveyed for myrtle rust.*

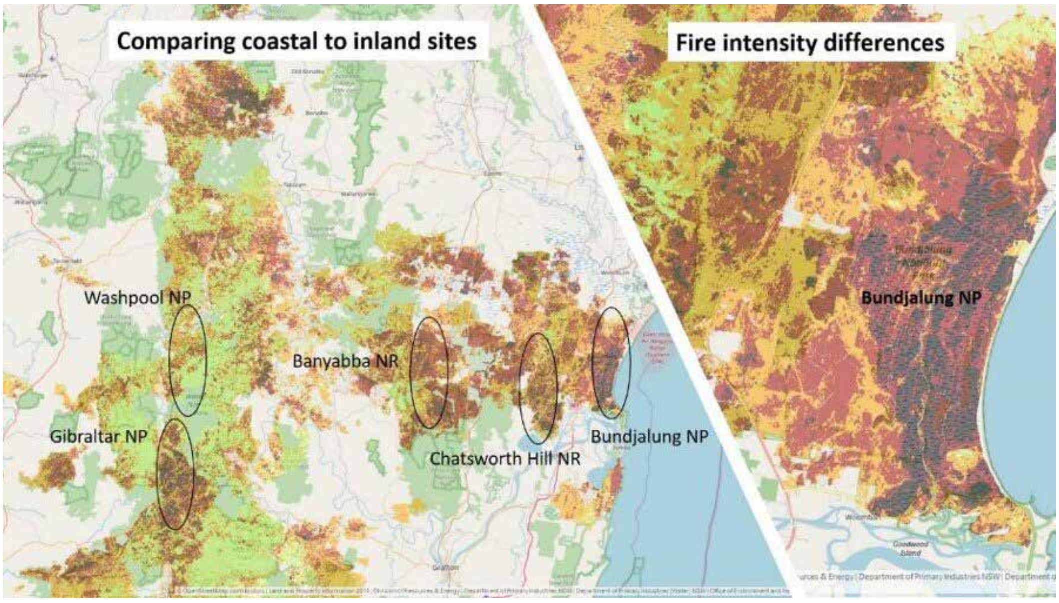

Figure 2: *Northern New South Wales fire sites examining differences in rust impact in different vegetation types in relation to proximity to coastal areas and variable fire severity levels. Circled areas identify sites surveyed for myrtle rust.*
Fire severity ☐ Unburnt; ■ Low-burnt understory, unburnt canopy; ■ Medium – partial canopy scorch;
■ High – full canopy scorch/partial consumption; ■ Extreme – full canopy consumption

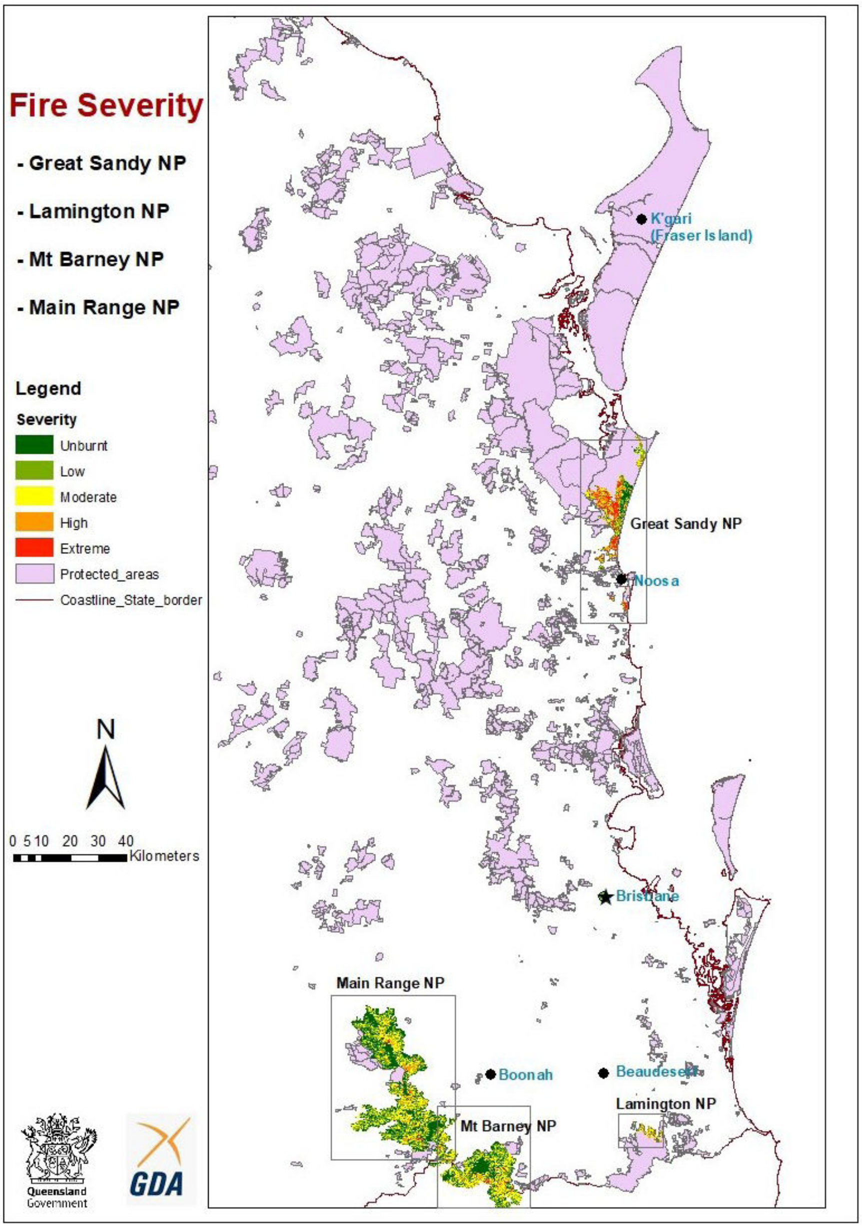

Figure 3: *Fire maps and post-fire myrtle rust impact survey sites in Queensland.*

Table 2: Survey sites across fire-affected areas in Queensland and New South Wales with sites including different vegetation types impacted by varying fire intensities.

State	Location	Vegetation type	Fire severity
Queensland	K'gari (Fraser Island)	Coastal heath, paper bark wetland and woodland	Moderate - High
	Great Sandy National Park	Coastal heath, paperbark wetland and woodland, Littoral Rainforest	Low-High
	Noosa National Park	Coastal heath, paperbark wetland	Moderate-high
	Lamington National Park	Subtropical Rainforest	Low-High
	Mt Barney National Park	Subtropical Rainforest	Low-Moderate
	Main Range National Park	Subtropical Rainforest	Low-High
New South Wales	Yarringully Nature Reserve	Woodland	High-Severe
	Double Duke State Forest	Eucalypt woodland	High-Severe
	Bundjalung National Park	Coastal heath, paperbark wetland, woodland	High-Severe
	Chatsworth Hill Nature Reserve	Woodland, paperbark wetland	Moderate-Severe
	Banyabba Nature Reserve	Woodland	Moderate- Severe
	Gibraltar & Washpool National Park	Warm temperate rainforest, Wet sclerophyll, coachwood rainforest	Low-Severe
	Kiwarrak State Forest*	Woodland	Low-Moderate
	Knappinghat National Park*	Woodland	High
	Wallaby Point*	Woodland	High
	Nabiac*	Coastal heath	Low
	Saltwater National Park*	Coastal heath, Littoral rainforest	High
	McClymont Creek*	Coastal heath	High
	South Eden - Victoria Border, 13 sites	Coastal woodland	High-Severe
	Moruya – Batemans Bay, 4 sites	Coastal woodland, woodland, Melaleuca swamp	High-Severe
	Batemans Bay – Ulladulla, 16 sites	Coastal woodland, Melaleuca swamp	High - Severe
	Nightcap Range National Park	Subtropical Rainforest	Low-High

**Surveys coordinated through NSW Environment funding. Full reporting not included.*

Survey Methodss

Surveys were conducted in wildfire-affected areas where Myrtaceae species were present. Surveys methods were dependent on the site conditions and the distribution of Myrtaceae or presence of specific species of interest. Locations within environments were selected at random and walk-through surveys to assess multiple species impacts carried out by assessing all trees along a transect. The length of the transect was dependent on the site circumstances.

Where particular species of known susceptibility, ecological and/or conservation significance were identified more targeted assessments were undertaken to capture information on as many individuals as possible. Location of surveys and targeted species were recorded using GPS InReach Tracker.

Selected sites and species

Semi-permanent plots have been established in some locations to allow for monitoring of disease levels and impact over time. This consisted of 50 m transects and single species plots where 50 trees of a selected species have been numbered and labelled.

