PLANT BIOSECURITY
science foundation

Expanding environmental biosecurity capacity to protect our unique ecosystems on K'gari (Fraser Island)

Final Report (PBSF025)

February 2022

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This document should be cited as:

Geoff Pegg, Louise Shuey, Janet McDonald, 2022, APBSF Project 025 Final Report, Expanding environmental biosecurity capacity to protect our unique ecosystems on K'gari (Fraser Island).

1. Executive Summary

Exotic pests threaten cultural and environmental biodiversity values unique to Australia, prime topical examples being myrtle rust affecting Australian Myrtaceae and the more recent decline of Bunya pines in the Bunya Mountains National Park. This project aims to develop and deliver training that enhances environmental biosecurity awareness, thereby increasing the capacity of the Butchulla, the traditional custodians of K'gari (Fraser Island), to detect, monitor and report on priority pests that may threaten culturally and environmentally significant species within Fraser Island (K'gari) World Heritage Area.

Training

This project initiated a train-the-trainer program to allow the extension of environmental biosecurity awareness and reporting capacity. Training in partnership with the Butchulla Land and Sea Rangers (BLSR) has been extended to Queensland Parks and Wildlife Service (QPWS) staff and community rangers including Landcare groups from Hervey Bay and Sunshine Coast (Gubbi Gubbi). An opportunity to develop networks for BLSR was provided through closely aligned PBSF projects, with workshops held with the Coffs Aboriginal Land Council and Minyumai Indigenous Protected Area (IPA). BLSR presented outcomes of the work on K'gari highlighting the importance of partnerships and communication within the community around what we are trying to protect.

Additionally, training in myrtle rust assessment and monitoring has been conducted, including in wildfire affected sites. General forest health surveys were also conducted with BLSR focussed on high-risk sites, primarily those with high visitation rates, and areas of significant tree dieback. Training included decontamination procedures, impact assessment, symptom description and sample collection methods.

Myrtle rust

Surveys have identified myrtle rust affecting *Myrtaceae* species in a wide range of ecosystems on the island. Myrtle rust impacts have been most significant in fire regeneration sites. The disease was detected for the first time on Satinay (*Syncarpia hillii*) occurring on seedlings and reshoots from fire affected trees. Substantial impacts were also recorded on regeneration of fire affected paper bark (*Melaleuca quinquenervia*) and black butt (*Eucalyptus pilularis*). Increasing levels of infection were noted on cinnamon myrtle (*Backhousia myrtifolia*) in disturbed and undisturbed sites. Infection on silky myrtle (*Decaspermum humile*) was detected for the first time on K'gari with dieback on affected saplings.

Capturing germplasm – species conservation strategy

Extensive fire damage across the island prevented any opportunity to collect germplasm (seed) of myrtle rust affected Myrtaceae on K'gari. However, through additional National Heritage Grant funding, sampling and storage equipment have been purchased. BLSR also completed a seed collection and storage training workshop run by Gavin Phillips from Australian PlantBank, Sydney Botanic Gardens. Capacity to maintain collections and run the associated nursery based at Eurong on K'gari is currently run through a volunteer program. Significant investment is required to ensure this nursery can produce seedlings for regeneration programs and species conservations programs on the island.

2. Introduction

Exotic pests threaten cultural and environmental biodiversity values unique to Australia. Myrtle rust is the second most significant plant pathogen to invade the native environment in Australia and several reviews have highlighted serious gaps relating to Australia's environmental biosecurity. Under the World Heritage Convention, the Federal Government (with day-to-day management devolved to the State) has responsibility for identifying and protecting the Outstanding Universal Value (OUV) and ensuring its conservation for current and future generations. Australia's World Heritage properties are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and are thus recognised as matters of national environmental significance under the EPBC Act's assessment and approval provisions. Therefore, ensuring biosecurity risks, including myrtle rust, are identified and managed effectively are paramount to fulfilling these obligations.

This project extends on the previous work done in project PBSF012, further expanding environmental biosecurity awareness training and forest health surveillance. Additional training in myrtle rust identification and assessment methods are also a focus. *Austropuccinia psidii* was first reported on K'gari in 2013 (Giblin & Pegg, unpublished) with limited surveys identifying disease on *Austromyrtus dulcis*, *Backhousia myrtifolia*, *Homoranthus virgatus*, *Melaleuca quinquenervia* and *Rhodamnia acuminata*. However, little information on impacts were gathered during these surveys.

3. Aim

This project aimed to increase the capacity of traditional custodians (Butchulla) to detect, monitor and report on pest and disease threats to K'gari (Fraser Island) World Heritage Area. Additionally, the project aimed to establish a train-the-trainer program to ensure continued capacity building on K'gari and neighbouring regions beyond the completion of this project. Facilitating knowledge sharing with other First Nations peoples was also a priority.

With regards to *A. psidii*, this study aimed to work with BLSR to determine the susceptibility of Myrtaceae species on K'gari and the impact of myrtle rust on these species, particularly following wildfire. Developing strategies to enable germplasm collection and storage was also an aim of this project.

4. Methods/Process

Myrtle rust on K'gari

Methods have been developed to capture myrtle rust impact on K'gari with a focus on determining the current impact status of myrtle rust priority species, cultural significant species at risk and ecosystems where rust is having an impact. The occurrence of wildfires in 2019 and 2020 resulted in a shift of focus to examine impacts of myrtle rust on regeneration of species. It also provided the opportunity to examine impacts in disturbed sites in comparison to undisturbed sites.

