Threatened Species Recovery Hub

National Environmental Science Programme

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

Update report

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Cover images (left to right): Myrtle rust symptoms developing on *Syncarpia hillii* seedlings regenerating after wildfire on K'gari (Fraser Island); Myrtle rust on reshooting Melaleuca quinquinervia, Bundjalung National Park. Images: Geoff Pegg

Contents

Executive summary

Extensive surveys assessing the impact of Austropuccinia psidii were conducted following the 2019/20 wildfires. This report provides an update. Additional surveys of fire affected coastal and rainforest ecosystems were conducted in 2021 to examine the impacts of repeated *Austropuccinia psidii* infection and assess species responses. New fire affected areas on K'gari were assessed and this is the first report of *A. psidii* symptoms on *Eucalyptus pilularis* and *Syncarpia hillii* on the World Heritage sand island. It is also the first report of *A. psidii* naturally infecting *Syncarpia hillii* (Satinay) seedlings and reshoots.

Regeneration of *Melaleuca quinquenervia*, particularly in New South Wales, is of concern. The loss of established trees, along with the fact that only 15 to 35% of the seedlings are showing evidence of resistance, raises questions over regeneration of the species at these sites. Longer-term monitoring is required to determine the consequences of:

1. The death of established trees and decline rates in relation to *A. psidii* infection levels
2. The impact of disease on seedling recruitment levels and the recovery of the species within sites
3. The impact on flowering and seed production over time.

Melaleuca nodosa is highly susceptible to *A. psidii* with only small numbers of trees showing resistance/tolerance to the disease. Dieback because of repeated *A. psidii* infection is reducing plant vigour and the ability to compete for space with non-Myrtaceae and other less susceptible Myrtaceae. Similarly, the decline of the highly susceptible *Rhodamnia rubescens* within fire affected Gondwana Rainforests continues.

While one-off surveys of sites can provide information on species susceptibility, longer term monitoring is required to understand impacts of *A. psidii* on Myrtaceae regenerating after wildfire. This includes:

- Long-term survival of species and/or individuals
- Recovery of species and/or changes in population levels
- Impacts on fecundity and long-term recruitment

The following manuscripts will be prepared for publication at the completion of assessments:

- Host range and impact of *A. psidii* on fire affected Myrtaceae in different ecosystems on K'gari
- Impact of *A. psidii* on Myrtaceae in fire affected rainforests of south-east Queensland and north-east New South Wales
- Impact of *A. psidii* on recovery of fire affected Myrtaceae in coastal heath and woodland environments in New South Wales and south-east Queensland

Introduction

Surveys of fire affected areas across Queensland and New South Wales were conducted from May to October 2020 – see Figures 1–3, pages 6–7 and the fire severity details in Table 2, page 8 of the interim report. Those surveys identified a range of locations where *Austropuccinia psidii* was impacting on regeneration of Myrtaceae species. Additional surveys were conducted in 2021 to examine the impacts of repeated infection over time and assess species responses. New fire affected areas on K'gari were also assessed in addition to study plots established following the 2019/20 fires.

Methods

Sites previously identified with *A. psidii* infection and impact were reassessed from February 2021 to June 2021 (Table 1). Accessibility to some sites over this period was affected by flooding and flood related road damage. Surveys within Washpool and Gibraltar National Park were restricted due to Covid lockdown in Brisbane, resulting in a premature conclusion to surveys.

Table 1. Sites re-assessed in Queensland and New South Wales

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
	Lamington National Park	Subtropical Rainforest	Low-High
	Main Range National Park	Subtropical Rainforest	Low-High
New South Wales	Nightcap Range National Park*	Subtropical Rainforest	Low-High
	Yarringully Nature Reserve	Woodland	High-Severe
	Bundjalung National Park	Coastal heath, paperbark wetland, woodland	High-Severe
	Chatsworth Hill Nature Reserve	Woodland, paperbark wetland	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

*Surveys of these sites were conducted as part of project work funded by NSW DPIE – see page 9 of the interim report for location details and fire severity.

Surveys and monitoring plots

Surveys included targeted assessments of species identified as significantly impacted by *A. psidii* and where semi-permanent plots had been established. Additional assessments were done on any species showing levels of infection and/or damage at the time of these surveys.

Survey and assessment methods were as per previously reported – see page 9 of the interim report. Disease incidence on susceptible new growth and severity of infection based on a scale of low, moderate, high and severe was collected. Additionally, impact data based on levels of branch dieback and total tree death was recorded. Where possible and only within monitoring plots, flowering data was also captured.

Results

Queensland

K'gari – Fraser Island World Heritage NP

In late 2020 a wildfire affected more than 87, 000ha of bushland on K'gari. Affected ecosystems ranged from inland lake wetlands, woodlands and fringing rainforest environments. Species assessed within fire affected environments are listed in Table 2.

Table 2. Myrtaceae species assessed for *Austropuccinia psidii* infection in fire affected areas on K'gari (Fraser Island)

Species	Regeneration type	Rust identified	Infection severity level
Angophora leiocarpa	R	N	
Austromyrtus dulcis	R	Y	L-M
Backhousia myrtifolia	R	Y	L-H
Corymbia intermedia	R	N	
Corymbia tesselaris	R	N	
Eucalyptus pilularis	S/R	Y	L-S
Melaleuca quinquenervia	S/R	Y	L-S
Leptospermum trinervium	R	Y	L-M
Syncarpia hillii	S/R	Y	L-S

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

No evidence of myrtle rust was detected on reshoots of *Angophora leiocarpa, Corymbia intermedia* or *C. tesselaris*. However, significant levels of *Quambalaria pitereka* were identified on *C. tesselaris* reshoots in fire affected areas north of Indian Head. This fungus is native to Australia and has been identified on *C. tesselaris* on K'gari previously (Pegg unpublished).

Deepwater Lake

The 2020 fire affected two key species around Deepwater Lake, *E. pilularis* and *M. quinquenervia*. Additionally, *A. psidii* symptoms were identified on *Austromyrtus dulcis*, but on less than 5% of individuals reshooting after fire. The fire severity at this site ranged from moderate, with partial canopy scorch, to severe in pockets with full canopy scorch and canopy consumption. *Melaleuca quinquenervia* trees were damaged severely along with pockets of *E. pilularis*. Reshoots and seedlings of both species were present and assessed for levels of *A. psidii* infection and impact.

Twenty five percent of *E. pilularis* trees with reshoots had *A. psidii* symptoms, ranging from 10 to 80% of susceptible foliage affected (Fig. 1). Of the 104 *E. pilularis* seedlings assessed, 40.38% had various levels of infection on susceptible foliage. Fifty percent of affected seedlings had disease incidence levels on >50% of susceptible foliage. Disease severity levels ranged from low, with small lesions, to severe with foliage and shoot dieback occurring (Fig. 2, Fig. 3).