Assessment methods

At each site information on the site characteristics were gathered including:

- GPS location
- General site description
- Vegetation type
- Fire severity - low severity (burnt understory, unburnt canopy), moderate severity (partial canopy scorch), high severity (complete canopy scorch, partial canopy consumption), severe (full canopy consumption)
- Presence/absence of susceptible growth – new shoots, expanding foliage, green stems

Assessment methods have been adapted from previous work done by Pegg *et al.* (2014a), Carnegie *et al.* (2016), Pegg *et al.* (2017) and Pegg *et al.* (2020). Ratings were simplified to be applicable across a range of species and for use by people less familiar with the disease and array of symptoms and impacts on the different host species. Disease incidence on susceptible new growth and severity of infection based on a scale of minor, moderate, high and severe was collected. Due to the variability in hosts and their response to infection, shoots and foliage were rated separately to juvenile stems. Where possible information on the levels of dieback caused by rust was also recorded as was presence of any flower or fruiting structures and evidence of infection.

Monitoring plots

Plots have been established in selected sites and focused on selected species to assess impact of repeated infection of myrtle rust on post-fire plant regeneration. Assessment of plots have been done in some locations and link with existing projects funded through the NSW Government and the Plant Biosecurity Science Foundation. Additional locations identified through this project are to be established soon. Assessments on these sites will be conducted on a regular basis to monitor disease progression, host impact levels and decline/recovery rates.

Monitoring plots have been established in:

- K’gari (Fraser Island) – southern fire-affected areas
- Great Sandy National Park
- Noosa National Park
- Nightcap National Park
- Yarringully Nature Reserve
- Glencoe State Forest
- Bundjalung National Park
- Knappinghat National Park
- Saltwater National Park
- Nabiac
- Kiwarrak State Forest

Training

Training opportunities were limited due to the Covid-19 situation and restrictions enforced by Department of Agriculture and Fisheries. Park staff were contacted prior to any travels and have been kept informed of any findings to date. Where possible, and to assist in expanding capacity to report on myrtle rust impacts, in-field myrtle rust identification and assessment training will be provided to regional Parks and Wildlife staff, land-owners and land care groups at a later date. An existing linkage with the Butchulla Land and Sea Rangers, allowed for a joint survey and rust impact assessment to be done on K’gari.

Results

Queensland

K'gari – Fraser Island World Heritage NP

Both heathland and closed forest communities provide refugia for relict and disjunct populations, which are important to ongoing speciation and radiation. Evolution and specialised adaptation to low fertility, fire, waterlogging and aridity is continuing in the ancient angiosperm flora of the heathlands and the associated vertebrate and invertebrate fauna.

The main surveys on K'gari focused on southern parts of the island affected by wildfire in November 2019. Vegetation types included coastal heath and woodland ecosystems with some encroachment into wet sclerophyll and rainforest vegetation.

Table 3: *Species and susceptibility to* Austropuccinia psidii *in fire-affected sites within fire-affected sites on K'gari (Fraser Island) National Park.*

Species	Regeneration type	Rust identified	Infection level
Syncarpia hillii	S	N	
Austromyrtus dulcis	R	N	
Acmena smithii	R	N	
Eucalyptus pilularis	S/R	N	
Leptospermum liversidgei	R	Y	L-M
Leptospermum semibaccatum	R	N	
Leptospermum polygalifolium	R	N	
Leptospermum trinervium	R	Y	L-M
Homoranthus virgatus	S	Y	L-M
Baeckea frutescens	R	N	
Melaleuca quinquenervia	S/R	Y	L-S

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Surveys across various sites failed to identify *A. psidii* infection occurring on seedling or epicormic regrowth of the iconic and ecologically significant satinay, *Syncarpia hillii* (Table 3), despite it being a known susceptible species in glasshouse studies (Pegg unpublished). Similarly, no infection was found on *Eucalyptus pilularis* despite high levels of infection recorded in other fire-affected areas assessed as part of this study. *Austropuccinia psidii* infection was detected on regenerating *Homoranthus virgatus* (twiggy Homoranthus) but there were also a number of individuals free of symptoms and producing flower buds at the time of assessment. Reports of significant levels of impacts on this species have been made previously, including sites around Boorangoora (Lake McKenzie), Dilli Village and Kingfisher Resort (Pegg *et al.* unpublished).

Infection and dieback caused by *A. psidii* was identified on both seedlings and epicormic reshoots of *M. quinquenervia*. Impact assessment plots were established with five plots located in a range of sites across the southern end of the island (Fig. 4). Fire impact levels were rated as high in all sites and 50 trees at each site, selected at random, were assessed for disease incidence, severity and impact of infection (dieback of epicormic reshoots). All sites had greater than 60% of trees showing some evidence of infection (Table 4) (Fig 5). Dieback levels were low at the time of assessment (Fig 6), but it was considered that the stage of infection was reasonably recent. There is a need to reassess these sites to better capture impact levels, particularly in relation to repeat infection events and the impact on flowering rates within the different sites over time.

Figure 4: *Fire affected* Melaleuca quinquenervia *wetlands, southern end of K'gari (Fraser Island), assessed by Butchulla Land and Sea Rangers for* Austropuccinia psidii *infection and impact.*

Table 4: Melaleuca quinquenervia *plot assessments for* Austropuccinia psidii *impact at different sites across fire-affected areas on K'gari*

Site	% trees infected	% infected trees with dieback
Sheep Station fire break	76	26
Broken Bridge	66	45
Garry's Anchorage	68	38
Inskip	68	41
Jabiru	76	36

Figure 5: Austropuccinia psidii *infection on fire affected* Melaleuca quinquenervia *reshoots on K'gari (Fraser Island).*

Figure 6: *Dieback on* Melaleuca quinquenervia *reshoots caused by* Austropuccinia psidii *following damage from wildfire.*

Great Sandy National Park – Cooloola section

The traditional custodians of the Cooloola section of the Great Sandy National Park are the Kabi Kabi people, bordering with the Butchulla in the north. Cooloola derives its name from the Kabi Kabi word Koolooloi that means Callitris, the native pine characteristic of the southern section of this park.

Fire affected a range of ecosystems within the Cooloola section, with severity ranging from low to high impact burning. Environments affected included coastal heath and woodland and Melaleuca wetlands along with edges of the notophyll vine rainforest (Fig 7). Eight species in total were identified with symptoms of *A. psidii* infection and associated impact (Table 5). *Homoranthus virgatus* was found in the southern section of the park near Teewah village with moderate to high levels of infection. This will be monitored over time to ascertain if dieback seen in other parks becomes evident. Individual plants of *L. polygalifolium* and *A. smithii* showed varying levels of infection. *Syzygium oleosum* was the only species found in the littoral rainforest section with rust, though this plant had a high level of infection (Fig 8).

Figure 7: *Environments in Great Sandy National Park – Cooloola section affected by wildfire in the 2019/20 season.*

Table 5: Species and susceptibility to Austropuccinia psidii *in fire-affected sites within fire-affected sites in Great Sandy National Park*

Species	Regeneration type	Rust identified	Infection level
Acmena smithii	R	Y	L-S
Austromyrtus dulcis	R	Y	L
Backhousia myrtifolia	R	N	
Baeckea frutescens	R	N	
Corymbia intermedia	R	N	
Corymbia tesselaris	R	N	
Eucalyptus pilularis	S/R	N	
Eucalyptus racemosa	R	N	
Eucalyptus robusta	R	N	
Homoranthus virgatus	R	Y	L-H
Leptospermum liversidgei	R	Y	L-M
Leptospermum polygalifolium	R	Y	L-S
Leptospermum semibaccatum	R	Y	L
Leptospermum trinervium	R	N	
Lophostemon confertus	S/R	N	
Melaleuca quinquenervia	R	Y	L-S
Rhodamnia acuminata	R	N	
Syzygium australe	R	N	
Syzygium leuhmannii	R	N	
Syzygium oleosum	R	Y	L-H

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 8: Austropuccinia psidii *infection on post-fire regeneration of (Left to Right)* Leptospermum liversidgei, L. polygalifolium *and* Syzygium oleosum.

Figure 9: Melaleuca quinquenervia *wetlands in the Great Sandy National Park – Cooloola section affected by different fire intensities (moderate top left, high top right) were assessed for* Austropuccinia psidii *infection and impact on reshoots, with infection identified on new growth.*

Table 6: Austropuccinia psidii *disease incidence on* Melaleuca quinquenervia *affected by different intensities in the Cooloola section of the Great Sandy National Park*

Fire severity rating	% trees infected	% infected trees with disease on >50% of susceptible foliage
Low	46	39.13
Moderate	52	38.46
High	64	87.5

Monitoring plots, consisting of 50 randomly selected trees at each site, have been established in *Melaleuca quinquenervia* wetlands with three locations selected based on different fire intensities, low, moderate and high (Table 6) (Fig 9). Assessment data from the site indicates increasing numbers of trees infected as fire impact increases, along with an increasing incidence of infection per tree. These plots will be reassessed over time to look at impact/ recovery in relation to fire severity and *A. psidii* infection.