Surveys and assessments

Fire affected areas

In November 2019, a wildfire was initiated following a lightning strike in the southern end of the island affecting areas of coastal heath, melaleuca wetlands and woodland and eucalyptus woodlands. In October 2020, a more extensive wildfire was initiated by an illegal campfire and burned for more than two months affecting around 80,000ha (Figure 1) or 44% of the island vegetation. Fire intensities were variable, and a range of vegetation types affected including coastal heath and woodland, wet sclerophyll forests and rainforest areas.

Given that myrtle rust is known to impact on regenerating Myrtaceae, seedlings and reshoots, much of the survey work focussed on fire affected ecosystems. This included coastal heath and woodland, paper bark wetlands, wet sclerophyll forests and rainforest areas. Data used in this report has been compiled as part of overlapping projects funded through the Australian Network for Plant Conservation (ANPC)/Threatened Species Recovery Hub. Full reports of the fire project can be found at (Fire and Rust | Australian Network for Plant Conservation (anpc.asn.au).

Surveys and assessments

Walk through and transect surveys were conducted at a range of sites in areas affected by fire with evidence of seedling regeneration and/or reshooting occurring. These surveys were designed to determine the presence of myrtle rust in different environments and on different species.

Surveys were conducted in wildfire-affected areas where Myrtaceae species were present. Survey 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 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. This consisted of assessments in multiple sites selected randomly or the establishment of plots.

Location of surveys and targeted species were recorded using Garmin InReach handheld GPS. The presence/absence of *A. psidii* was then mapped to determine distribution on the island and vegetation types affected.

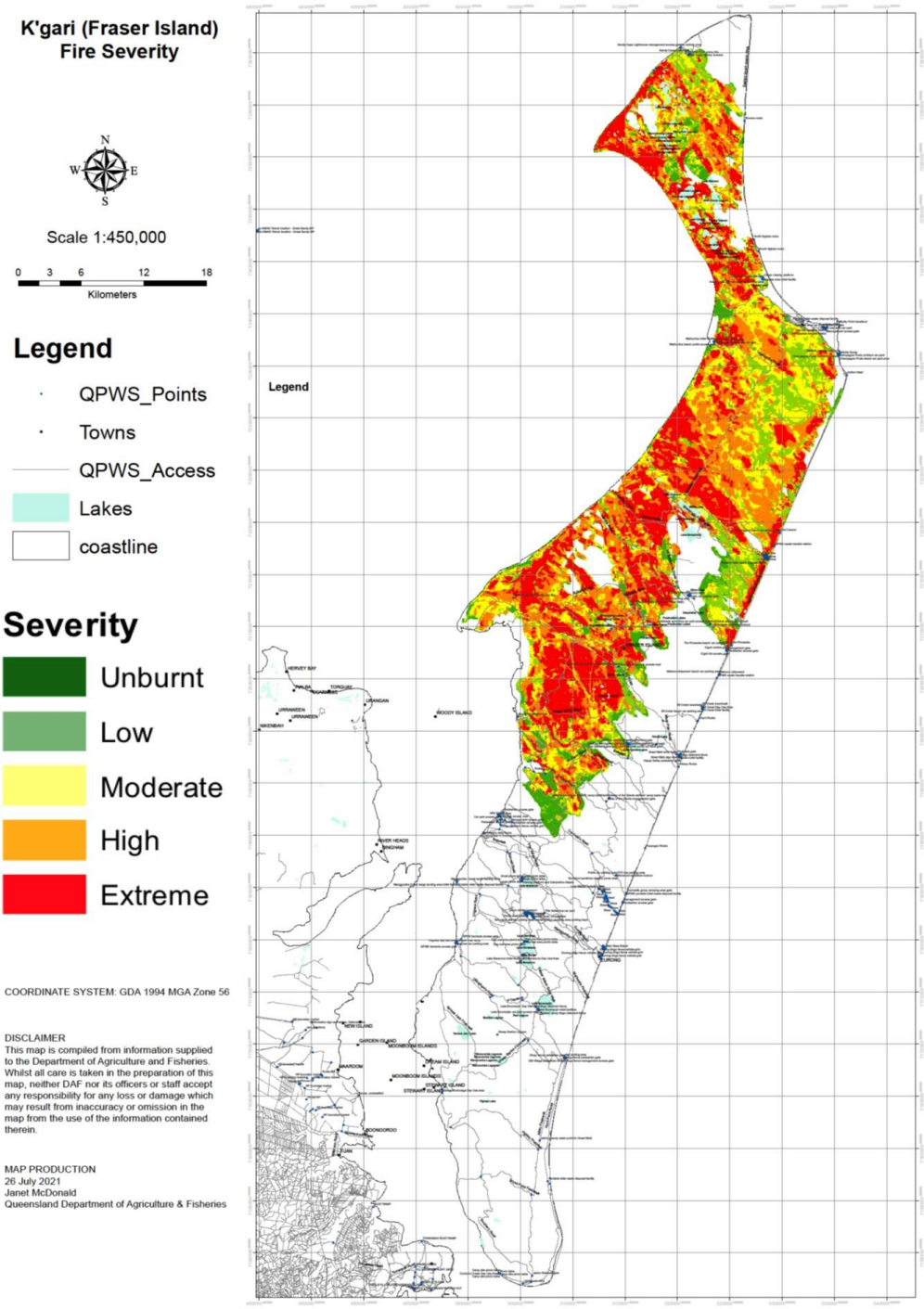

Figure 1 K'gari 2020 fire map showing fire intensity levels, red being the most intense fire ratings. The 2019 fires affected areas in the southern part of the island, but fire intensity levels were not mapped in this case.