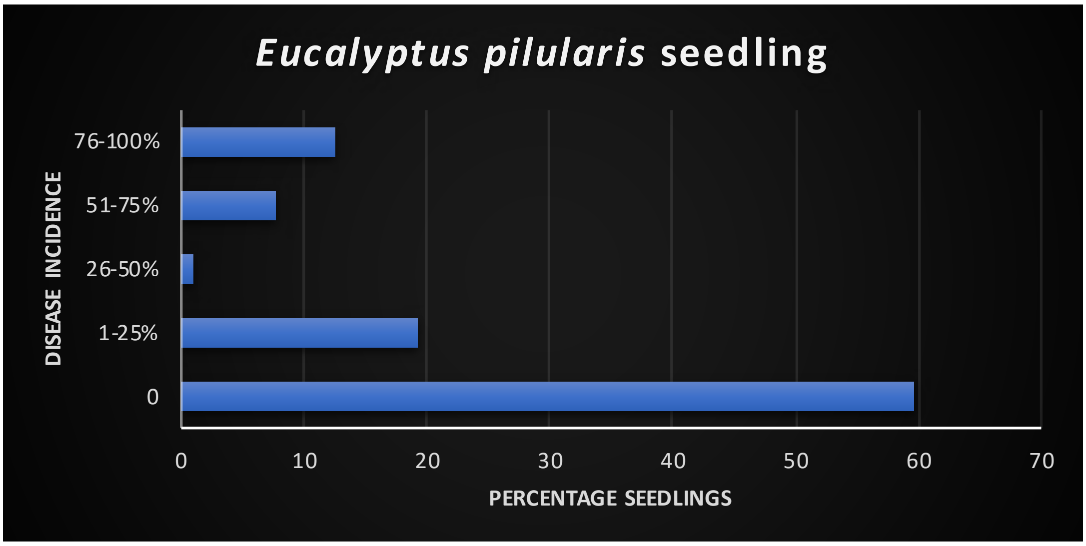

Figure 1. Incidence of *Austropuccinia psidii* infection on *Eucalyptus pilularis* seedlings at Deepwater Lake, K'gari (Fraser Island)

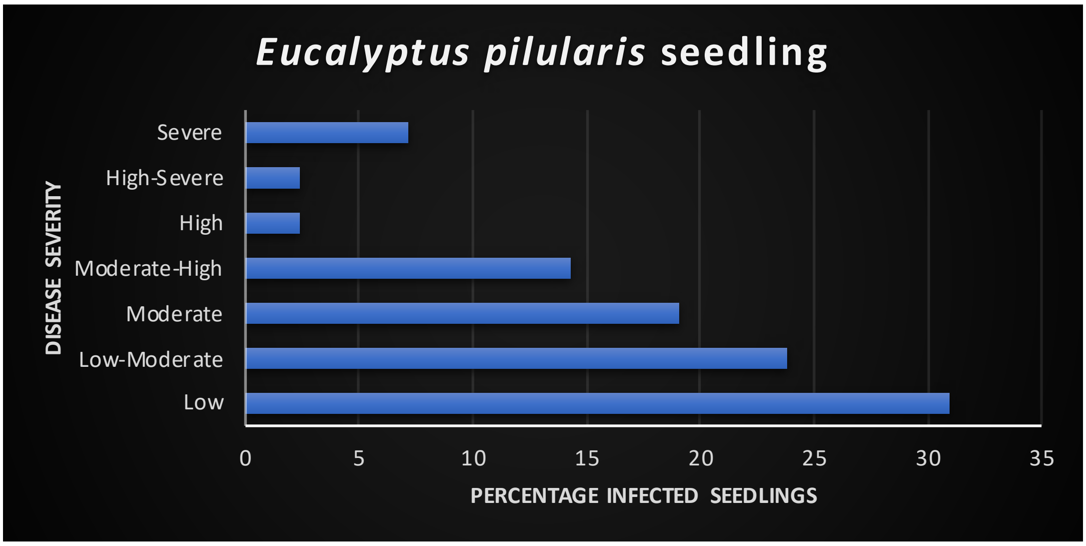

Figure 2. Severity of *Austropuccinia psidii* infection on affected *Eucalyptus pilularis* seedlings at Deepwater Lake, K'gari (Fraser Island)

Figure 3. *Austropuccinia psidii* infection causing dieback of *Eucalyptus pilularis* seedlings emerging after the 2020 fires on K'gari, Queensland.

Forty-eight percent of reshooting *Melaleuca quinquenervia* trees had evidence of rust (Fig. 4). Disease severity levels varied but the majority (35.9%) of trees only had low levels of rust pustules present (Fig. 5). It is unknown if this is an indicator of susceptibility of the population, conditions for disease development, or if there will be an increase or decrease in disease levels over time.

A higher percentage (60.98%) of *M. quinquenervia* seedlings were identified with infection, most (42.68%) having a high disease incidence level (75-100% susceptible foliage with infection) (Fig. 6). Twenty-six percent of the affected seedlings were rated as severe with large numbers of pustules per leaf and associated dieback of susceptible foliage, shoots and juvenile stems (Fig. 7). This would suggest a more significant impact on recruitment with low levels of resistance within the population. However, on-going monitoring would be required to fully understand impacts on recruitment.

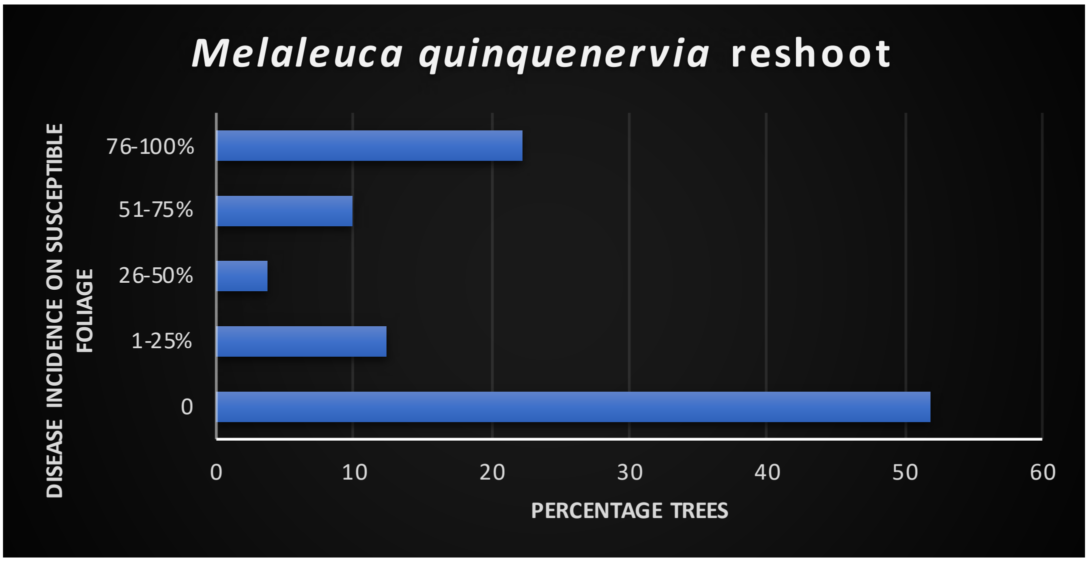

Figure 4. Incidence of *Austropuccinia psidii* infected *Melaleuca quinquenervia* at Deepwater Lake, K'gari (Fraser Island)

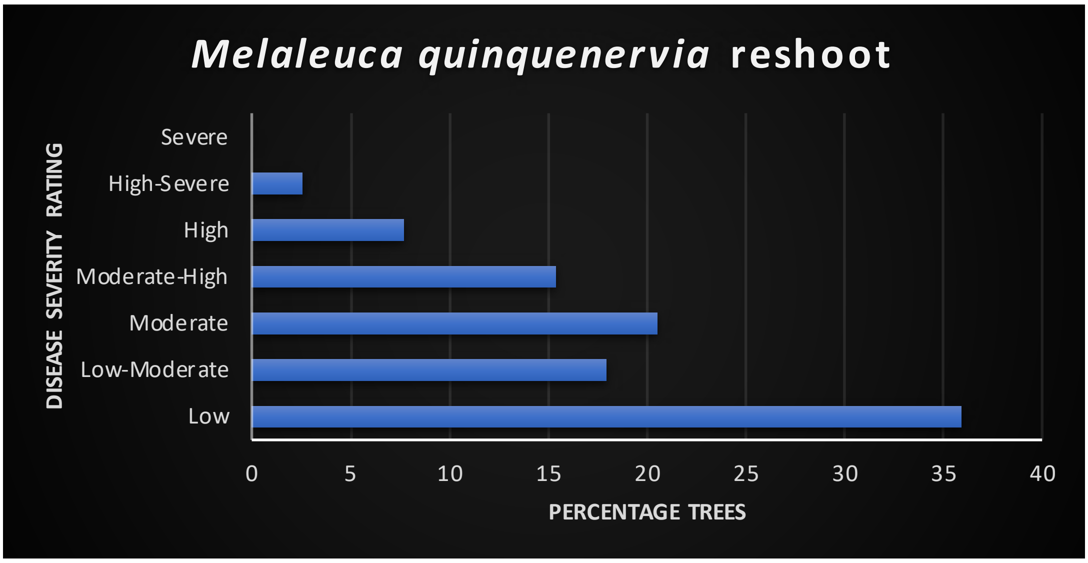

Figure 5. Severity of *Austropuccinia psidii* infection on susceptible *Melaleuca quinquenervia* trees at Deepwater Lake, K'gari (Fraser Island)