Noosa National Park - Peregian and Emu Swamp Sections

The Peregian and Emu Swamp sections of Noosa National Park reside on lands traditionally owned by the Kabi Kabi people. Fire severity levels varied from moderate to high intensities. No rust was found in the Peregian section which is comprised of Melaleuca open forest and coastal heath. The Emu Swamp section was comprised of wet coastal heath and Melaleuca open forest. *Melaleuca quinquenervia* had varying levels of rust, with trees showing severe symptoms in close proximity to those with low or no levels of infection. Two *Leptospermum species, L. liversidgei* and *L. polygalifolium* also showed various levels of infection (Table 7). No rust was found on *Homoranthus virgatus*, which contrasts with Cooloola National Park and K'gari (Fraser island).

Table 7: *Species and susceptibility to* Austropuccinia psidii *in fire-affected sites within fire-affected sites in Peregian Nature Reserve*

Species	Regeneration type	Rust identified	Infection level
Austromyrtus dulcis	R	N	
Baeckea imbricata	R	N	
Baeckea frutescens	R	N	
Corymbia intermedia	R	N	
Homoranthus virgatus	R	N	
Leptospermum liversidgei	R	Y	L-M
Leptospermum polygalifolium	R	Y	L-M
Leptospermum semibaccatum	R	N	
Melaleuca pachyphylla	R	Y	L
Melaleuca quinquenervia	R	Y	L-S
Melaleuca thymifolia	R	N	
Ochrosperma lineare	R	N	

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Gondwana Rainforests of Australia World Heritage Area Fire Impacts

Fire impacts varied across sites examined within the Gondwana Rainforests of Australia World Heritage Area from low severity leaf litter/O horizon fires to more severe crown fires, with the more severe fires associated with the presence of 'Eucalypts' such as *Eucalyptus, Syncarpia* and *Lophostemon*. Within sites there was considerable variation with patches of unburned forest amongst burned areas. Lower severity leaf litter fires in rainforests were variable in their impacts within sites, affecting mostly seedlings and saplings but also sometimes significantly impacting larger trees. Often seedlings and saplings had browned leaves or were defoliated either from heat exposure or from damaged root systems. Many saplings were burned off at ground level and were reshooting from the base and/or root suckers, and smaller trees were often defoliated or browned off and reshooting epicormically as well as having basal and root suckers. In rainforest areas with low to moderate fire severity, larger trees were often left with damage to their lower bark, buttresses, spreading surface roots and finer roots in the O and A horizons of the soil. Some surface roots and buttresses were visibly burned or undermined by a burned humus layer. Trees were also damaged or killed by fire catching onto their heartwood and burning them from the inside or by vines carrying the fire into the canopy. Some very well-developed rainforest understories in tall wet Eucalypt forests, including some mature rainforest trees had been torched by intense fire leaving mainly Eucalypts standing.

Main Range National Park

A variety of sites were examined across Main Range National Park with varying fire impacts. High to severe severity fires occurred mainly where Eucalypts or Leptospermums occurred in conjunction with steep topography or on ridge crests in sites such as Lower Mt Mitchell Trail, Governors Chair, Bare Rock and to a lesser extent on the edge of the escarpment on the eastern side of Winders Track. Other areas examined were mostly affected by low to moderate severity fires such as sites around Moss's Well, the base of Mt Mathieson, Mt Cordeux, Mt Castle Lookout and the west side of Winders Track.

Only three Myrtaceae species were identified with active *A. psidii* infection or associated damage in surveys across ten sites in Main Range National Park (Table 8). *Rhodamnia rubescens* is the worst affected of the species assessed (Fig 10, 11). Fifty trees were assessed from eight locations with 35 trees still alive at seven locations and 89% of those with infection/dieback caused by *A. psidii.* Infection was also identified on *Rhodamnia whiteana* (six trees at three locations, one dead, five infected) and *Syzygium australe* (34 trees at six locations, nine with very low infection or dieback) but incidence and severity levels were low with no or minimal impact detected at the time of assessment.

Table 8: *Species and their susceptibility to* Austropuccinia psidii *within fire-affected sites in Main Range National Park*

Species assessed	Regeneration type	Rust identified	Infection level
Acmena ingens	S/R	N	
Acmena smithii	R	N	
Angophora subvelutina	R	N	
Corymbia intermedia	R	N	
Eucalyptus acmenoides	S/R	N	
Eucalyptus campanulata	R	N	
Eucalyptus dunnii	R	N	
Eucalyptus microcorys	S/R	N	
Eucalyptus punctata	R	N	
Eucalyptus saligna	R	N	
Eucalyptus tereticornis subsp. basaltica	R	N	
Leptospermum variabile	S/R	N	
Lophostemon confertus	S/R	N	
Rhodamnia rubescens	R	Y	L-S
Rhodamnia whiteana	R	Y	L
Syzygium australe	R	Y	L

Mt Barney National Park

A variety of sites were examined across Mt Barney National Park with varying fire impacts. The most severe fires occurred in the Palen Creek area. Other areas examined were mostly affected by low to moderate severity fires such as upper and lower Burnett and Cronin Creeks.

Similar to the findings in Main Range National Park, post-fire regeneration of *Rhodamnia rubescens* was significantly impacted by *A. psidii* (Table 9). Nine *R. rubescens* trees were found with one dead and the remaining with infection and/or dieback on reshoots. *Backhousia myrtifolia* was the only other species identified with symptoms associated with *A. psidii* infection. While rust has previously been reported on this species, there has been no indication of significant damage as a result of infection.

Table 9: *Species and their susceptibility to* Austropuccinia psidii *within fire-affected sites in Mt Barney National Park*

Species assessed	Regeneration type	Rust identified	Infection level
Backhousia myrtifolia	R	Y	L
Eucalyptus grandis	S	N	
Eucalyptus microcorys	R	N	
Eucalyptus propinqua	R	N	
Gossia acmenoides	R	N	
Lophostemon confertus	S/R	N	
Rhodamnia rubescens	R	Y	L-S
Syncarpia glomulifera	R	N	
Syzygium australe	R	N	
Syzygium oleosum	R	N	

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 10: *Post-fire regeneration of* Rhodamnia rubescens *in Gondwana World Heritage Main Range and Mt Barney National Parks.* Austropuccinia psidii *had significant impacts on reshoots and root sucker. Infection was also identified on flower buds.*

Figure 11: *Post-fire regeneration of* Rhodamnia rubescens *with severe levels of* Austropuccinia psidii *infection causing dieback of root suckers in Gondwana World Heritage Main Range and Mt Barney National Parks.*

Lamington National Park

A variety of sites were examined across Lamington National Park with varying fire impacts (Fig 12). Moderate to high severity fires occurred in a number of sites including the upper caves circuit, Bellbird Lookout circuit and parts of the Illinbah circuit, associated with tall Eucalypt forest. Rainforest understory, possibly as old as 100 years, was reduced to ash on the Bellbird Lookout track. Other areas examined were mostly affected by low to moderate severity fires such as many areas on the Illinbah circuit, West Canungra Creek and the periphery of the rainforest at the Bellbird Lookout track.

Fire impacts ranged, with more severely affected areas at the rainforest margins with predominantly understory damage within rainforest systems. A range of different ecotypes were surveyed including complex Notophyll Vine Forests dominated by Hoop Pine, White Booyong, Ficus spp. and Giant Stinging Trees. Sclerophyll and rainforest Myrtaceae species (Table 10) were assessed across a range of sites with post-fire *Rhodamnia rubescens* (19 trees at three locations, 17 infected) regeneration the most affected by *A. psidii* (Table 10, Fig 13). Only two other species were found with symptoms of *A. psidii* infection, *Pilidiostigma glabrum* (one infected out of seven at two sites) and *Acmena ingens* (two infected out of 16 trees at two sites).

Table 10: *Species and their susceptibility to* Austropuccinia psidii *within fire-affected sites in Lamington National Park.*

Species	Regeneration type	Rust identified	Infection level
Acmena ingens	S/R	Y	L
Acmena smithii	R	N	
Backhousia myrtifolia	R	N	
Eucalyptus acmenoides	R	N	
Gossia bidwillii	R	N	
Lophostemon confertus	S/R	N	
Pilidiostigma glabrum	R	Y	L-M
Rhodamnia rubescens	R	Y	L-S
Syzygium francisii	S/R	N	
Syzygium oleosum	R	N	

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 12: *Different vegetation types and fire intensities within Lamington National Park.*

Figure 13: Fire affected Rhodamnia rubescens *trees regenerating as root suckers and epicormic reshoots affected by* Austropuccinia psidii.