Assessment methods

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

- GPS location

- General site description
- Vegetation type
- Fire intensity - 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. (2014), Carnegie et al. (2016), Pegg et al. (2017) and Pegg et al. (2020a). Ratings were simplified to be applicable across a range of species and for the use by people less familiar with the disease and the 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 low, 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 of fifty tree were established in selected sites and focused on *Melaleuca quinquenervia* (paperbark) to assess impact of repeated infection of myrtle rust on post-fire plant regeneration. Trees were selected at random but only trees with evidence of reshoots were included.

One meter radius plots were established in areas where seedlings of *Eucalyptus pilularis*, *M. quinquenervia* and *Syncarpia hillii* seedlings were regenerating. Plots were randomly selected, and the number of plots assessed was dependent on the total area of seedlings.

5. Achievements, Impacts and Outcomes

Biosecurity and forest health – train-the-trainer program

A partnership between Department of Agriculture and Fisheries (DAF), Department of Environment and Science (DES) and the Butchulla Land and Sea Rangers (BLSR) made a successful application for funding through the Australian Heritage Grants. This enabled the employment of an additional BLSR focussed on Forest health and Biosecurity. Matilda (Tilly) Davis was the successful candidate and commenced working with the BLSR in late July 2020. This enabled there to be a full time focus on Forest health and Biosecurity for K'gari, including myrtle rust.

A Forest health and biosecurity training workshop was run by Dr Pegg and Dr Shuey in collaboration with the BLSR and Alana Hazel from the World Heritage Unit, DES. This training was delivered to Community Rangers and Landcare groups from the Fraser Coast and Sunshine Coast Regions, along with Queensland Parks and Wildlife Rangers. Butchulla Elders Aunty Joyce Bonner and Aunty Rachel

Currie also attended the training day. Funding to assist with the running of the workshop was provided through a small Local Council Grant.

Training was a combination of theory and practical exercises. The key message presented was "Biosecurity is a shared responsibility – we can all contribute to protect our unique environments". The training was aimed at increasing awareness and capacity to detect and report on forest health and biosecurity threats. Training was also provided to Women's workshop on K'gari, with modules modified and delivered by Tilly Davis. Tilly has since developed a training program aimed at primary school children as part of this and other project outcomes (National Heritage Grant). Additional training with QPWS Rangers was not possible due to Covid lockdowns and the wildfires.

Facilitating knowledge sharing

A joint forest health and biosecurity training workshop was held as part of PBSF020. Workshops were held with Aboriginal Rangers in Coffs Harbour (Coffs Harbour Local Aboriginal Land Council and Gumma IPA) and Minyumai IPA. BLSR (Chantel Van Wamelen, Tilly Davis) presented on partnerships and biosecurity programs on K'gari and what it is "we" are trying to protect. This was vital for the success of the workshops, with NSW Aboriginal Rangers able to learn from the experiences from K'gari and programs that can be developed to "spread the biosecurity message". The workshops also allowed for cross-cultural discussions on the importance of cultural values for biosecurity agencies and the need for monitoring the impact of invasive species on country.

Figure 2 Expanding networks and knowledge of biosecurity and forest health – BLSR and Coffs Harbour Local Aboriginal Land Council and Gumma IPA, Minyumai IPA.

2019 fire - myrtle rust impact assessments

Several surveys have been conducted with the BLSR team to record *A. psidii* hosts on K'gari and assess

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

Table 1 Species and susceptibility to *Austropuccinia psidii* within fire affected sites on K'gari (Fraser Island) National Park in November 2019

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* occurring on seedling or epicormic regrowth of the iconic and culturally and ecologically significant Satinay, *Syncarpia hillii* (Table 1), 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 in New South Wales following the 2019/20 fires.

Austropuccinia psidii was detected on regenerating *Homoranthus virgatus* (twiggy Homoranthus) but there were also high numbers of individuals free of symptoms and producing flower buds at the time of assessment. Significant *A. psidii* impacts on this species have been made previously, including sites around Boorangoora (Lake McKenzie), Dilli Village and Kingfisher Resort (Pegg *et al*. unpublished). Infection causing stem distortion and dieback was also found on reshoots of *Leptospermum liversidgei* (Table 1) but incidence levels across sites assessed were relatively low.

Table 2 *Melaleuca quinquenervia* plot assessments for myrtle rust 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

Austropuccinia psidii symptoms and associated dieback were found on both seedlings and reshoots of *M. quinquenervia* (Fig. 3,4). Five monitoring plots were established in different locations at the southern end of the island focussed on reshooting trees. 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 reshoots). All sites had greater than 60% of trees showing some evidence of infection (Table 2).

Figure 3 Assessing paperbark regeneration on K'gari for myrtle rust on reshoots following 2019 wildfire.

Dieback levels at the time of assessment were low, but, based on symptoms, it was considered that the infection was recent and only on the most recent growth flush event affected. However, infection severity levels on some trees were likely to cause significant levels of dieback.

Figure 4 Myrtle rust symptoms on reshoots of fire damaged paperbark trees on K'gari

Melaleuca plot revisit - 2021

Three of the five plots established were revisited in 2021 and assessed for disease incidence and

severity and dieback levels.

Plot 1 – Broken Bridge

Five trees, all assessed as being highly susceptible to *A. psidii* at the first assessment in 2020, were dead at the second assessment. However, without more regular monitoring it is difficult to determine if this is due to myrtle rust alone or a combination of factors e.g., insect attack. 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

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 assessment. This included three that were previously assessed as being free of myrtle rust. Of the remaining nine trees, seven had moderate to high (≥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 myrtle rust symptoms in 2021.

2020 fire - myrtle rust impact assessments

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 for *A. psidii* symptoms and impact within fire affected environments are listed in Table 3.