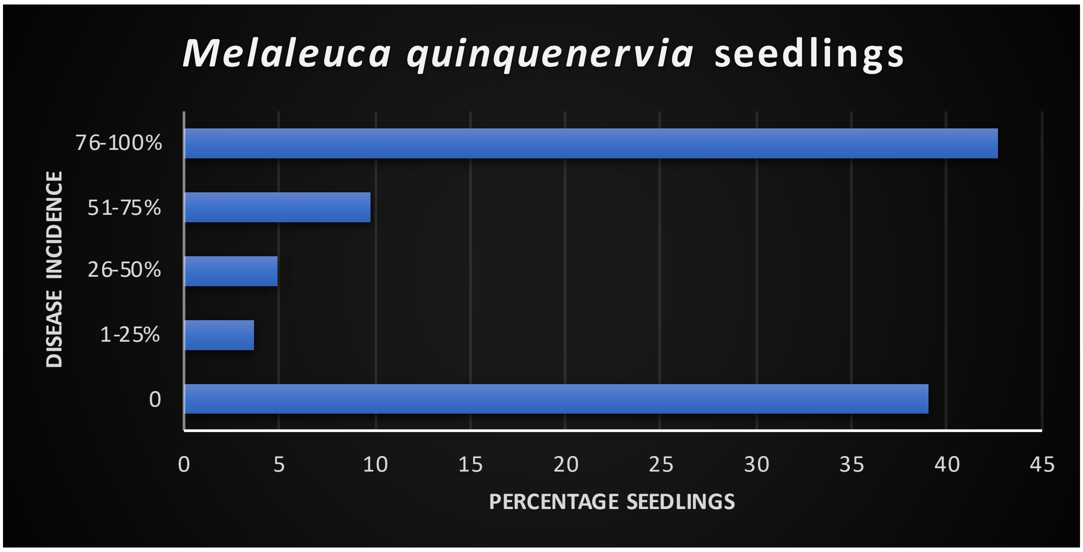

Figure 6. Incidence of *Austropuccinia psidii* infection in *Melaleuca quinquenervia* seedlings at Deepwater Lake, K'gari (Fraser Island)

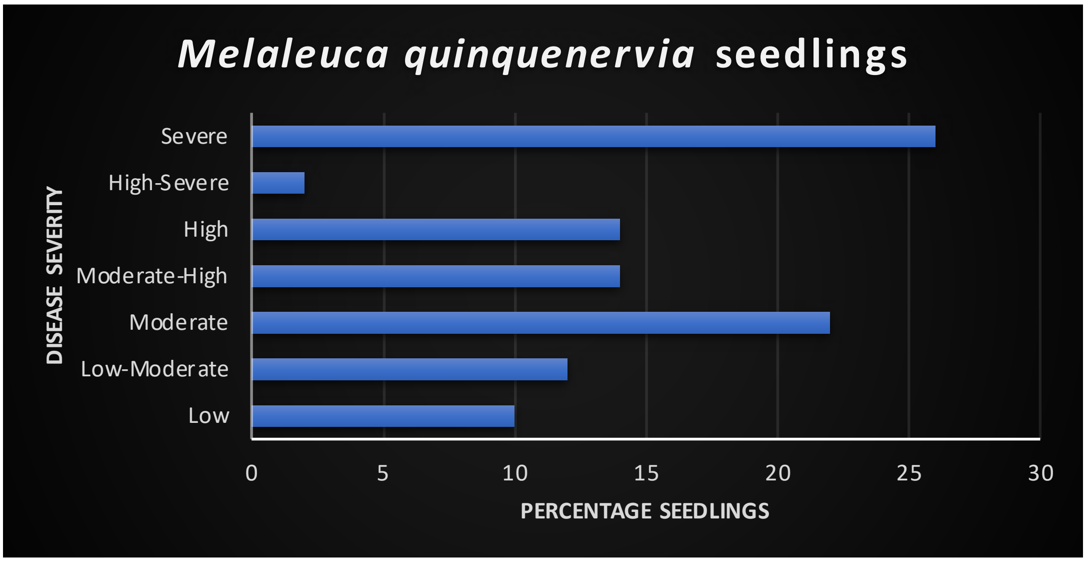

Figure 7. Severity of infection on susceptible *Melaleuca quinquenervia* seedlings at Deepwater Lake, K'gari (Fraser Island)

Cornwells Break Rd

Fire severity levels were considered low with the understory burnt and little or no evidence of impact in the tree canopies. *Eucalyptus pilularis* and *Syncarpia hillii* were the dominant Myrtaceae at the site. Fire was absent from areas across the fire break with the same species present (Fig. 8). However, the lack of seedling and reshoot regeneration in the unburnt areas meant that *A. psidii* impact comparisons between burnt and unburnt areas were not possible.

Figure 8. Cornwells Break Road burn site – low intensity fire stimulated regeneration of the understory including *Syncarpia hillii* and *Eucalyptus pilularis*. Fire was absent on the southern side of the track as was any evidence of seedlings or reshoots to allow comparison studies.

Seedlings of both species were assessed at the site, along with reshoots of *S. hillii*. This report is the first record of *A. psidii* infection on *S. hillii* outside of glasshouse studies and the first report of impact on this culturally and ecologically significant species on World Heritage (K'gari) Fraser Island. However, the number of seedlings with infection at the time of assessment were low, with 17% showing symptoms ranging from one or two spots (38.57% of infected seedlings) on leaves to severe blighting on new leaves and juvenile stems (15.71% of infected seedlings) (Fig. 9-13). Of the 61 reshoots assessed, only seven had symptoms of *A. psidii* infection (Fig. 14).