New South Wales

Nightcap Ranges National Park

The Nightcap Ranges National Park is 8,028ha situated in the Nightcap Range in northern New South Wales. Nightcap Ranges National Park is included within the Shield Volcano Group, that lie in the Border Ranges (NSW NPWS 2004). Nightcap is part of the World Heritage Central Eastern Rainforest Reserves of Australia (CERRA) *representing* links in a chain of ancient subtropical rainforest remnants. It is an area of refuge in Australia of ancient rainforest communities, plants and animals with evolutionary links to Gondwana. Approximately 70% of Nightcap NP is covered by a variety of rainforest communities, and the rest is covered by mostly wet sclerophyll forest and partly dry sclerophyll forest. The park also supports lowland species of the former Big Scrub, which was the largest area of subtropical lowland rainforest that was intensively cleared with less than 1% remaining.

Fire severity levels were variable within the sites assessed ranging from low severity burns affecting the understory to high severity fire damage affecting the forest canopy (Fig 14). Fire impacts were also patchy with unburnt sections bordering burnt areas. A range of Myrtaceae were assessed across four survey sites (Table 11). The most significant levels of *A. psidii* infection and associated dieback was identified on *Rhodamnia rubescens* (Fig 15) and *Uromyrtus australis* (Endangered species EPBC Act 1999) (Fig 13). At the time of assessment ten *R. rubescens* trees were located with 90% showing some level of *A. psidii* infection. Six trees were recorded as having dieback because of *A. psidii* infection on epicormic reshoots.

Longer term plots have been established to monitor disease development and impact of *A. psidii* on populations of *U. australis* affected by fire (Fig 16). A total of 90 plants were assessed, with 38% showing evidence of infection and/or dieback because of infection at the time of assessment. Other species found with rust infection included A. *beckleri, Decaspermum humile, Eucalyptus pilularis, Leptospermum petersonii* and *Syncarpia glomulifera* (Fig 17).

Table 11: *Species and their susceptibility to* Austropuccinia psidii *within fire-affected sites in Nightcap Ranges National Park*

Species	Regeneration type	Rust identified	Infection level
Acmena smithii	R	N	
Archirhodomyrtus beckleri	R	Y	L
Backhousia myrtifolia	R	N	
Decaspermum humile	R	Y	L-M
Eucalyptus microcorys	R	N	
Eucalyptus pilularis	S/R	Y	L
Leptospermum petersonii	S	Y	L
Lophostomen confertus	R	N	
Rhodamnia rubescens	R	Y	L-S
Syncarpia glomulifera	R	Y	L-M
Syzygium oleosum	R	N	
Uromyrtus australe	R	Y	L-S

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 14: *Fire damage within Nightcap Ranges National Park was patchy in severity, with some areas suffering significant fire damage.*

Figure 15: *Fire affected* Rhodamnia rubescens *reshoots dying back as a result of infection by* Austropuccinia psidii.

Figure 16: Uromyrtus australe *affected by* Austropuccinia psidii *infection, with evidence of variability in severity of infection and impact.*

Figure 17: Austropuccinia psidii *infection of* Syncarpia glomulifera *in Nightcap Ranges National Park. The number of trees assessed with infection present was low.*

Yarringully Nature Reserve & Double Duke State Forest

Bungawalbin National Park, Bungawalbin Nature Reserve, Bungawalbin State Conservation Area, Yarringully Nature Reserve and Yarringully State Conservation Area are located in north-eastern NSW (NSW NPWS 2012). Bungawalbin and Yarringully parks and reserves play a significant role in the protection of ecologically important floodplain subtropical rainforest, coastal swamp forests and coastal floodplain wetlands as well as dry sclerophyll forest. These reserves protect eastern red gum vegetation, including populations of slaty red gum (*Eucalyptus glaucina*) which is listed as vulnerable under the Threatened Species Conservation Act (TSC Act). Much of the Yarringully section is coastal floodplain wetland incorporating interconnected permanent and intermittent lagoons. The area is part of a landscape of cultural importance to the Aboriginal people of the Bundjalung Nation and Bandjalang people.

A severe fire went through the Yarringully Nature Reserve and Double Duke State Forest in November 2019 burning large areas of woodland, destroying canopies of large overstory species (Fig 18). Sites assessed in Yarringully included wetland areas dominated by large diameter *Melaleuca quinquenervia, M. nodosa* growing as a small tree and *Eucalyptus pilularis* and *Angophora subvelutina* in drier areas.

Double Duke State Forest covers an area of about around 2,600ha and is located south of Woodburn. The state forest conserves swamp and grassy sclerophyll forest and freshwater wetlands. Double Duke forest survey sites were dominated by *Eucalyptus pilularis* overstory with a mix of Myrtaceae in the understory. Patches of *E. pyrocarpa*, a species with a restricted range, were also assessed with seedling and epicormic reshooting observed. Long term monitoring plots have been established in both sites as part of the Plant Biosecurity Science Foundation (PBSF) funded project with monthly assessments continuing.

Figure 18: *A severe fire affected large areas of National Parks and Nature Reserves in the Bungawalbin area and Double Duke State Forest.*

All species assessed, aside from *C. intermedia*, had some evidence of *A. psidii* infection (Table 12). However, the most susceptible species were *M. quinquenervia* and *M. nodosa*. Moderate levels of infection were identified on *E. pilularis* (54% of seedlings assessed) and *E. pyrocarpa* seedlings (40% of seedling assessed) (Fig19) with evidence of severe dieback and deaths associated with *A. psidii* infection. Infection on epicormic reshoots on both *E. pilularis* and *E. pyrocarpa* were primarily confined to the lower canopy with reshooting in the mid and upper canopy either free of disease or with low disease incidence. This is the first report of infection on *E. pyrocarpa* in Australia. The detection of rust on *E. amplifolia* subsp. *amplifolia* is also the first report of *A. psidii* infection on this species in Australia (Fig 20). No evidence of *A. psidii* infection was detected on *C. henryi*. However, the majority of reshoots and seedlings were heavily infected by *Q. pitereka* resulting in shoot and foliage dieback (Fig 21).

Table 12: *Species and their susceptibility to* Austropuccinia psidii *in fire-affected sites within fire-affected sites in Yarringully Nature Reserve and Double Duke State Forest*

Species	Regeneration type	Rust identified	Infection level
Angophora subvelutina	S/R	Y	L
Austromyrtus dulcis	R	Y	L
Corymbia intermedia	R	N	
Corymbia henryi	R	N*	
Eucalyptus amplifolia subsp amplifolia	S/R	Y	L-M
Eucalyptus baileyana	R	N	
Eucalyptus pilularis	S/R	Y	L-S
Eucalyptus pyrocarpa	S/R	Y	L-S
Leptospermum polygalifolium	R	Y	L
Leptospermum trinervium	R	Y	L-S
Melaleuca nodosa	R	Y	L-S
Melaleuca quinquenervia	S/R	Y	L-S
Melaleuca sieberi	S/R	Y	L-M

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 19: Austropuccinia psidii *infection causing dieback of* Leptospermum trinervium *reshoots and* Eucalyptus pilularis *and* E. pyrocarpa *seedlings in Double Duke State Forest.*

Figure 20: Austropuccinia psidii *infection on* Eucalyptus amplifolia *subsp. amplifolia reshoots from fire affected trees.*

Figure 21: Quambalaria pitereka*, an endemic fungus, causing shoot and stem blight on post-fire regeneration of* Corymbia henryi.

Ninety-six percent of *M. quinquenervia* assessed in Yarringully Nature reserve had evidence of *A. psidii* infection, with 88% having some level of myrtle rust related dieback. Additional dieback was also associated with mirid bugs (*Eucerocoris suspectus*), a sap sucking insect that attacks the new growth and can cause dieback on reshoots. Disease incidence levels were similarly high on *M. nodosa* with 92% of trees having *A. psidii*-related dieback with no evidence of trees being totally resistant. Evidence of flowering on some trees was observed and has been recorded as part of the longer-term monitoring.

A small number of *M. nodosa*, small tree form, were found in Double Duke State Forest but in an area affected by low severity fire. Twenty trees were assessed with 35% showing *A. psidii* symptoms on susceptible growth and 40% with evidence of *A. psidii* associated dieback.

Bundjalung National Park

Large areas of Bundjalung National Park, particularly the southern areas, were subjected to severe fire damage with the fire peak occurring in late November 2019 (Fig 22). Patches of lower severity burns were present and northern areas were unaffected by this fire episode due primarily to control burns having been completed at an earlier date. Surveys were conducted in coastal heath areas consisting of low growing “hedge” like shrubs, coastal swale and wetland, paperbark swamp areas, river bank ecosystem (Esk River) and coastal woodlands and a small area of littoral rainforest that was affected by a low severity fire. A series of monitoring plots have been established as part of the PBSF project with monthly assessments on a range of species to document disease progress and host decline rates and impacts on survival and fecundity. Twenty-eight species of Myrtaceae have been assessed within the area (Table 13).