Table 3 Myrtaceae species assessed for *Austropuccinia psidii* infection in fire affected areas on K'gari (Fraser Island) in May 2021

Species	*Regeneration type*	*Rust identified*	*Infection severity range*
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 *A. psidii* was detected on reshoots of *Angophora leiocarpa*, *Corymbia intermedia* or *C.*

tesselaris.

Deepwater Lake

Deepwater Lake is a perched lake north-west of Happy Valley. Vegetation ranges from fringing rainforest to the north, merging into blackbutt (*E. pilularis*) stands and paperbark (*M. quinquenervia*) occurring around the fringe of the lake. The blackbutt and paperbark were severely affected by wildfire.

May 2021

The 2020 fire affected two key species around Deepwater Lake, *E. pilularis* and *M. quinquenervia*, with *A. dulcis* occurring in patches in the fires affected areas. 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 severely damaged along with pockets of *E. pilularis*. Reshoots and seedlings of both species were present and assessed for levels of *A. psidii* infection and impact.

Eucalyptus pilularis – black butt

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

Melaleuca quinquenervia – paper bark

Forty-eight percent of reshooting *Melaleuca quinquenervia* trees had evidence of *A. psidii*. Disease severity levels varied but the majority (35.9%) of trees only had low levels of rust pustules present. 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). Twenty-six percent of the affected seedlings were rated as severe with a significant portion of leaf area covered in pustules and dieback occurring on susceptible foliage, shoots and juvenile stems. This would suggest a more significant impact on recruitment at this site, with low levels of resistance occurring within the population. However, on-going monitoring would be required to fully understand impacts on recruitment.

Austropuccinia psidii symptoms were identified on *Austromyrtus dulcis*, but only at low levels with minor leaf spotting recorded.

September 2021 – site re-visit

Melaleuca quinquenervia – paper bark

Seventy-one percent of reshooting *M. quinquenervia* trees had evidence of *A. psidii* with 21% of the total trees assessed having some level of myrtle rust related dieback. Fifty percent of infected trees had moderate or above levels of disease. Of the seedlings assessed, 43.33% were infected, a 17.65% reduction in levels from assessments back in May 2021.

Eucalyptus pilularis – black butt

Twenty-two percent of reshooting *E. pilularis* trees had *A. psidii* symptoms, like levels observed in May 2021. Only 16.22% of trees had evidence of myrtle rust associated dieback. The number of seedlings assessed with myrtle rust symptoms dropped in comparison to assessments made in May 2021 with on 22.37% of seedlings assessed with *A. psidii* symptoms. This may have been the result of the most susceptible seedlings dying between assessment dates.

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. 5). However, the lack of seedling and reshoot regeneration in the unburnt areas meant that myrtle rust impact comparisons between burnt and unburnt areas were not possible. It does demonstrate the role disturbance events can play in myrtle rust development and impact.

Figure 5 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.

May 2021

Seedlings of both species were assessed at the site, along with reshoots of *S. hillii*. This report is the first record of *A. psidii* affecting *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 as of May 2021 were low, with 17% showing symptoms but ranged in severity 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. 6). Of the 61 reshoots assessed, only seven had symptoms of *A. psidii* infection.

Figure 6 Satinay seedlings regenerating after the 2020 fires with symptoms of myrtle rust on foliage and juvenile stems

September 2021

A similar level of disease incidence was found during assessments in September, with 18.26% of seedlings showing symptoms of active *A. psidii* and/or dieback caused by infection (Fig. 7, 8). During this assessment it was noted that a high percentage of seedlings were appearing to wilt due to an extended dry period, conditions less suitable for disease development. These dry conditions will also impact on disease levels.

Figure 7 Satinay seedling assessments for myrtle rust in September 2021. Conditions were dry and seedlings germinating post fire were stressed showing wilting symptoms (RHS).

Figure 8 Myrtle rust symptoms on Satinay seedlings in fire affected areas on K'gari in September 2021

November 2021

The same site was again assessed in November 2021. This assessment followed periods of decent rainfall, conditions more conducive to disease development. Disease was again detected on seedlings with these ranging in size. However, of the 495 seedlings assessed, only 11.49% had symptoms but on those affected seedlings disease incidence levels were considered high (≥50%) on 64% of seedlings with moderate or higher disease severity levels on 54.9% of seedlings causing dieback. Some of these seedlings were considered well established with relatively recent infection occurring on the newest shoots (Fig. 9, 10).

Figure 9 Established Satinay seedlings with myrtle rust infection on the newest growing shoots and leaves

Figure 10 Dieback of Satinay seedling caused by myrtle rust affecting the new shoots and young foliage

Moon Point – Happy Valley Rd

May 2021

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. This site appeared to be significantly drier than the Cornwell Rd site, with seedling establishment patchy and less advanced.

September 2021 – site re-visit

Syncarpia hillii seedlings were wilting severely due to low rainfall and there was no evidence of *A. psidii* symptoms observed. However, at the same site, *A. psidii* infection symptoms were identified on *S. oleosum* and *B. myrtifolia* reshoots.

Garawongera Road – September 2021

Austropuccinia psidii infection levels were compared in a burnt and unburnt section on forest along Garawongera Rd. *Backhousia myrtifolia* is a dominant understory species and in the unburnt section 25.71% of trees assessed had some level of infection and/or myrtle rust associated dieback. In the burnt section (moderate intensity fire) 29.41% of reshoots were found with disease, indicating little difference between fire affected and unaffected trees for this species.

Boorangoora – September 2021

Homoranthus virgatus shrubs were assessed for *A. psidii* symptoms and levels of dieback. Thirty-two plants were assessed in total with six trees showing low levels of active myrtle rust. Seventeen trees had varying levels of *A. psidii* associated dieback.