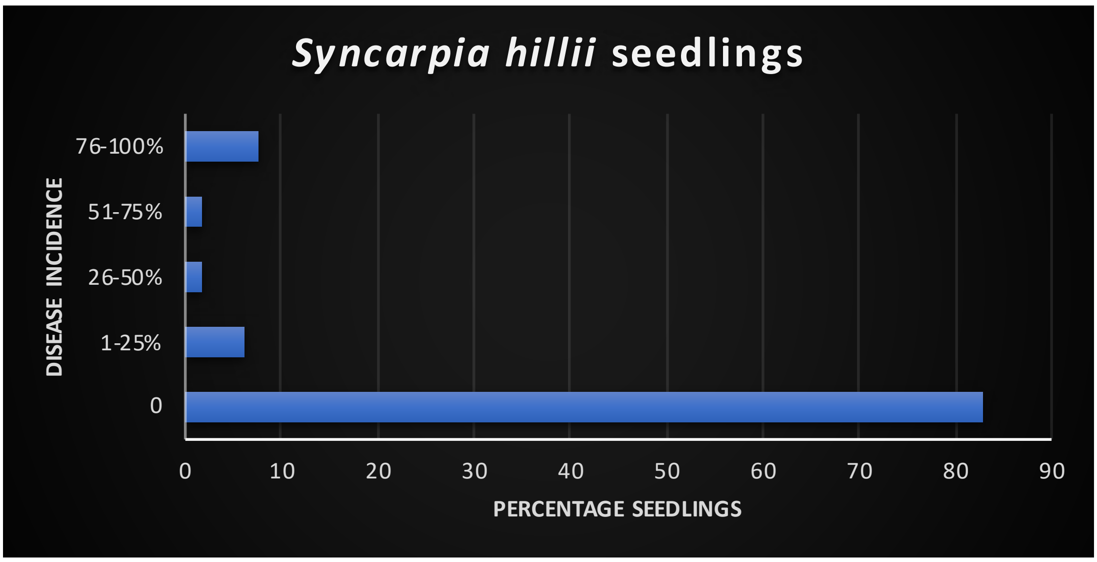

Figure 9. Incidence of *Austropuccinia psidii* within populations of *Syncarpia hillii* seedlings, Cornwells Break Road, K'gari, Queensland

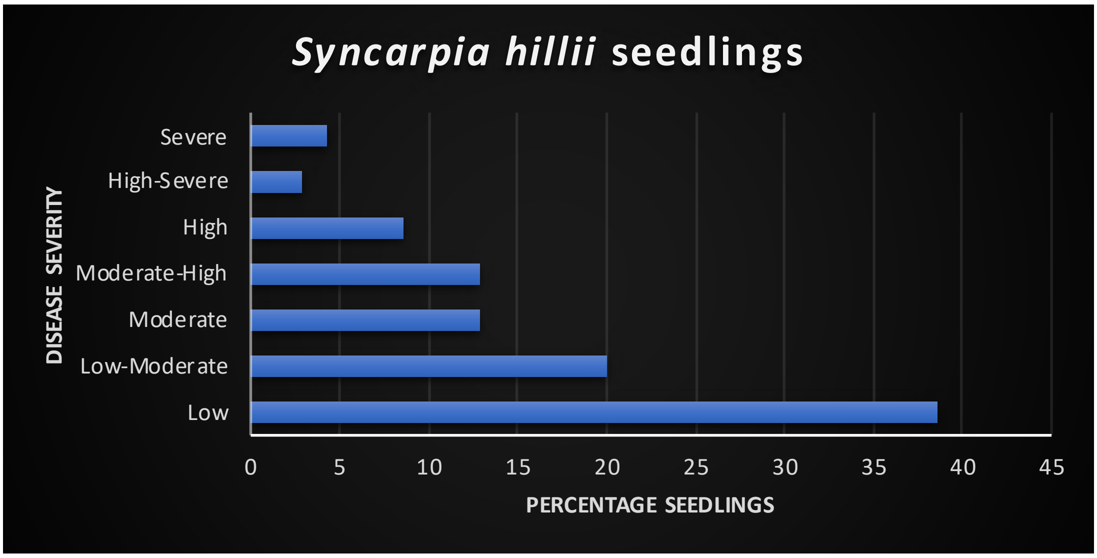

Figure 10. Severity of *Austropuccinia psidii* infection on *Syncarpia hillii* seedlings, Cornwells Break Road, K'gari, Queensland

Figure 11. Regenerating *Eucalyptus pilularis* and *Syncarpia hillii* seedlings in fire affected areas on K'gari, Queensland

Figure 12. Different stages of development of *Austropuccinia psidii* symptoms on regenerating *Syncarpia hillii* seedlings in fire affected areas on K'gari, Queensland

Figure 13. *Austropuccinia psidii* symptoms on regenerating *Syncarpia hillii* seedlings in fire affected areas on K'gari, Queensland

Figure 14. *Austropuccinia psidii* symptoms on regenerating *Syncarpia hillii* reshoots in fire affected areas on K'gari, Queensland

Moon Point – Happy Valley Rd

Reshoots of *Leptospermum trinervium*, growing in severely burnt woodland areas east of Moon Point, were found with rust infection on the newest growth flush. However, only 10% of plants assessed had evidence of infection at the time. Disease severity levels on infected trees were low and unlikely to impact on regeneration unless disease levels increase over time.

Further east along the Happy Valley Road, where the vegetation transitions from woodland to fringing rainforest, fire affected *Backhousia myrtifolia* (reshoot), *E. pilularis* (seedlings), *S. hillii* (seedlings) and *Syzygium oleosum* (reshoot) were assessed for *A. psidii* infection and impact. Forty percent of *B. myrtifolia* reshoots were identified with active *A. psidii* infection and/or associated dieback. No seedlings of this species were identified at the site.

Austropuccinia psidii infection was also detected on seedlings of *S. hillii*. However, only 5% of the 100 seedlings assessed had symptoms. These ranged from single spots to moderate levels of infection on new foliage.

Melaleuca plot revisit

Plots were established in five fire affected sites in August 2020 and were to be revisited in November 2020 but wildfires on K'gari prevented access to the island. Due to time constraints, only three of the five plots were assessed prior to this report being written. In some plots, missing tags reduced the number of trees assessed.

Plot 1 – Broken Bridge

Five trees, all assessed as being highly susceptible to *A. psidii* at the first assessment in 2020, were dead at this assessment. However, without more regular monitoring it is difficult to determine if this is due to myrtle rust only or a combination of factors. At the time of the first assessment 17 of the 50 trees were found to be disease free. All but two of the trees were again assessed as disease free.

Plot 2 - Sheep Station Rd

All trees initially rated as being free of disease (24%), and possibly resistant to rust, were again free of disease symptoms. Conversely, the majority of those rated as highly susceptible at the initial assessment (44%) rated similarly for disease incidence and severity. No tree deaths were recorded.

Plot 3 – Gary's Anchorage

Twelve trees were found to be dead at the second site. This included three that were previously assessed as being free of *A. psidii* symptoms. Of the remaining nine trees, seven had moderate to high ($\geq$50% foliage infected) disease incidence on the reshoots in 2020. Disease incidence levels on the other two dead trees were 10% and 25% with disease severity ratings of low and low-moderate respectively. Of those assessed as free from rust in 2020 (16 trees), nine trees were assessed as being free of *A. psidii* symptoms in 2021.

Cooloola section North- Freshwater - low fire severity

An area of open eucalypt forest (regional ecosystem (RE) 12.2.8) bordering on littoral rainforest (RE 12.2.1) that was assessed in September 2020 had a single *S. oleosum* (Fig. 15) with moderate levels of rust. Of the five trees of this species assessed in March 2021, four had rust symptoms, though the incidence and severity of these infections was low.

Figure 15. *Austropuccinia psidii* impact on reshoots of *Acmena smithii* and *Syzygium oleosum* in fire affected areas of Cooloola National Park, Queensland

Of note in this area, *B. myrtifolia* were found to be infected where previously there were no symptomatic trees recorded (Fig. 16). Of the 68 regenerating trees assessed, 41% (28 individuals assessed) had rust infections ranging from low to high severity. In addition, four individuals showed significant levels of dieback that was most likely due to myrtle rust as old urediniospores were observed. In the previous survey, not a single *B. myrtifolia* had rust symptoms or evidence of dieback. Interestingly, none of the 30 seedlings assessed had rust infections, though new growth was present.

Figure 16. *Austropuccinia psidii* impact on reshoots of *Backhousia myrtifolia* in fire affected areas of Cooloola National Park, Queensland

Austromyrtus dulcis that was symptom-free in September 2021 had very low levels of infection observed on two individuals in the second survey. Other Myrtaceae in this area included *Eucalyptus pilularis* in both coppice and seedling forms, *Lophostemon confertus* and *Rhodamnia acuminata*. None of these species had rust symptoms during either survey.