Figure 22: *Severe fire damage occurred in November 2019 in large parts of Bundjalung National Park with regeneration first appearing in late January 2020.*

Table 13: *Species and their susceptibility to* Austropuccinia psidii *in fire-affected sites in Bundjalung National Park*

Species	Regeneration type	Rust identified	Infection level
Acmena hemilampra	R	Y	L
Acmena smithii	R	Y	L
Austromyrtus dulcis	R	Y	L-S
Baeckea frutescens	R	Y	L
Calytrix tetragona	R	N	
Corymbia henryi	S/R	Y	L
Corymbia intermedia	R	Y	L
Eucalyptus pilularis	S/R	Y	L-H
Eucalyptus planchoniana	S/R	Y	L-H
Eucalyptus robusta	R	Y	L
Eucalyptus tindaliae	R	Y	L
Homoranthus virgatus	S/R	Y	L
Leptospermum juniperinum	R	N	
Leptospermum liversidgei	S/R	Y	L-M
Leptospermum polygalifolium	R	Y	L
Leptospermum semibaccatum	R	Y	L
Leptospermum speciosum	R	Y	L
Leptospermum trinervium	R	Y	L-S
Leptospermum whitei	R	Y	L-M
Lophostemon suaveolans	S/R	Y	L
Melaleuca alternifolia	R	Y	L
Melaleuca nodosa	R	Y	L-S
Melaleuca quinquenervia	S/R	Y	L-S

Species	Regeneration type	Rust identified	Infection level
Melaleuca linearis	S	Y	L-M
Melaleuca salignus	S/R	Y	L-H
Melaleuca sieberi	S/R	Y	L-M
Melaleuca squamea	S/R	Y	L-M
Ochrospermum citriodorum	R	N	

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Twenty-eight species of Myrtaceae were assessed for rust in Bundjalung NP. Symptoms of *A. psidii* infection or associated dieback was found on 25 species. This included new field host records for *Melaleuca squamea* and a new host record for *Leptospermum speciosum* with low levels of infection found on seedlings and reshoots. Infection levels of *M. squamea* ranged from low to moderate with stem infection causing distortion and dieback (Fig 23).

Figure 23: *Post-fire* Melaleuca squamea *regeneration with* Austropuccinia psidii *infection on juvenile stems causing distorted growth.*

Infection was found on reshoots and seedlings of *E. pilularis* and *E. planchoniana* at a number of sites (Fig 24, 25, 26). Infection on seedlings caused significant dieback and deaths of severely infected plants of both species. Seedling monitoring plots have been established to look at decline over time. Infection on epicormic reshoots of mature trees was more severe on the lower canopy compared to the mid canopy, with little to no evidence of infection or *A. psidii* associated dieback in the upper canopy. Plots have been established to monitor disease and impact over time. Leaf spots and minor shoot dieback were recorded on *E. tindaliae*, both juvenile and adult foliage. Surveys of *C. henryi* failed to find *A. psidii* infection on reshoots but small leaf spots were found on emerging seedlings. As was the case in the Yarringully Nature Reserve & Double Duke State Forest area, *Q. pitereka* was prominent on reshoots causing significant levels of shoot and foliage dieback.

Figure 24: Austropuccinia psidii *infection and associated dieback on reshooting fire affected* Eucalyptus planchoniana.

Figure 25: Austropuccinia psidii *infection and associated dieback on reshooting fire affected* Eucalyptus pilularis.

Figure 26: Austropuccinia psidii *infection on post-fire seedlings of* Eucalyptus pilularis *and* E. planchoniana.

Figure 27: *Dieback on reshooting* Leptospermum trinervium *caused by* Austropuccinia psidii *in fire-affected areas of Bundjalung National Park.*

Six species of *Leptospermum* were identified with symptoms of *A. psidii* infection and/or associated dieback. The most susceptible species was *L. trinervium* with infection causing significant dieback. Two sites were assessed, one in the coastal heath area and the other in a more typical coastal woodland site. In the coastal heath site 18 trees were assessed with 94% confirmed as susceptible to *A. psidii* and 94% of those were recorded with dieback associated with the infection (Fig 27). Seventy-five percent were considered severely affected with dieback on 50% or more branches. Fifty percent had dieback recorded on all branches. Sixty-nine trees were assessed from two coastal woodland sites with 55% trees having evidence of *A. psidii* infection, 68% of these having some level of associated dieback. Plots have been established to monitor impact on tree survival and fecundity over time. Infection and dieback of *Austromyrtus dulcis* was also observed at a number of sites surveyed (Fig 28).

Figure 28: *Dieback on reshooting* Austromyrtus dulcis *caused by* Austropuccinia psidii *in fire-affected areas of Bundjalung National Park.*

High levels of *A. psidii* infection and impact have been identified on *M. nodosa* and *M. quinquenervia* seedlings and reshooting trees and shrubs growing throughout Bundjalung NP (Fig 29, 30, 31). Only a small number of *M. nodosa* seedlings were identified during the surveys. All assessed had evidence of infection. A larger number of reshooting plants were assessed, 162 in total, with 83 % of trees identified as susceptible at the time of assessment. However, approximately 8% of trees didn't have susceptible flush present at the time of assessment and approximately 9% showed no evidence of infection or dieback. Fifty-eight percent of the susceptible trees had $\geq$50% of their total branches with *A. psidii* related dieback.

Figure 29: *Regrowth on fire affected* Melaleuca nodosa *infected by* Austropuccinia psidii.

Figure 30: *Dieback of regrowth on fire affected* Melaleuca nodosa *and emerging seedlings caused by* Austropuccinia psidii *infection of new growth*

Figure 31: *Some evidence of disease tolerance to* Austropuccinia psidii *was observed (top left, top middle) within thickets of* Melaleuca nodosa *in coastal heath areas. More susceptible plants suffered significant levels of branch dieback because of* Austropuccinia psidii *infection.*

Surveys in September in the coastal heath environment in Bundjalung National Park allowed for an assessment to determine what impact *A. psidii* infection and associated dieback might have on *M. nodosa* flower production (Table 14, Fig 32, 33). One hundred plants were selected at random and assessed for the level of branch dieback, based on the percentage of total with dieback symptoms present, and the level of flowering based on percentage of branches with flowers or flower buds. Fifty-three percent of trees had substantial levels of dieback, >60% of branches with dieback. In comparison to trees with lower dieback levels (<40% branches affected), flowering levels were reduced in trees with >60% of branches assessed with dieback. No flowers were recorded on 5.7% of the severely affected trees.

Table 14: *Assessment of* Melaleuca nodosa *flowering rates in relation to disease levels based on percentage of branches with* Austropuccinia psidii *related dieback.*

Impact - branch dieback (%)	Trees in each category	Flowers absent	≤50% branches with flower	>50% branches with flower
>40	25	0	36	60
40-60	22	0	50	50
>60	53	5.7	82.9	11.4

Figure 32: Melaleuca nodosa *in coastal heath in fire-affected areas of Bundjalung National Park showing little to no evidence of dieback caused by* Austropuccinia psidii *and branches with large numbers of flowers and flower buds.*

Figure 33: Melaleuca nodosa *in coastal heath in fire-affected areas of Bundjalung National Park showing significant levels of branch dieback caused by* Austropuccinia psidii *and a reduced level of flower bud and flower production.*

Melaleuca quinquenervia occurs in different sites in Bundjalung NP ranging from the Esk River edge, with a role in stabilizing the bank, large diameter trees in swamp ecosystems along the river, coastal swales along 10-mile beach, and to inland lagoons or wetlands (Fig 34). Sizes of trees varied considerably. A total of 195 trees were assessed with monitoring plots established in three sites. Eighty percent of trees were identified as susceptible at the time of assessment. Of the susceptible trees, approximately 68% had evidence of rust related dieback occurring on epicormic reshoots, 48% of these had ≥50% of epicormic growths with evidence of *A. psidii* related dieback. There is some indication that the position of the epicormic reshoots and position within the canopy may be influencing disease incidence and severity levels. Reshooting in the upper canopy of taller trees appeared to be less affected than those lower on the stem. However, this requires further monitoring.

Figure 34: *Fire affected* Melaleuca quinquenervia *in Bundjalung National Park along the Esk River (Left) and in periodically inundated swamp ecosystems.*

Low levels of *A. psidii* infection were found on *Acmena hemilampra* with no evidence of dieback at the time of assessment in littoral rainforest areas west of Shark Bay, Iluka in forest where fire levels were considered low. Some of the more severely affected areas of rainforest, based on fire maps were relatively inaccessible but attempts to access other sites will be made in the near future.