November 2021 surveys

Surveys in November 2021 aimed to assess for *A. psidii* impacts in areas not previously assessed and included burnt and unburnt areas. This included areas along Cornwells Break Road (heath woodland, wet eucalypt forest), Postans Cul-de-sac (burnt and unburnt wet eucalypt forest), Ocean Lake (burnt heath/woodland), Wathumba (burnt woodland, heathland), Lake Allom (unburnt wet eucalypt forest, hoop pine), Central Station (unburnt wet eucalypt/rainforest).

Table 4 November 2021 myrtle rust assessments on K'gari

Location	Forest type	Fire status	Species	Myrtle Rust identified	Severity Range
Cornwells Break Road (western)	Woodland/heath	Burnt	*Leptospermum trinervium*	Y	M-H
			Homoranthus virgatus	N	
			Austromyrtus dulcis	N	

	Rainforest	Unburnt	*Backhousia myrtifolia*	N	
			Decaspermum humile	Y	L-M
			Rhodamnia acuminata	Y	L
			Syzygium oleosum	Y	L
Postans Rd	Dry eucalypt	Unburnt	*Backhousia myrtifolia*	Y	L-M
		Burnt	*Backhousia myrtifolia*	Y	L-H
Ocean Lake	Woodland	Burnt	*Austromyrtus dulcis*	Y	L-S
			Melaleuca quinquenervia	Y	L-S
Wathumba	Woodland/heath	Burnt	*Austromyrtus dulcis*	N	
			Leptospermum trinervium	N	
			Melaleuca quinquenervia	N	
Lake Allom	Wet eucalypt/hoop pine	Unburnt	*Austromyrtus dulcis*	N	
			Backhousia myrtifolia	Y	L-S
Central Station	Wet eucalypt	Unburnt	Austromyrtus dulcis	N	
			Backhousia myrtifolia	Y	L-M

Symptoms of *A. psidii* infection were found in burnt and unburnt sites on a range of species and in a range of ecotypes (Table 4) (Fig. 16).

Decaspermum humile – silky myrtle

This survey recorded *A. psidii* symptoms on *Decaspermum humile* for the first time on K'gari. Symptoms were identified on regenerating saplings along the road edge with high disease incidence occurring on new shoots (Fig. 11).

Figure 11 *Rhodamnia acuminata* (Cooloola ironwood) and *Decaspermum humile* (Silky myrtle) affected by myrtle rust on K'gari

Austromyrtus dulcis

Surveys across K'gari have generally found *A. dulcis* to be free of myrtle rust. However, assessments in fire affected areas around Ocean Lake identified *A. psidii* on 28% of plants assessed. Of those infected, all had infection on the immature fruit and/or flowers (Fig. 12, 13). At the same location 70% of *M. quinquenervia* reshoots had infection, with severity levels ranging from low to severe. This same area was assessed back in 2018 pre fire, with no evidence of myrtle rust identified.

Figure 12 Healthy (LHS) and myrtle rust affected *Austromyrtus dulcis* (midyim) – shoots and juvenile fruits at Ocean Lake, K',gari

Figure 13 Myrtle rust on juvenile fruits of *Austromyrtus dulcis* (midyim) at Ocean Lake, K'gari

Backhousia myrtifolia

Backhousia myrtifolia was assessed in several locations, both burnt and unburnt, with myrtle rust identified at all but one site (Fig. 14, 15). At a site on Postans Rd, unburnt and fire affected trees were assessed. Twenty-five percent of trees were infected in the unburnt site compared to 56% of trees recovering from fire damage.

Figure 14 *Backhousia myrtifolia* (cinnamon myrtle) on K'gari with myrtle rust on juvenile stems and foliage

Diseased trees (saplings and mature trees) were also identified around the banks of Lake Allom. Several mature trees had significant crown dieback with epicormic reshoots occurring at the tree base. The cause of the dieback is unknown. It was however, in a location where significant dieback of mature hoop pine was evident. Soil samples have been collected to test for *Phytophthora* root rot. Of the trees assessed 42.6% had some level of *A. psidii* symptoms identified with severity levels ranging from low to high.

Figure 15 Symptoms of myrtle rust on *Backhousia myrtifolia* (cinnamon myrtle) on K'gari

Thirty *B. myrtifolia* trees were assessed for myrtle rust near the Central Station camping ground. Twenty percent of trees were found with symptoms ranging from low to moderate severity levels. This same area was assessed back in September 2021, but no disease was identified then.

Distribution and species susceptibility

Table 5 and Fig 16 provide a summary and location information for areas surveyed, species assessed and susceptibility of these to myrtle rust.

Table 5 Summary of all Myrtaceae species assessed for *Austropuccinia psidii* infection in fire affected areas on K'gari (Fraser Island) S=Seedling; R=Reshoot; L=Low, M=Moderate, H=High, S= Severe

Species	*Regeneration type*	*Rust identified*	*Infection severity range*
Angophora leiocarpa	R	N	
Acmena smithii	R	N	
Austromyrtus dulcis	R	Y	L-M
Backhousia myrtifolia	R	Y	L-H
Baeckea frutescens	R	N	
Corymbia intermedia	R	N	
Corymbia tesselaris	R	N	
Decaspermum humile	R	Y	L-M
Eucalyptus pilularis	S/R	Y	L-S
Homoranthus virgatus	S	Y	L-M
Leptospermum liversidgei	R	Y	L-M
Leptospermum polygalifolium	R	N	
Leptospermum semibaccatum	R	N	
Leptospermum trinervium	R	Y	L-M
Melaleuca quinquenervia	S/R	Y	L-S
Rhodamnia acuminata	R	Y	L
Syncarpia hillii	S	Y	L-S
Syzygium oleosum	R	Y	L