In an area 2 kms away in an unburnt region, 72 *B. myrtifolia* trees were assessed. None had signs of myrtle rust infection, giving an indication that fire may have contributed to the infection rates. This area was within the littoral rainforest RE 12.2.1.

Cooloola section South- Teewah - low-moderate first intensity

Several areas across two different open woodland ecosystem types, RE 12.2.5 and 12.2.9 was reassessed. *Austromyrtus dulcis* that previously had low levels of infection showed no rust symptoms in the southern section of the park. *Leptospermum polygalifolium* and *L. liversidgei* also showed lower levels than previous surveys. This is evidence that environmental conditions may not be conducive to rust in all microclimates at the same time when compared to the northern section of the park. *Acmena smithii* showed similar levels of infection to past surveys, as did *S. oleosum*.

The three *M. quinquenervia* plots at low, medium and high fire intensities were reassessed in March 2021 (Fig. 17). There was no rust present at any of these sites at the time of assessment. Plots will continue to be assessed.

Figure 17. Different fire damage levels in *Melaleuca quinquenervia* stands in Cooloola National Park, Queensland

Main Range and Lamington National Park

Revisits to two SE Queensland locations were carried out in April 2021, six months after initial assessments: These sites were in Main Range National Park and Lamington National Park at around 700m altitude but receive markedly different rainfall with the site in Main Range receiving an average of 1043.0 mm annually and the site in Lamington National Park receiving 1865.0 mm annually. (BioClim Bio12 Model). A third visit was planned for Illinbah in the lowlands of Lamington National Park, however, heavy rainfall in previous weeks led to flooding causing access roads on private properties to be damaged and non-traversable indefinitely.

Main Range National Park

Moss's Well at Spicers Gap

Access to this short track is maintained and understory pioneer and weed regeneration was limited, hence, it was easier to revisit plants at this site than nearby sites and at Binna Burra. Twenty-one *Rhodamnia rubescens* were identified in this section, all of which had reshot after the 2019 fires and most of which had new growth bearing symptoms of myrtle rust. Foliage symptom incidence ranged from 15 to 100% infection with infection severity rated as low in most cases but with a few medium ratings. Eight dead *R. rubescens* were noted. Dieback on the living specimens ranged from 5 to 80% and infection severity was low to medium. Infection levels, dieback, and mortality were significantly greater than six months earlier.

Further down the road, the verge was more difficult to penetrate due to native pioneer regeneration and weeds. Active myrtle rust was present, along with evidence of old lesions. Three *R. rubescens* had considerable dieback and two rated with high symptom levels on 30 and 80 % of the foliage respectively. Of eight *Acmena smithii* assessed, two had lesions with 20% and 5% of foliage infected at a low level and dieback severity of 30% and 60%. Two *Syzygium australe* seedlings were flushing but with no infection (old lesions were observed on one and 15% dieback on the other)) and one *Eucalyptus dunnii* was healthy.

A large roadside *R. rubescens* on Spicers Gap Rd (-28.08171, 152.41819 - Moss's Well 16) which was relatively healthy and flowering at first visit with no signs of infection and 15% dieback in 2020 (mostly on the lower parts of the canopy) was, this time, showing signs of defoliation with 60% dieback more evenly distributed.

Binna Burra

Two main trails were revisited in this area, however, dense understorey post-fire regeneration, including weeds, native pioneers and vines had grown over 2m in height and access was limited. Locating some of the *Rhodamnia rubescens* observed in 2020 was difficult and it is possible that some were no longer identifiable or had died.

Between the upper caves-circuit track and the teahouse carpark near the camping ground and Grooms Cottage (-28.19768, 153.18644), the undergrowth was >2m high and dense so only four Myrtaceae could be located. Two *R. rubescens* showed moderate foliage infections of 50 and 60% of their remaining foliage affected but with 95 and 90% dieback respectively. These trees appeared to be close to death. Two *Pilidiostigma glabrum* were also identified with low infection on only 5% of foliage and 10% dieback.

On the Bellbird lookout track, five *R. rubescens* were located, one of which was 5m tall but covered in vines making it assessment difficult. However, from what could be observed, 95% dieback was observed. Of the other four trees located, two were dead, and the other two had 99-100% dieback with no new flush.

Site Comparisons

All *R. rubescens* observed on the second visit in the Binna Burra area had greater than 90% dieback, which compared to the observations made around Binna Burra in 2020 was a significant change and concerning. In 2020, infections ranged from low to severe on foliage and high to severe on stems with an average of 65% of leaves and stems infected. Dieback ranged from 0 to 60%

This contrasts with the sites at Spicers Gap where the trees were healthier with maximum dieback levels of 60%. This may be due to the marked rainfall differences between the two sites and differences in other factors such as cloud cover and temperature impacting on host growth rates and pathogen activity.

New South Wales

Nightcap National Park

Monitoring plots have been established for populations of *Uromyrtus australe*, Peach myrtle, in different parts of Nightcap National Park affected by fire. This species was identified as having symptoms of myrtle rust during the initial surveys. Data from this site has been collected but not finalised in time for inclusion in this report. However, an increase in disease incidence and severity was observed along with infection on fruit (Fig. 18, 19).

Figure 18. *Austropuccinia psidii* symptoms on *Uromyrtus australe*, Nightcap National Park, NSW

Figure 19. *Austropuccinia psidii* uredinia and urediniospores on immature and maturing fruit of *Uromyrtus australe*, Nightcap National Park, NSW

Washpool National Park

Rhodamnia rubescens was targeted based on myrtle rust infection levels at the first assessment. In 2021, 45 plants were found with reshoots on fire affected trees (Fig. 20-22). This was an increase from the 25 plants found to be reshooting in 2020. Of the 45 plants, 38 had active susceptible growth and 37 of these had symptoms of *A. psidii* infection. In 2020, 52% of trees had evidence of rust related dieback. In 2021, 38 of the 45 trees assessed had rust related dieback. Of the remaining seven trees, six had active *A. psidii* infection at the time of assessment. Three of these had high disease incidence and/or severity scores suggesting high likelihood of dieback developing over time.

Near to the *R. rubescens*, dieback was identified on reshoots of 35% of *Archirhodomyrtus beckleri* assessed. However, all trees assessed had evidence of *A. psidii* infection on new shoots and leaves with disease incidence levels per tree ranging from 5 to 100%.

Figure 20. Severe dieback on reshoots of *Rhodamnia rubescens* because of repeated *Austropuccinia psidii* infection, Washpool National Park, NSW

Figure 21. Different levels of dieback on young reshoots of *Rhodamnia rubescens* because of repeated *Austropuccinia psidii* infection, Washpool National Park, NSW

Figure 22. *Austropuccinia psidii* associated dieback of reshooting *Rhodamnia rubescens* in Washpool National Park, NSW

Chatsworth Hill Nature Reserve

Access to this site was limited due to washouts on the only access road caused by the March 2021 flooding. Unfortunately, this meant the population of *Melaleuca nodosa* that was assessed in 2020 was not reassessed. However, the *Melaleuca quinquenervia* swamp was accessible and assessed for *A. psidii* impact on reshooting trees and seedling recruitment.

Reshoots

Of the 110 *M. quinquenervia* trees selected at random and assessed, 91 trees (82.73%) had no reshoots and appeared dead. Of those trees that were alive, 11 had active rust infection on new shoots. Seven trees were found to have flowers present. Five of the seven had no evidence of rust infection (Fig. 23).