Chatsworth Hill Nature Reserve

Chatsworth Hill Nature Reserve is located west of Bundjalung National Park and conserves areas of endangered swamp sclerophyll forest, coastal saltmarsh, subtropical coastal floodplain forest and swamp oak floodplain forest. It is part of a wildlife corridor between the coastal floodplains and forested hinterland (OEH, 2012). Chatsworth Hill State Conservation Area is located on the south-eastern extension of the Richmond Range, with a small area located on the Clarence River floodplain. Vegetation within the reserve includes shrubby dry sclerophyll forest, dominated by coastal blackbutt and large-fruited blackbutt (*E. pyrocarpa*). The other is described as Clarence Lowland Needle-bark Stringybark, which is dominated by *E. planchoniana*. Also present in the understory are Leptospermum trinervium and *L. polygalifolium*, *Persoonia stradbrokensis, Xanthorrhoea spp.* and *Lambertia formosa*. The swamp sclerophyll forest in the reserve is a tall to very tall open forest dominated by *Melaleuca quinquenervia* (Fig 35). Swamp sclerophyll forests on coastal floodplains are endangered ecological communities under the TSC Act (OEH 2012).

Table 15: Species and their susceptibility to Austropuccinia psidii *in fire-affected sites within fire-affected sites in Chatsworth Nature Reserve*

Species	Regeneration type	Rust identified	Infection level
Acmena smithii	R	Y	L
Corymbia henryi	S/R	N	
Corymbia intermedia	S	N	
Eucalyptus pilularis	S/R	Y	L
Eucalyptus planchoniana	S/R	Y	L-M
Leptospermum petersonii	R	Y	L
Leptospermum polygalifolium	R	N	
Leptospermum trinervium	S/R	Y	L-M
Lophostemon suaveolans	S/R	N	
Melaleuca alternifolia	R	N	
Melaleuca nodosa	R	Y	L-S
Melaleuca quinquenervia	S/R	Y	L-S
Melaleuca salignus	S/R	Y	L-M
Melaleuca sieberi	R	Y	L-S
Melaleuca styphelioides	R	Y	L
Syncarpia glomulifera	S/R	N	
Syzygium oleosum	R	Y	L
Waterhousea floribunda	R	N	

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Figure 35: Melaleuca quinquenervia *wetland in the Chatsworth Hill Nature Reserve was affected by severe fire and reshoots are affected by* Austropuccinia psidii*, which is causing dieback of epicormic shoots.*

Austropuccinia psidii infection or dieback associated with infection was identified on eleven of the 18 species encountered (Table 15). *Melaleuca nodosa, M. quinquenervia,* and *M. sieberi* had symptoms ranging from low to severe with dieback recorded on all species. The *M. nodosa* assessed where in an area considered to be low to moderate fire severity with approximately 70% of trees assessed having infection and/or dieback. *Melaleuca sieberi*, present in the same area as *M. nodosa*, were also infected with 80% of the 20 trees assessed showing some evidence of infection or dieback.

Melaleuca quinquenervia in the swamp sclerophyll forest was affected by high to severe fire severity. Of the 119 trees assessed, 94% were identified with *A. psidii* infection symptoms. Approximately 73% of infected trees had *A. psidii* associated dieback, with 56% having dieback on ≥50% of reshoots with evidence of dieback (Fig 32). Twenty seedlings were also assessed at this site, with 75% identified with *A. psidii* infection symptoms.

Eucalyptus planchoniana, E. pilularis, Leptospermum trinervium, and *M. salignus*, were assessed in an area with severe fire damage, with infections ranging from low to moderate. Of 43 *E. planchoniana*, primarily seedlings, only two had infection. Both reshooting mature trees and seedlings of *E. pilularis* were assessed with only seedlings found with infection and then only 8% of the 45 assessed with *A. psidii* symptoms. Infection was also identified on *L. trinervium* reshoots (five out 16 trees), *M. styphelioides* (three out five trees) and *S. oleosum* (one out of four trees).

Banyabba Nature Reserve

Banyabba Nature Reserve is part of an area forming the watershed between the Clarence River catchment to the west and the Richmond River catchment to the east (OEH 2016). The reserve consists of a series of largely unmodified, rugged sandstone ridges and valleys which protect the headwaters of Sportsmans Creek, Banyabba Creek and Rocky Creek. Dry sclerophyll forests dominate the area occupying ridges and exposed slopes. Dominant species include *Eucalyptus pilularis, E. baileyana, E. planchoniana, E. tereticornis, E. siderophloia, E. propinqua*, spotted gum species *Corymbia henryi* and *C. variegata* and rough-barked apple *Angophora woodsiana*. This landscape is of cultural importance to the Bandjalang and Western Bundjalung Aboriginal peoples. Moderate to severe levels of fire damage were observed in the reserve during our assessments.

Table 16: *Species and their susceptibility* Austropuccinia psidii *in fire-affected sites within fire-affected sites in Banyabba Nature Reserve*

Species	Regeneration type	Rust identified	Infection level
Corymbia henryi	S/R	N	
Eucalyptus baileyana	R	N	
Eucalyptus glaucina	S/R	N	
Leptospermum trinervium	R	Y	L-S
Melaleuca nodosa	R	Y	L-S

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Only *L. trinervium* and *M. nodosa* were identified with symptoms of *A. psidii* infection (Table 16). Five of the 34 *L. trinervium* reshooting trees were identified with *A. psidii* infection on new growth flush and/or associated dieback. Of the 40 *M. nodosa* trees assessed, three had active rust on new growth with 17 having dieback caused by infection. Regrowth of *M. nodosa* trees was relatively recent, which is likely to have influenced both infection and dieback levels at the time of assessment.

Gibraltar and Washpool National Park

The Gibraltar and Washpool areas consist of a diversity of plant communities including wet sclerophyll and rainforest communities. The warm temperate rainforest of Washpool National Park is the largest rainforest wilderness in New South Wales. Subtropical rainforest is restricted to more sheltered sites on better soils. At high altitudes along ridges the dominant eucalypt is *Eucalyptus campanulata*, with tallowwood *E. microcorys,* Sydney blue gum *E. saligna* and brush box *Lophostemon confertus* communities at lower levels. Wet and dry heath is restricted to steep rocky outcrops at high altitudes. Several of the heathland community species are endemic to the Gibraltar Range.

Fires caused significant damage to the area, but severity levels ranged, with pockets of rainforest only exposed to low levels of fire where other areas suffered severe fire damage (Fig 36, 37). Areas of heath in Gibraltar were assessed for myrtle rust, but only a small number of plants exhibited evidence of old damage. Cold temperatures preceding our survey, including widespread frost, will have reduced growth rates and affected *A. psidii* levels. Dieback and evidence of old pustules were, however, found on L. trinervium in some of the heath areas. Reassessment of this area would be needed to get a better understanding of host species likely to be affected by *A. psidii.*

Figure 36: *Fire-affected areas in Gibraltar National Park with dieback caused by* Austropuccinia psidii *identified on* Leptospermum trinervium.

Table 17: *Species and their susceptibility to* Austropuccinia psidii *in fire-affected sites within fire-affected sites in*

Species	Regeneration type	Rust identified	Infection level
Acmena smithii	R	N	
Archirhodomyrtus beckleri	R	N	L-S
Eucalyptus campanulata	R	N	
Eucalyptus olida	R	N	
Eucalyptus pilularis	S/R	N	
Eucalyptus tindaliae	R	Y	L
Leptospermum polygalifolium	R	N	
Leptospermum trinervium	R	Y	L-H
Rhodamnia rubescens	R	N	L-S

S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

In Washpool National Park symptoms of *A. psidii* infection were found on a range of species (Table 17). *Rhodamnia rubescens* plants found in wet sclerophyll and rainforest margins were affected by low-moderate fire impacts with some trees still having tree canopies intact (Fig 38). Of the 25 plants assessed, 12 had active infection on reshoots and dieback and an additional tree with dieback but no current rust on newly emerged shoots. Infection and dieback were also recorded on *A. beckleri* reshoots occurring at the base of small diameter trees. Sixty-seven trees were assessed in total with 13 showing low to high levels of dieback (Fig 39). Eleven trees had active rust at the time of assessment. *Austropuccinia psidii* symptoms were additionally found on *E. pilularis seedlings* and *L. trinervium* reshoots in drier ridge top areas in the park. Small leaf spots caused by *A. psidii* were identified on *E. tindaliae* epicormic reshoots, but no dieback was observed.