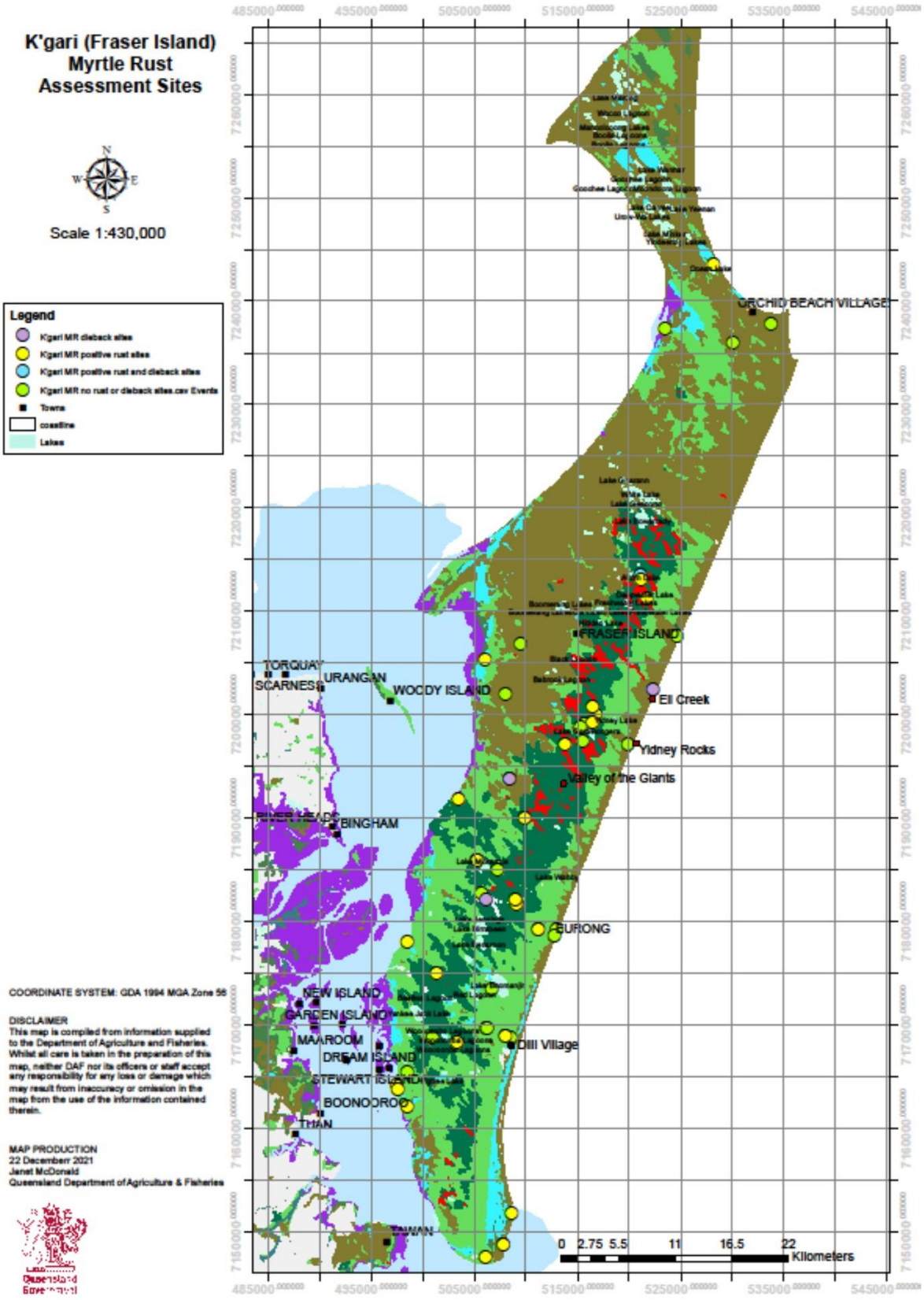

Figure 16 Map of K'gari showing locations of surveys and detection of myrtle rust (yellow dots)

Other forest health issues

Dieback was detected at several sites during surveys on K'gari. These included:

- Xanthorrhoea dieback in fire affected regeneration occurring in patches on the western side of the island

Dieback of Xanthorrhoea regenerating after fire was identified occurring in patches towards the western side of the island off Cornwells Break Rd. Soil samples were collected for Phytophthora baiting but results to date have been negative. The recovery of plants in this area will continue to be monitored.

Figure 17 Dieback of fire affected Xanthorrhoea. Soil samples collected and decontamination process demonstrated to reduce the risk of spreading any potential soil borne pathogens

- Hoop pine and cinnamon myrtle around Lake Allom

Figure 18 Dieback of *Araucaria cunninghamii* and *Backhousia myrtifolia* at Lake Allom

Similarly, dieback was identified on stands of hoop pine (*Araucaria cunninghamii*) and cinnamon myrtle (*B. myrtifolia*) and around Lake Allom (Fig. 18) and *Lophostemon confertus* (Brush Box) (Fig. 19) but again the causal agent hasn't yet been determined.

- Brush box near central station

- Eli Creek dieback

Figure 19 Paper barks (*Melaleuca quinquenervia*) line the banks of Eli Creek, a popular tourist destination. All trees are exhibiting some level of dieback with little evidence of recovery or seedling regeneration

Dieback of *M. quinquenervia* at the popular tourist destination of Eli Creek was also assessed and will be closely monitored over time. While likely not to be due to a pest or pathogen, the lack of evidence of regenerating seedlings to replace the species is of concern. It is a dominant tree species along the creek bank and plays an important role in bank stabilisation.