While plots were not established at this site in 2020, which would have allowed for better comparisons, 116 trees were assessed with no evidence of widespread deaths observed. However, at the time of the 2020 assessments, 67.24% of trees assessed had *A. psidii* related dieback on reshoots and 13.79% of trees had dead reshoots because of *A. psidii* infection. Thirty six percent of trees had disease incidence levels ≥50% of new growth, with disease severity levels ranging from low-moderate to severe. Only 11% of trees assessed were rated as free of *A. psidii* symptoms.

Figure 23. Dieback of *Melaleuca quinquenervia* and *Austropuccinia psidii* affected seedling regeneration in Chatsworth Hill Nature Reserve, NSW

Recruitment

One-hundred and thirty-four seedlings, growing under the fire-affected mature trees, were randomly selected and assessed for *A. psidii* incidence and severity. Seedlings were well established and ranged in height from 20-60cm. Only 15.67% of seedlings assessed had no symptoms of *A. psidii* infection (Table 3).

Table 3. Susceptibility of *Melaleuca quinquenervia* seedlings to *Austropuccinia psidii* in Chatsworth Hill Nature Reserve, NSW

Disease incidence	% Seedlings	Disease severity (average)*
0 – nil disease	15.67	
1-25%	26.87	1.11
26-50%	5.97	2.37
51-75%	14.92	2.5

* Seven-point scoring system – Low = 1; L-Moderate = 2; M = 3, M-High = 4; H = 5; H-Severe = 6; S = 7

Severity of disease on affected seedlings varied from limited spots on foliage to severe blighting and dieback of infected shoots. In severe cases, apical dominance was lost, and repeated infection had created a shrub-like growth habit. With only 15.67% of seedlings showing field resistance at the time of assessment and the number of deaths of mature trees recorded, there is some concern over short- and long-term *M. quinquenervia* recruitment at this site.

Yarringully Nature Reserve

Semi-permanent plots have been established at this site focussed on reshooting *Melaleuca quinquenervia* and *M. nodosa*. These plots are being monitored monthly as part of a PBSF funded project that will continue until February 2022 and a full analysis of results conducted at this time.

Melaleuca nodosa

Since establishments of the 50-tree plot in March 2020, 29% of trees have died as of April 2021. All these trees have had *A. psidii* infection recorded, the majority at multiple assessment times, suggesting myrtle rust is a significant contributing factor to decline of these trees. Of the remaining trees, 82% had evidence of dieback caused by myrtle rust. Only three of the 50 trees assessed have produced flowers during the assessment period.

Recruitment

No *M. nodosa* seedlings have been identified at the site.

Melaleuca quinquenervia

In March 2020, there was no evidence of *A. psidii* symptoms on reshoots of *M. quinquenervia*. This increased to 42% of trees with symptoms in April and a further increase to 64% of trees in May. At the June 2020 assessment, 82% of trees had some level of *A. psidii* infection on reshoots. Tree deaths were first detected in August 2020, with four trees affected, all of which had some level of myrtle rust on reshoots in previous assessments. A further 27 trees (58.69%) were recorded with reshoot dieback at this time. Tree deaths have continued to increase with 38% of trees identified as dead as of June 2021. Only eight trees have been identified as having some level of flowering as of June 2021.

Recruitment

Plots were established in areas where *M. quinquenervia* seedling germination was apparent, and assessments were made for incidence and severity of *A. psidii* infection. Seedlings free of *A. psidii* symptoms made up 35.66% of the population assessed (Table 4).

Table 4. Susceptibility of *Melaleuca quinquenervia* seedlings to *Austropuccinia psidii* in Yarringully Nature Reserve, NSW

Disease incidence	% Seedlings	Disease severity (average)*
0 – nil disease	35.66	
1-25%	23.90	1.73
26-50%	20.22	2.53
51-75%	10.29	2.98
76-100%	9.93	3.33

* Seven-point scoring system – Low = 1; L-Moderate = 2; M = 3, M-High = 4; H = 5; H-Severe = 6; S = 7

One-hundred and thirty-six *Eucalyptus pilularis* seedlings were also assessed at the same location. Twenty-seven percent of these had varying levels of infection. Sixty-two percent were considered highly susceptible with infection on $\geq$50% of susceptible foliage, shoots and stems.

Bundjalung National Park

Like Yarringully, semi-permanent plots have been established to look at impacts of repeated *A. psidii* infection of *M. quinquenervia, M. nodosa* and *L. trinervium*. Additional assessments conducted during April and May 2021 included assessment of *L. whitei, L. polygalifolium, Homoranthus virgatus and M. sieberi*. Assessments of *M. quinquenervia* seedlings were also conducted to gauge impact on recruitment.

Leptospermum whitei

Ninety-six reshooting *L. whitei* trees were assessed across two separate sites within Bundjalung NP. Seventy-eight percent of trees had no *A. psidii* symptoms. Of the 22% of plants with symptoms, dieback levels recorded were low on 11 trees with <25% of stems affected, moderate on eight with 26-50% stem dieback and two with stem dieback ranging from 51-75%. While continued monitoring should be done, the low levels of infection and impact would suggest minimal impact to this species in Bundjalung NP.

Leptospermum polygalifolium

Thirty percent of *L. polygalifolium* seedlings (n=69) were identified with *A. psidii* associated dieback. Seventy-one percent of infected seedlings had only low impact levels with dieback on <50% of stems. Nineteen percent of plants assessed had severe levels of *A. psidii* associated dieback recorded.

Homoranthus virgatus

While *H. virgatus* has previously been rated as highly susceptible to *A. psidii* (Pegg unpublished), disease levels on seedlings in Bundjalung NP were low with only six of 32 assessed found with symptoms. Infection levels were also low with disease incidence on all seedlings <10%. No dieback related to infection was observed at the time of assessment.

Melaleuca sieberi

Reshoots on 43 *M. sieberi* trees were assessed for *A. psidii* infection symptoms and severity, with 46.51% having some level of infection (Fig. 24, 25). Most trees (80%) with infection present had low disease incidence levels ($\leq$25% of susceptible foliage/stems). The remaining four trees had high disease incidence levels. Dieback was present on four trees but only at low levels (1-25% of branches affected).

Figure 24. *Austropuccinia psidii* infection symptoms on young *Melaleuca sieberi* shoots and dieback associated with infection on juvenile stems, Bundjalung National Park, NSW

Figure 25. *Austropuccinia psidii* infection symptoms on *Melaleuca sieberi* reshoots, Bundjalung National Park, NSW

Melaleuca quinquenervia recruitment – seedling impact assessment

Melaleuca quinquenervia seedlings from four sites in Bundjalung NP were assessed for disease incidence and infection severity levels (Fig. 26, 27). A total of 494 seedlings were assessed with 34.21 % free of disease symptoms at the time of assessment (Table 5). An additional 18.29% had disease symptoms on ≤25% of susceptible foliage, shoots and juvenile stems. Forty-one percent of seedlings assessed had disease symptoms on ≥75% of susceptible foliage, new shoots and juvenile stems. Unsurprisingly, severity of infection increased with increasing disease incidence.