Figure 37: *Fire affected eucalypt forest in Washpool National Park.*

Figure 38: *Fire affected* Rhodamnia rubescens *in Washpool National Park with dieback caused by* Austropuccinia psidii *infection.*

Figure 39: *Fire affected* Archirhodomyrtus beckleri *in Washpool National Park. Reshoots from the base of trees was affected by* Austropuccinia psidii *causing dieback of juvenile shoots, foliage and stems.*

Southern New South Wales

Southern New South Wales sites were assessed in October 2020 in fire-affected sites from the NSW/Victoria border to Eden (13 sites), Moruya to Batemans Bay (4 sites) and Batemans Bay to Ulladulla (16 sites). All sites where considered a high to severe fire impact rating (Fig 40). Species assessed were *Angophora* spp., *Acmena smithii, Backhousia myrtifolia, Corymbia spp. Eucalyptus* spp. (including *E. elata*), *Kunzea* sp., *Melaleuca* spp. (*M. ericifolia* and *M. linarifolia*), *Leptospermum* spp. (including *L. trinervium, L. polygalifolium*), *Syncarpia glomulifera* and *Tristaniopsis laurina*. At the time of assessment, and despite the presence of active and susceptible new reshoots and seedlings, no symptoms typical of *A. psidii* infection were observed. A number of these species have been reported as susceptible (Sowerto *et al.* 2019). In the Tomerong area (Phil Craven Property) infected *Rhodamnia rubescens* was detected, however this area was not a fire affected site. Similarly, in the Booderee Botanic Gardens, *A. psidii* infection was found on *R. rubescens*, *Gossia acmenoides* and *Austromyrtus dulcis* in the propagation nursery indicating that myrtle rust is in the region.

Figure 40: Fire-affected areas in Southern New South Wales with seedlings and reshoots regenerating. No evidence of Austropuccinia psidii *was found at the time of assessment in October 2020.*

Species comparisons

Melaleuca nodosa comparison

Austropuccinia psidii impact data on *M. nodosa* populations assessed as part of this study have been collated in the table below (Table 18). While *M. nodosa* was found in Queensland, unfortunately no plants were found in fire-affected areas surveyed. Data presented includes survey data from plots that have been established on the central coast of NSW as part of a study funded by the NSW government. Sites assessed included different tree forms, heath shrub form and the small tree forest form, as well as sites with different burn intensities.

Table 18: Comparison of Austropuccinia psidii *impact levels on* Melaleuca nodosa *across fire-affected sites in New South Wales*

NSW region	Locations	Fire Se-verity	Tree Habit	% Susceptible trees with dieback on >50% of branches
Central Coast	Nabiac	L	Heath shrub form	10.4
Central Coast	Saltwater NP	H	Heath shrub form	55.8
Central Coast	McClymont Ck	H	Heath shrub form	94
Northern Rivers	Bundjalung NP	S	Heath shrub form	70.5
Northern Rivers	Double Duke SF	L	Small tree forest form	40
Northern Rivers	Chatsworth Hill NR	L-M	Small tree forest form	31.2
Central Coast	Kiwarrak SF	L-M	Small tree forest form	40
Central Coast	Knappinghat NP	H	Small tree forest form	38.8
Northern Rivers	Banyabba NR	H	Small tree forest form	41.2
Central Coast	Wallaby Pnt	H	Small tree forest form	72.7
Northern Rivers	Yarringully NR	H	Small tree forest form	74.4

Melaleuca quinquenervia comparison

Sites assessed in lower fire severity sites were in general less affected than those in high or severe fire damage sites with lower numbers of trees with infection (Table 19). Similarly, numbers of trees with dieback of reshoots was lower in sites with lower fire damage. The dieback levels recorded on K'gari were more likely to be due to infection of reshoots being reasonably recent at the time of assessment and, while there were high levels of infection on the newest shoots, dieback had not started to occur. Monitoring sites have been established in all but the Chatsworth Hill Reserve site.

Table 19: Comparison of Austropuccinia psidii *impact levels on* Melaleuca quinquenervia *across fire-affected sites in Queensland and New South Wales*

Location	Burn Severity	Trees assessed	Susceptible trees (%)	Trees with die-back (%)
K'gari (Fraser Island) Qld	H	249	71.1	37.8
Great Sandy NP, Qld	L-H	212	41.5	2.3
Emu Swamp, Peregian, Qld	M-H	50	68	4
Yarringully NR, NSW	S	50	100	90
Bundjalung NP NSW	S	194	80.4	64.7
Chatsworth Hill NR, NSW	S	119	94.2	72.8

Discussion

Austropuccinia psidii symptoms and damage were found in all survey sites in fire-affected areas of south-east Queensland and NSW south to the Central coast region. This included coastal heath, woodland and swamp environments, littoral and notophyll vine forests along the coast, inland paper bark swamp ecosystems, inland eucalypt woodlands, wet sclerophyll and rainforest ecosystems as far west as the Great Dividing Range. However, no evidence of *A. psidii* was identified in surveys of fire-affected areas south from Ulladulla in southern NSW. Areas in Victoria were not assessed due to Covid 19 restriction. Despite large areas of seedling regeneration and epicormic regrowth coupled with above average autumn and winter rainfall, and perfect conditions for *A. psidii* development and spread, no evidence of current rust activity or previous damage was detected. Several species in this area are known to be susceptible (Sowerto *et al.* 2019), including the highly susceptible *L. trinervium*. Reports from Victoria suggest that rust levels in the recently dry seasons have been low but optimum times for symptom development are usually in autumn months. However, sentinel sites in Melbourne are currently (Spring) showing evidence of *A. psidii* activity (Pers. Comm. David Smith). Recent epidemiology studies suggest that climatic conditions are suitable in this region for disease development (Beresford *et al.* 2018).

Our surveys have identified new host species for Australia including *L. speciosum, E. pyrocarpa* and *E. amplifolia* subsp. *amplifolia*. Incidence of *A. psidii* infection across *L. speciosum* populations assessed in Bundjalung NP and the low severity of impact, suggests that myrtle rust won't impact on the post wildfire recovery of this species. Similarly, a low number of *E. amplifolia* subsp. *amplifolia* reshoots and seedling were affected at the time of assessment. However, the severity of impact on infected individuals was higher and may result in the decline or a slower rate of recovery of affected individuals. While *E. pyrocarpa* seedling deaths were recorded, there were also a high number of unaffected individuals at the survey sites, many of which were in close proximity to those with infection. While it can't be confirmed that these unaffected individuals were resistant, studies on a range of Eucalyptus and Corymbia species have identified resistance at a family level (Pegg *et al.* 2014b, Lee *et al.* 2015, Roux *et al.* 2015, Shepherd *et al.* 2015). In some cases, in-land provenances, or those from drier ecotypes, have shown higher levels of resistance to *A. psidii* in controlled inoculation studies. However, the question around potential long-term impacts myrtle rust has on the post wildfire recovery of a range restricted species like *E. pyrocarpa*, even the removal of a small individual, needs to be examined in more detail. Our studies would suggest that there won't be a broad scale change to this species as a result of rust, but controlled inoculation studies would help to better understand the resistance/susceptibility patterns within the species and across provenances.

Of the eucalypts, *E. pilularis* and *E. planchoniana* had the highest incidence of infected seedlings and the highest infection severity levels. Seedling infection, dieback and deaths were recorded for both species. However, at all sites assessed there were also seedlings free of disease. High levels of susceptibility have been recorded for *E. pilularis* seedlings assessed in controlled inoculation studies (Pegg, Lee, Carnegie – Unpublished data). Similarly, affected and unaffected epicormic reshoots on trees ranging in size, including mature overstorey trees, was observed for both species. Interestingly, infection levels on epicormic shoots decreased with increasing height, with shoots high in the canopy apparently free of disease and evidence of dieback despite the fact that shoots closer to the ground had high disease incidence and severity levels and associated dieback. This influence of canopy height on disease development has previously been reported in studies in eucalypt plantations in Brazil (Zauza *et al.* 2010), with incidence and severity declining in taller trees. However, Pegg *et al.* (2017) have reported disease to be present in the upper canopy of 80-100 year old rainforest overstorey species like *Syzygium corynanthum*, suggesting that this "rule" does not apply to all species or could also be influenced by localised climatic conditions.

In the Gondwana Rainforest areas assessed, *A. psidii* infection and associated dieback was commonly identified on *Rhodamnia rubescens*. While there was some variability in disease levels at the time of assessment, there was no evidence of resistance. Longer term monitoring is required to determine if the combination of fire and rust will increase the rate of decline of this species. However, based on the level of infection observed on epicormic reshoots and root suckers on fire affected trees, this seems a likely scenario. *Rhodamnia rubescens* was identified as being highly susceptible soon after *A. psidii* was first detected in Australia (Carnegie & Lidbetter 2012 , Pegg *et al.* 2014a) and studies across the host range by Carnegie *et al.* (2015) identified the significant impact on *R. rubescens* populations. Once considered a common species, it is now listed in NSW as Critically Endangered. Our findings suggest that there is an urgent need to focus germplasm collections into fire-affected areas if material has not yet been collected from these sites. While studies have been done on the NSW populations with regards to genetic structure (Pers. Comm), there is a need to expand this into Queensland populations to help guide conservation programs.