Conservation of species

Extensive fire damage prevented any opportunity to collect germplasm (seed) of myrtle rust affected Myrtaceae on K'gari. However, through additional National Heritage Grant funding, sampling and storage equipment have been purchased. BLSR completed a seed collection and storage training workshop run by Gavin Phillips from Australian PlantBank, Sydney Botanic Gardens. Target species for seed collection will be confined to species with woody seed due to ease of storage in comparison to those with fleshy fruits. Species to be targeted include *M. quinquenervia*, *L. liversidgei* and *S. hillii*. Ideally follow-up training focussed on species on K'gari would be conducted with a focus on how to select mature seed. Unfortunately, Covid19 border restrictions prevented this from taking place.

Capacity to maintain collections and run the associated nursery based at Eurong on K'gari is currently run through a volunteer program. Significant investment is required to ensure this nursery can produce seedlings for regeneration programs and species conservations programs on the island. The nursery could provide an ideal opportunity to "screen" for myrtle rust resistance. Under conditions of natural infection, seedlings with symptoms would be discarded.

Figure 20. Butchulla Rangers at a seed collection and storage training workshop in Coffs Harbour run by Gavin Phillips from Sydney Botanic Gardens.

6. Discussion and Conclusion

Myrtle rust

Myrtle rust, caused by the fungus *A. psidii*, has been identified from a range of species and sites on K'gari (Table 5, Figure 16). The disease has been detected on seedlings and reshoots as plants attempt to recovery from the effects of wildfire. However, impacts are not restricted to disturbed sites, with infection being identified on cinnamon myrtle (*B. myrtifolia*), in undisturbed environments. This species is dominant in the understory of wet sclerophyll forests found on K'gari. The incidence of infection on this species appeared to be at its highest during the final survey in November 2021. This may be the result of more favourable weather conditions for disease development following years of below average rainfall. However, it must also be considered that the fungus is still spreading and establishing within some of these environments with the full consequences of its presence yet to be determined.

The influence of fire

The influence of fire on disease development and the impact on different species in different ecosystems has only recently been studied (Fire and Rust | Australian Network for Plant Conservation (anpc.asn.au). In the absence of a disease like myrtle rust, native species in these fire affected areas will regenerate by producing either reshoots or seedlings or in some cases both. However, the presence of large numbers of susceptible hosts producing new growth provides ideal conditions for *A.*

psidii disease development and spread. In some cases, such as paperbark (*M. quinquenervia*), fire severity appears to influence disease severity and impact levels on reshooting trees. Data collated as part of these studies also identified higher levels of infection, both incidence and severity, on fire affected *B. myrtifolia* trees compared to trees in unburnt/undisturbed sites. In the case of *S. hillii* and *E. pilularis*, *A. psidii* had not been reported for either species on K'gari prior to these fire events. For both species, the fires resulted in mass seedling germination events, with myrtle rust causing infection of new shoots and leaves and subsequent dieback of seedlings. For *S. hillii*, new infections were still occurring on well established seedlings close to 2m in height almost 12 months post the fire event. To date the incidence of disease within the populations assessed remains low, with <20% of seedlings being impacted. However, this is the first record of myrtle rust on *S. hillii* (Satinay) outside of glasshouse studies and we recommend that continued monitoring is done to better understand the impacts.

A high incidence of *A. psidii* infection was identified from all populations of *M. quinquenervia* assessed on K'gari, with dieback of reshoots and seedlings recorded. The impact of myrtle rust on *M. quinquenervia* recovery (seedlings and reshoots) has previously been documented across fire affected sites in New South Wales and Queensland (Pegg *et al*. 2020a,b, Pegg *et al*. 2021). Repeated *A. psidii* infection causes dieback and death of reshoots and in some cases total tree death (Pegg *et al*. 2020a, Pegg *et al*. 2021). Seedling infection rates have varied across sites assessed but severe infection has resulted in distorted growth and deaths. While not assessed on K'gari, *A. psidii* infection has also been shown to prevent flowering. This is due both to the severe dieback or death of the tree as well as infection of the growing tips from which flower buds emerge. While there is evidence of resistance to *A. psidii* within populations of this plant species, the long-term consequences to this species and associated ecosystems are unknown, particularly in relation to changes in stand density and genetic diversity within remaining population.

Surveys of midyim berry (*A. dulcis*) on K'gari have generally found little or no evidence of impact. However, the most recent surveys in November 2021 coincided with flower and fruit development, particularly in fire affected areas, and identified significant levels of disease affecting the immature fruit of midyim. This included an area around Ocean Lake that was previously surveyed in 2018 when there was no evidence of myrtle rust found. Whether or not this was entirely because of fire and the masses of susceptible regeneration are unknown but worthy of further investigation. A more detailed assessment of fruiting across a range of sites, both disturbed and undisturbed, would be required to better understand this. This species is widespread across the island and is of cultural significance.