Table 5. Susceptibility of *Melaleuca quinquenervia* seedlings to *Austropuccinia psidii* in Bundjalung National Park

Disease incidence	% Seedlings	Disease severity (average)*
0 – nil disease	34.21	
1-25%	18.29	1.31
26-50%	6.5	2.19
51-75%	8.4	2.56
76-100%	32.6	4.58

* Seven-point scoring system – Low = 1; L-Moderate = 2; M = 3, M-High = 4; H = 5; H-Severe = 6; S = 7

Figure 26. Severe *Austropuccinia psidii* infection levels on established *Melaleuca quinquenervia* seedlings in Bundjalung National Park, NSW

Figure 27. *Austropuccinia psidii* infection on established *Melaleuca quinquenervia* seedlings resulting in distorted growth and loss of apical dominance. Bundjalung National Park, NSW

Melaleuca quinquenervia reshoots

Three short-term monitoring plots have been established assessing impact on *Melaleuca quinquenervia* reshooting after the fires within different locations in Bundjalung National Park. Each plot consists of 50 randomly selected trees and are assessed monthly for disease incidence and severity, dieback levels and impacts on flowering. These assessments will continue until February 2022 as part of a PBSF funded project that compliments this project. The plots are:

- Narrow diameter trees along the banks of the Esk River
- Narrow diameter trees associated with an "inland" lagoon/waterhole
- Large diameter trees within a swamp environment

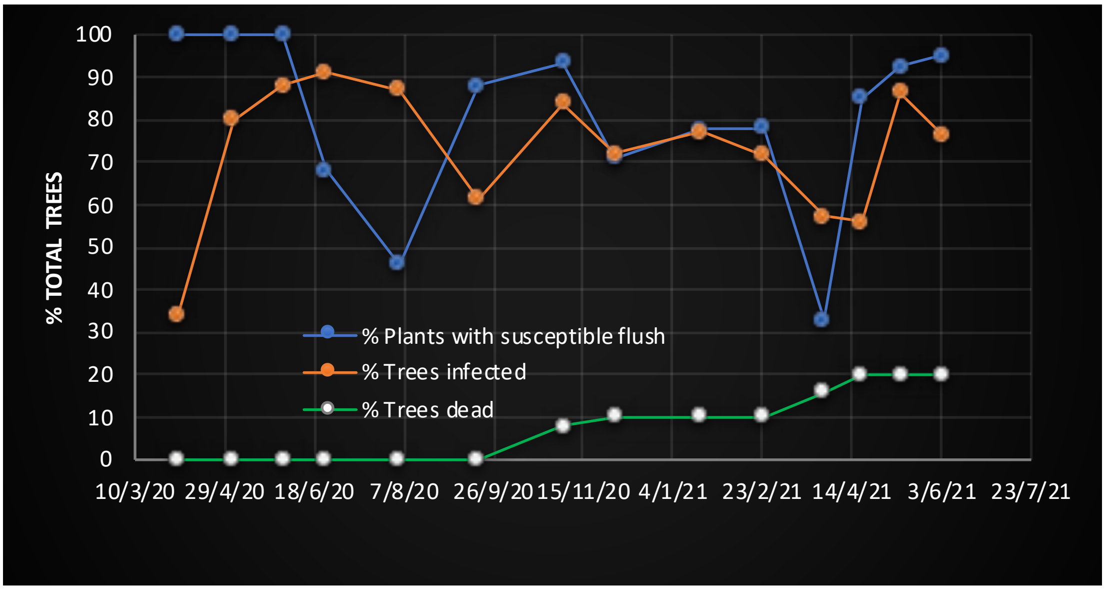

Figure 28. Esk River *Melaleuca quinquenervia* reshoot study plot showing reshoot growth patterns, trees with *A. psidii* infection over time and accumulation of tree deaths because of repeated *A. psidii* infection

Susceptible flush on reshooting *M. quinquenervia* at the Esk River plot (Fig. 28) has been repeatedly infected by *A. psidii* since regeneration started in January 2020. This has resulted in a gradual increase in shoot dieback (Fig. 29) and more recently the number of dead trees (20%). Number of infected trees has fluctuated over time but there is little evidence, at this stage, of any seasonal influence. Instead, disease presence appears more closely linked to the presence/absence of flush events. Only three trees have produced flowers over the assessment time. While all three have had symptoms of rust recorded at some time, both incidence and severity levels have been low. A detailed analysis of data will be completed at the end of the study.

Tree deaths have also been recorded in the other two plots – "swamp" and "waterhole". Forty percent of the large diameter trees within the "swamp" plots were dead at the last assessment (June 2021). While all but two of these trees have had *A. psidii* infection recorded at some time, the effects of other factors, like insect attack or just the intensity of the fire, and how they have contributed to tree health decline need considering. Damage from mirid bugs have been recorded on all trees, particularly during the spring months. Like *A. psidii*, mirids attack the new growth and can cause considerable damage to new shoots causing defoliation and dieback. A combination of myrtle rust uredinia and mirid damage is often observed on the same leaf. Tree deaths are, to date (June 2021) much lower (two out of 50) at the "water hole" site but these trees appear much slower growing, possibly due to the site being unsuitable nutritionally. As a result, levels of active flush suitable for *A. psidii* infection have been less frequent than at the other two sites. Additionally, these trees were more severely impacted by mirid bug attack resulting in lower levels of susceptible leaf available for *A. psidii* infection.

Figure 29. *Austropuccinia psidii* associated dieback of *Melaleuca quinquenervia* reshoots on the bank of the Esk River, Bundjalung National Park, NSW

Melaleuca nodosa reshoots

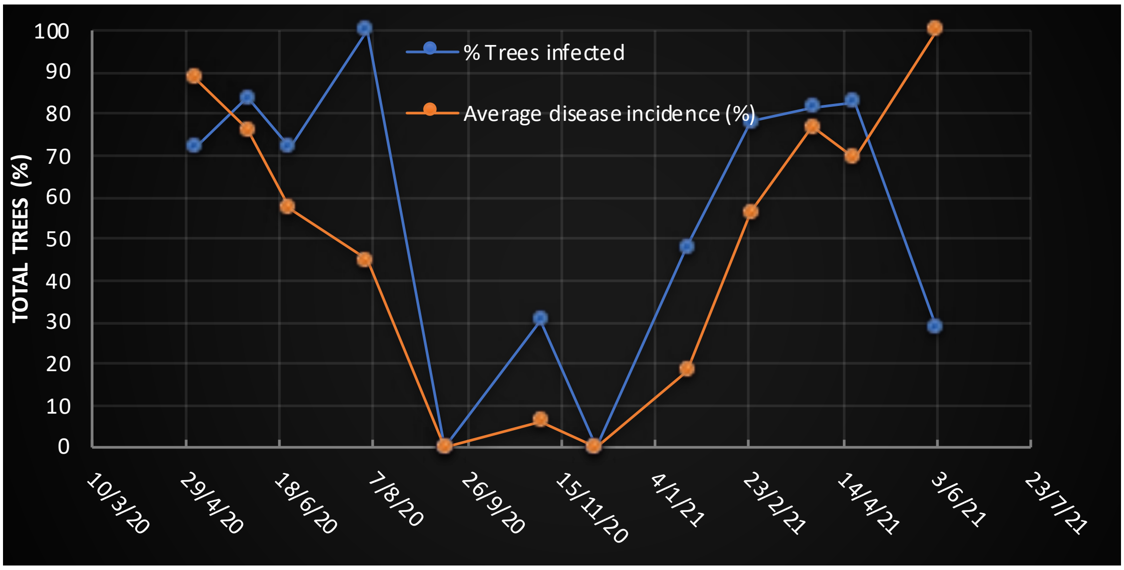

Figure 30. *Melaleuca nodosa* trees in Bundjalung National Park, NSW, infected by *A. psidii* and disease incidence levels over a 14-month assessment period

At the last assessment (June 2021), only 18% of *M. nodosa* trees assessed were free of dieback symptoms associated with *A. psidii* infection on new growth. The number of trees infected and disease incidence, as an average, dropped during the Spring and Summer months, peaking during the Autumn/Winter months. Assessments will continue at this plot allowing us to examine infection patterns in more detail (Fig. 30) along with impacts on survival and flowering.