Fire affected *Uromyrtus australis* reshoots in the Nightcap Ranges NP were dying back due to *A. psidii* infection. While only 38% of individuals assessed during our surveys were infected, this might result in the decline of a range restricted species and further monitoring of impacts is necessary. *Uromyrtus australis* is found only in north east NSW on the Nightcap Range with an estimated 800–1000 plants occurring across 45 locations (NPWS, 2003). The species is restricted to high rainfall, high altitude areas on Nimbin Rhyolite geology in the Nightcap Range and nearby areas in north east NSW (NPWS, 2003). This very limited range for a plant species is an important risk factor for the species alone without the additional fire threat and *A. psidii* infection influencing recovery. To better understand the impact *A. psidii* will have on *U. australis*, it will be important to our studies to link with other researchers who have studied this species in detail. We plan to work with botanist Dr Rob Kooyman in monitoring sites over time.

Post wildfire regeneration of *Archirhodomyrtus beckleri* was also reported as a rainforest species in NSW affected by *A. psidii*. It was not detected in any of the Queensland areas assessed as part of this study. The impact levels ranged from no infection or impact to severe dieback of basal reshoots. *Archirhodomyrtus beckleri* has a disjunct distribution with a population in the south occurring from Williams River in New South Wales to Kin Kin in south-east Queensland (Brophy *et al.* 1996), and the northern population extending from Eungella to Mt Lewis in far north of Queensland. The species grows in rainforests on a variety of sites and can also grow as an edge species or as an understory tree in wet sclerophyll forest dominated by *Eucalyptus grandis*. The species is encouraged by disturbance and is a typical re-growth species. Pegg *et al*. (2017) reported severe decline of *A. beckleri* in lowland wet sclerophyll forests transitioning to rainforest in south-east Queensland. Similar observations by the authors have been made in other parts of north-east NSW including forest edges at Sleepy Hollow and Burringbar and Manea *et al.* (2019) reported *A. psidii* associated dieback in other NSW populations. Based on this information, monitoring the impact of this species in relation to fire recovery, and in general, would appear to be important. More detailed studies in population diversity and the consequences of the decline of the species in different ecosystems are warranted.

Leptospermum trinervium is a species with a widespread distribution from south-east Queensland to north eastern part of Victoria (Atlas of Living Australia - https://bie.ala.org.au/species/https://id.biodiversity.org.au/node/apni/2908252). It can be found in dry sclerophyll forest, heath and scrub environments. Fire affected trees were found to be affected by *A. psidii* across all sites except in the Great Sandy National Park – Cooloola section. This included western areas of Banyabba NR and Gibraltar and Washpool National Parks. Pegg *et al.* (2020) previously reported tree dieback following repeated *A. psidii* infection on reshooting *L. trinervium* trees affected by wildfire in the Lennox Heads area in 2013. Monitoring plots have been established in Double Duke SF and Bundjalung NP as part of a PBSF funded project. Again, understanding the ecology of this species will better help our assessment of the impact *A. psidii* is having on this species and associated ecosystems.

Infection and dieback caused by *A. psidii* was identified in all populations of *M. nodosa* and *M. quinquenervia*. Two forms of *M. nodosa* were assessed, the shrub like habit growing in coastal heath plant communities and those of a small tree habit growing in woodland areas away from the coastal fringe. Both showed high levels of impact, but differences appear to be influencing impact levels. Again, assessment of longer-term plots is necessary to look not only at the effects of repeated infection but also the difference factors like canopy height might have on disease development as well as local climatic conditions. The site in Banyabba Nature Reserve appeared to be recovering from fire slower than other sites with only relatively recent emergence of reshoots at the time of assessment. This, coupled with evidence of very recent *A. psidii* infection and no evidence of a previous infection event, has influenced the level of dieback recorded at the site. The susceptibility of *M. nodosa* and the impact of *A. psidii* on populations recovering post wildfire has previously been studied (Pegg *et al.* 2020). Similarly, at this site there was evidence of severe dieback but also evidence of tolerance in populations. Unlike that study, seedling emergence and *A. psidii* infection has been reported as part of this survey. However, a one-off survey is unlikely to be able to provide information on the mortality rate of seedlings in comparison to reshooting plants. Infection and decline of young seedlings, like those observed in this study, are likely to be rapid and need more intensive monitoring plots to be established.

Controlled inoculation studies of seed collected from across the range of this species would provide valuable information on the potential impacts of *A. psidii* on *M. nodosa* recruitment. Collection of seeds from trees showing field tolerance would also provide valuable information into potential recruitment of more resistant/tolerant generations.

Dieback caused by *A. psidii* on *M. nodosa* appears to directly impact on flowering rates, with increasing dieback levels resulting in decreasing numbers of flowers or flower buds. While there are still individuals showing field tolerance to rust with no or limited amounts of dieback, this was only 25% of trees in this site out of all those assessed. How this reduction in overall flowering rate at a site affects pollination processes is unknown. *Melaleuca* species are pollinated by a wide suite of generalist insect vectors, including native and introduced honeybees, beetles and flies (Beardsell *et al.* 1993). A lower density of flowering may therefore interfere with pollination, particularly in flora diverse sites. Examining distribution patterns within different environments would be valuable.

High levels of *A. psidii* infection were recorded on *Melaleuca quinquenervia* with more than 50% of trees assessed being susceptible, except for trees in the Great Sandy NP (41.5%). Interestingly, this site consisted of trees assessed from a range of burn severity sites and when looking at the data separately trees in sites where fire damage was lowest were least affected by *A. psidii*. Unfortunately, there were no opportunities to compare different burn intensities at other sites. In general, dieback due to *A. psidii* infection was greatest in areas where fire impact severity was greatest. However, continued monitoring of sites will be valuable in determining influences of fire severity. Studying tree size in relation to decline rates from repeated infection as well as canopy heights and infection rates within the different canopy positions will be necessary. The interaction between *A. psidii* impact and that from other "pests", like the mirid bug (*Eucerocoris suspectus*), is important to examine the long-term impacts on tree survival and fecundity. This interaction has previously been reported from Florida where *M. quinquenervia* is a pest. It was found that the combined impact of rust and insects (primarily *Oxyops vitosa*) on cut stump regrowth had an additive effect on stump and reshoot mortality (Rayamajhi *et al.* 2010). Unpublished data (Pegg *et al.*) had similar findings in trials established in northern NSW. Flowering was not observed at any of the sites during our surveys.

Conclusions

Austropuccinia psidii is having an impact on the regeneration of a range of Myrtaceae species in a range of ecosystems recovering from the 2019/20 wildfire events. Given the broad environment types, some of which are under various protection acts, and the range of fire affected host species impacted by *A. psidii*, recognition of this disease as a key threatening process to Myrtaceae nationally should be considered. While this study provides an insight into the impacts of *A. psidii* on the post-fire recovery of individual Myrtaceae species, it does not look at the more detailed and long-term ecological effects. What are the effects of losing a species with a narrow range versus one that is common and dominates habitats like *M. quinquenervia* wetlands? There is a clear need to expand the current research network to include broader knowledge beyond just the disease experts currently driving much of the research.

The effects of seedling recruitment have been difficult to study and this needs more attention. While resistance appears abundant within some species and natural recovery likely, for others resistance is absent or minimal and recovery and long-term survival within the site seems less likely. This includes species like *Rhodamnia rubescens, Melaleuca nodosa* and *Melaleuca quinquenervia*. It must also be considered that we have little current understanding of how or if the *A. psidii* population in Australia is changing. If it is changing are there any implications for different hosts or hosts that have some or high levels of resistance.

While the data gives us an insight into the role fire severity has on disease development and severity of impact, there is a need to better understand this. Comparing impacts of rust under different fire regimes (e.g. wildfire versus prescribed burn) would have added to the value of our studies and perhaps provided insight into the importance of fire management strategies that might limit *A. psidii* impact. However, conducting such an experiment would be challenging. Additionally, studying host changes and response to infection over time along with the impact of repeated infection over time will be important. In previous impact studies (Pegg *et al.* 2017) it has been shown that it can take many years of repeated infection and associated dieback for tree mortality to occur. However, in fire affected trees, Pegg *et al.* (2020), observed deaths of *M. quinquenervia* trees after 18 months.

The threat that exotic pests and pathogens, and those emerging due to changing climate patters, pose to our native plant species and the associated cultural and ecological values is real and increasing. *Austropuccinia psidii* is one of many pest and disease challenges our forest ecosystems are likely to encounter. Creating awareness of what it is we are trying to protect may just be the catalyst to enhance our capacity to not only manage our current pest and disease challenges but prevent new ones from establishing.

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Further information:

http://www.nespthreatenedspecies.edu.au

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