The results from this study and those in other fire affected regions suggest that managing fire intensity could help reduce *A. psidii* impacts on some species. However, understanding the benefits of implementing any management strategy requires a better understanding of the consequences of multiple disturbance factors on tree and forest health. Halofsky *et al*. (2020), when discussing changing fire patterns in the USA, highlighted interactions between fire and other disturbances, such as drought and insect outbreaks, as potentially primary drivers of ecosystem change. He *et al*. (2021), when studying the interaction between fire and sudden oak death (*Phytophthora ramorum*), stated that while individual forest disturbances are well studied, interactions between multiple disturbances and changes of spatial patterns of forested landscapes are rarely quantified. Findings from their study, when looking at different landscape patterns, suggested a significant role of wildfire in the re-emergence of this invasive pathogen. Interestingly, they concluded that wildfire together with sudden oak death had a long-term detrimental effect on forest recovery. Collectively, fire and disease

interactions appeared to slow forest recovery and reduce diversity of some metrics of landscape structure for at least eight years. However, different diseases are influenced by different factors and these outcomes don't necessarily provide an indication of what is occurring with *A. psidii* and fire and the influence of different fire intensities on different plant species and different ecosystems. Lombardo and Ayres (2011), when studying bark beetles and fires, concluded that post-fire disease or insect spread not only depends on the complex environmental factors, but also relies on the spatial patterns of host tree recovery. The density of susceptible Myrtaceae and the ecological role the individual species play is an aspect that needs further investigation in Australia. Our studies, both that reported here and in Pegg et al. 2020 (a & b) and Pegg et al. 2021, have captured the decline of species over a relatively short period of time but have not focussed on species level changes in affected environments. It must be also noted that myrtle rust has had a significant impact on a range of Myrtaceae in the absence of any disturbance event.

Cultural impacts

The impacts of myrtle rust from a cultural perspective are poorly understood. Significant effort by BLSR's have increased our knowledge of culturally important plant species on K'gari. This will allow for analysis of impacts from a different perspective and enable structured programs to focus future surveys, assessments, and conservation/management programs. Importantly, and as a potential management strategy, studies across the fire sites in Queensland and New South Wales indicated a possible link between fire intensity and myrtle rust impacts. In areas where fire didn't impact on the tree crown, disease levels were comparatively low suggesting that traditional cooler burning could help reduce myrtle rust impacts for this species. Designing studies to examine the influence of fire intensity on disease impact, with a focus on traditional burning practices would be of great value. Studying impacts of myrtle rust on shrubs species (e.g., *Melaleuca nodosa*, *A. dulcis*) compared to trees (*M. quinquenervia*) in cool/low intensity burning would provide valuable information to what has already been gathered.

Expanding capacity

Training programs have been developed to help expand the knowledge of forest pests and disease and the threat exotics like myrtle rust pose to native plant species and associated ecosystems. As a result of this project, a larger network has been formed and there is an improved knowledge of what it is we are trying to protect and how to structure training and subsequent on ground activities. Plans to expand the program further are underway. However, like all programs funding is a major issue and structuring a program that can become national is likely to be complex.

A general forest health survey system has now been established on K'gari and a baseline of information of the susceptibility of species to myrtle rust and other forest health issues mapped. These will provide a valuable guide for future BLSR forest health activities. However, the level of commitment to forest health and biosecurity activities is dependent on funding.

While training programs and joint forest health and myrtle rust surveys completed as part of this project have contributed greatly to knowledge gain on everyone's behalf, there is much to learn to understand the impacts that exotic pests might have on culturally important tree species and associated environments. Our tree species and associated ecosystems remain vulnerable to invasive pests and disease that, once established, are difficult to manage.

7. Recommendations

Myrtle rust

Longer term monitoring programs are needed to determine the impact of *A. psidii* on different species and in different ecosystems on K'gari. Understanding the interactions between disturbance events like fire and cyclones will add to our knowledge and ability to develop management strategies. The role of traditional burns in reducing disease impacts on different species and ecosystems needs further investigation. With there being reduced levels of epicormic reshooting and mass seedling regeneration with cooler burns, impacts on disease levels are potentially significantly reduced. However, this will not protect all species from myrtle rust with records of the decline of many species in undisturbed sites.

Facilities to collect and store seed of selected Myrtaceae on K'gari are now available. The wildfires and Covid restrictions have prevented any collecting from occurring. Further on country training on seed collection and storage would be of value. The existing nursery facilities at Eurong are limited and run on a volunteer basis. However, they could provide a useful resource for regeneration of species/sites and have a "natural" myrtle rust screening process implanted.

Training and expanding capacity

There is a need to build on the current training programs that have been developed through PBSF funded projects. The program needs expand and be aimed at improving the capacity of Indigenous Rangers, Natural Resource Management agencies (NRM) and other land managers across Australia to prepare for, detect and respond to plant pests and diseases threatening Australia's forests. Outcomes from such a program would include:

- Enhanced preparedness for incursion of exotic pests and pathogens and management options tools for existing threats to Indigenous culture
- A greater shared understanding of Indigenous perspectives on biosecurity threats and management
- Strong, collaborative networks between Indigenous groups, natural resource managers, land managers and government agencies

Additionally, benefits to Indigenous cultural heritage protection would be through:

- Enhanced capacity of Indigenous Rangers to identify and respond to threats to culture and Country
- Capacity for communities to independently manage the health of country will be enhanced
- Capturing the cultural values of plant species and ecosystems to assist in the development of pest and disease surveillance activities and management
- Capturing the cultural values of plant species and ecosystems to hand down to the next generation

    - Aboriginal cultural knowledge and values will be better understood and valued
    - Aboriginal connection to culture strengthened
- Capturing, where appropriate, the cultural values of plant species and ecosystems to better inform risk assessment under National Biosecurity Planning programs and to better inform the public
    - Frameworks and networks to incorporate Indigenous knowledge into environmental biosecurity preparedness plans
- Development of methods to capture diverse cultural values and assess potential impacts of exotic pests and pathogens, using myrtle rust as an example
- Development of ways to record and report on the health of forest ecosystems from a cultural and ecological perspective

A program focused on these outcomes is being developed in collaboration with the Australian Chief Environmental Biosecurity Office.

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