Forty-eight percent of trees had tip dieback on all new growth. Seventy-six percent of trees had evidence of branch death because of repeated infection since reshoot recovery started. The level of branch dieback ranges from ≤25% of branches (38% of trees) to 100% of branches with dieback evident (10% of trees) (Fig. 31, 32). Flowering and seed capsule formation was identified on 52% of trees. However, only three trees had flowers on >50% of branches. Trees are beginning to become suppressed by competing non-Myrtaceae and/or less susceptible Myrtaceae species (*Baeckea frutescens, Leptospermum polygalifolium*).

Figure 31. Branch tip dieback on *Melaleuca nodosa* caused by *Austropuccinia psidii* infection on new growth, Bundjalung National Park, NSW

Figure 32. Branch dieback on *Melaleuca nodosa* because of repeated *A. psidii* infection, Bundjalung National Park, NSW

Eucalyptus species

No evidence of *A. psidii* symptoms were found on reshoots of *E. pilularis* or *E. planchoniana*, even on trees previously identified as susceptible. Similarly, no further seedling infection was identified. The cause of the change in susceptibility is not known but could be related to changes in growth rate, changes in leaf morphology or other tree physiological changes.

Training

Myrtle rust identification training was delivered to the Iluka Landcare, Yaegl Bushcare and Rangers from NSW Parks and Wildlife (Fig. 33). This entailed an introduction session about myrtle rust – where did it come from, where has it spread to, what does it affect, what are the symptoms and impacts - followed by a field tour of study sites established in Bundjalung National Park. Levels of infection on *M. quinquenervia* were high at the time allowing for easy demonstration of symptoms. The group was also shown the impact of repeated infection on *M. quinquenervia* and *M. nodosa*. The importance of identifying disease free trees was emphasised in relation to collection of seed for any tree planting program.

Figure 33. Myrtle rust training day, Bundjalung National Park NSW – Iluka Bushcare, NSW National Parks and Wildlife, Yaegl Bushcare. Photo: Dell Gorring (NSW National Parks & Wildlife Service)

Central Coast

Additional *M. nodosa* assessment sites were established in fire affected areas along the Central Coast of New South Wales - Knappinghat National Park, Saltwater National Park, Nabiac and Kiwarrak. Seven assessments were completed from August 2020 to May 2021. Disease incidence and severity, dieback levels associated with *A. psidii* infection, and flowering/seed capsule levels per tree were captured. Dieback of *M. nodosa* because of repeated *A. psidii* was recorded at all sites. Tree deaths were recorded at three of the six sites assessed with 26% of trees recorded as dead at one of the sites in Knappinghat National Park.

Not previously reported, a fire affected *M. quinquenervia* swamp site was assessed in January 2021. Reshoots of 50 trees were assessed for disease incidence and severity and levels of dieback. Only one tree was identified as symptom free at the time of assessment and dieback recorded on all trees ranging from 20% of reshoots affected to 100% (average 65.36%).

A full analysis of the data will be conducted at the conclusion of studies being conducted in other sites.

Discussion

While one-off surveys of sites can provide information on species susceptibility, longer term monitoring is required to better understand impacts of repeated *A. psidii* infection on Myrtaceae regenerating after wildfire. This includes capturing information on long term survival of species and/or individuals, recovery of species and/or changes in population levels, impacts on fecundity and long-term recruitment. It also allows opportunities to identify individuals more accurately within susceptible species that may be resistant or tolerant to *A. psidii*, a valuable resource for germplasm capture and use in regeneration programs.

Additionally, some species reported as free of disease symptoms during initial surveys were identified with significant levels of infection and associated dieback during the most recent surveys (e.g. *Backhousia myrtifolia*). While a small amount of funding will allow the continuation of some monitoring until February 2022, this will likely raise more questions than answers regarding impact.

Surveys on K'gari (Fraser Island) were extended to include more recent fires that affected around 80,000ha of the island's vegetation. This study provides the first report of *A. psidii* symptoms on *E. pilularis* and *S. hillii* on K'gari. It is also the first report of *A. psidii* affecting *S. hillii* seedlings and reshoots outside of studies under controlled inoculation conditions. Known to Aboriginal people as Peebang, *S. hillii* is culturally and ecologically significant. Growing to >3m in diameter, the species is endemic and restricted to the region and one of the dominant species in the notophyll vine forest and mixed notophyll evergreen forest. Logged during the forestry days on K'gari, the timber, identified as resistant to marine borers, was used for the construction of the Suez Canal and rebuilding of London's docks after the war (Flora – Fraser Island Defenders Organisation (fido.org.au)). While the numbers of *S. hillii* seedlings and reshoots affected were low, symptoms observed suggested that the numbers infected were likely to increase. However, regular assessments are required to better understand susceptibility within the regenerating populations and impacts over time.

Dieback of *Melaleuca quinquenervia* in some sites, particularly those in New South Wales, is of concern. Whether or not *A. psidii* is the primary cause of the death of reshooting trees or a contributing factor along with insect attack is still unknown. As documented in the original report, studies conducted in Florida (Rayamajhi *et al.* 2010) and in Australia (Pegg *et al.* Unpublished) identify a combined impact on tree survival resulting from insect attack and *A. psidii* infection. Adding to the concern for *M. quinquenervia* is the levels of *A. psidii* infection on seedling recruitment with approximately 30% of the regenerating population symptom free at the time of assessment. At the Chatsworth Hill Nature Reserve only 15% of seedlings were symptom free. This population is more isolated in comparison to Yarringully and Bundjalung populations and may explain a lower level of diversity. However, this can't be confirmed without looking at population genetics. The low number of trees producing flowers is also of concern and the data to date suggests trees with high levels of *A. psidii* infection do not flower or produce low numbers of flowers.

Variability in disease severity was also observed at all sites but the consequences of the different disease severity levels on survival are unknown. Certainly, the mortality has been observed for the more susceptible seedlings along with changes in tree habit with repeated loss of apical shoots resulting in multibranched trees with a shrub like habit. Unlike *Eucalyptus* species, which seem to become resistant with age, infection levels continue to ebb and flow seemingly only dependant on the presence of new growth. Ultimately longer-term monitoring is required to determine the consequences of (1) the death of established trees and decline rates in relation to *A. psidii* infection levels, (2) the impact of disease on seedling recruitment levels and the recovery of the species within sites and (3) the impact on flowering and seed production over time. Do populations become more resistant over time through "natural" selection processes? If so, how diverse are these populations in comparison to what was present previously? Does this matter for this species' long term survival?

As reported previously, *M. nodosa* is highly susceptible to *A. psidii* with only small numbers of trees showing resistance/tolerance to the disease. Repeated *A. psidii* infection is now resulting in dieback and reducing plant vigour and their ability to compete within the sites with non-Myrtaceae and other less *A. psidii* susceptible Myrtaceae. The consequences of reduced numbers producing flowers on pollination processes is unknown.

The decline of *R. rubescens* within fire affected Gondwana Rainforests continues. Populations assessed in Washpool NP, Main Range NP and Lamington NP continue to decline because of *A. psidii* infection of reshoots. In some sites (Binna Burra) *R. rubescens* trees seemingly can't compete with weed species and are becoming suppressed and difficult to find in some sites. Additional surveys are required to better understand impacts on other rainforest species, primarily *A. beckleri* and *U. australe*.

Publications to be prepared

- Host range and impact of *A. psidii* on fire affected Myrtaceae in different ecosystems on K'gari
- Impact of *A. psidii* on Myrtaceae in fire affected rainforests of south-east Queensland and north-east New South Wales
- Impact of *A. psidii* on recovery of fire affected Myrtaceae in coastal heath and woodland environments in New South Wales and south-east Queensland

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Further information:

http://www.nespthreatenedspecies.edu.au

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Threatened Species Recovery Hub

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