

Pandanus Preservation Project Noosa: Protecting an icon and coastal biodiversity with science, collaboration and action- Final Report



Funded and supported by: Noosa Biosphere Reserve Foundation

Supported by: Peregrine Beach Community Association Inc., local Bushcare Groups, and Noosa Council



**NOOSA
COUNCIL**

Joel Fostin

ECOSYSTEM MANAGEMENT AND BIOSECURITY SOLUTIONS June 2018

Contents

| | |
|---|----|
| Foreword | 2 |
| Introduction | 2 |
| Project Aims and objectives | 3 |
| Future Requirements to Restore Noosa Shire’s Pandanus Populations | 3 |
| Project Outcomes Summary | 4 |
| Inkind Support | 4 |
| Education and Collaboration..... | 4 |
| List of primary collaborators | 6 |
| Education and Collaboration..... | 7 |
| Council Staff Education and Collaboration..... | 8 |
| Research | 9 |
| Insects of interest initial and ongoing research | 11 |
| Pathogens | 18 |
| Documenting animals utilising Pandanus..... | 19 |
| Survey Summary | 20 |
| Summary of all works all sites..... | 21 |
| Entire site map | 21 |
| Pandanus Health Rating and Population Count | 21 |
| Southern Boundary to Peregian Beach Skate Park | 23 |
| Peregian Beach Skate Park to Marcus Creek..... | 26 |
| Marcus creek to Castaways Creek | 28 |
| Castaway Creek to Noosa Heads NP | 30 |
| Noosa Heads National Park..... | 32 |
| Noosa heads NP Day Use Area to Noosa River | 33 |
| Synopsis of leaf strip work performed at Noosa Main Beach | 34 |
| Noosa River to Teewah | 39 |
| Treatment and Prevention of Pandanus Dieback | 41 |
| Consistent Biannual Monitoring-Detailed Localised Pest and Predator Assessment..... | 41 |
| Leaf Strip Work | 42 |
| Why beneficial | 42 |
| Competitive shading of Pandanus | 43 |
| Weeds of Concern..... | 44 |
| Revegetation..... | 44 |
| Direct seeding | 44 |
| Natural Regeneration..... | 45 |
| Conclusion | 45 |
| Appendix..... | 47 |
| Photographic Survey Summary | 47 |

Foreword

This project funded by Noosa Biosphere Reserve Foundation is itself a reflection of Government and society collaborating for a sustainable and flourishing environment, and has personally revealed the depth of how many locals from diverse backgrounds love and cherish Noosa's natural environment and the amazing work spanning decades that so many have done to preserve and protect it.

The project has without a doubt been a resounding success with innumerable inkind hours of support provided by dozens of individuals assisting with logistical planning and promotion and with the hands on mitigation, revegetation, and regeneration work.

Many thanks and much respect to all the kind-hearted and environmentally conscious people who have supported, assisted and collaborated throughout the project.

It has been truly inspiring to see firsthand how many people care for our natural environment and willingly offer assistance for its preservation, and the power and what can be achieved through collaboration.

It is my intent and hope to continue on the work initiated through this project, with a focus on population restoration, further education, consistent monitoring, and early low resource preventative mitigation work.

Introduction

This report is the third and final report providing a summary of works performed under the NBRF funded project containing a summary of notable project outcomes, and future directions to preserve and restore Noosa Shires pandanus populations.

The first report produced was an interim report containing all relevant field observations, supporting information, survey methodology, and dieback mitigation justifications:

https://drive.google.com/open?id=1Z-59a4Rxy_I2OhXI-Y_Fz_5OH6ZUHqj5

The second interim report contains information of educational workshops and some of the dieback mitigation work performed:

https://drive.google.com/open?id=1GEWx4dAe1eC_TcSI1XCwa86AuY9XpxIn

A photographic summary of entire site findings can be found in the appendix section of this report

Project Aims and objectives

The purpose of the project is to manage and prevent existing and emerging cases of Pandanus dieback primarily cases by infestations of the Pandanus Leaf hopper (*Jamella australiae*), occurring within the Noosa Shire and adjacent land tenures (Noosa National Parks), by performing a strategic undertaking to treat infested trees, using established biological control measures, and dieback mitigation work (eg. parasitoid wasp translocations, leaf stripping, and if/as required isolated strategic chemical control).

Additional to performing the immediate dieback mitigation work required, long term preservation objectives remain a key focus, namely; to assist natural regeneration and to perform revegetation works at severely affected dieback sites. Stakeholder and community education is a fundamental aspect of the project for positive long-term preservation outcomes.

Many strong collaborative relationships have been previously established, and new relationships have developed, which has increased Pandanus dieback awareness and preservation objectives, both locally and across eastern Australia, as well as to contribute both short and long term to upholding Noosa Biosphere's environmental objectives.

Collaborating with local Bushcare groups has enabled community education and involvement for Pandanus population restoration and other pressing NRM issues.

Research performed and ecological findings contribute greatly to long term pandanus preservation locally and interstate with findings being contributed to Government online data base resources, and a Pandanus dieback education page.

Future Requirements to Restore Noosa Shire's Pandanus Populations

The collaborative works performed during the duration of this project has been exceptionally successful and has been a great start for the ongoing works required. The primary future works required are:

- Twice yearly monitoring of the entire coastal strip (public areas) to identify emerging cases of dieback and perform wasp translocations and small-scale cost saving preventative mitigation work.
- Follow up monitoring and works required at pre-existing dieback sites.
- Further Community engagement to empower residents with knowledge on how to manage their Pandanus, as well as to provide more hands for revegetation and regeneration works required.
- Pandanus population restoration work. Rearing plants for revegetation, and direct seeding regeneration work throughout many kms of degenerated coastal foreshores. *A personal goal to mitigate all existing or emerging cases of dieback, and boost Noosa Shires pandanus population by 2000 plants by June 2019 can be achieved with further support and collaboration.
- Recognising a need for sharing the important information relative to Noosa Shires an educational video was drafted with the self-funded aid form an amateur videographer yet was of inadequate quality for release. If funding and collaboration with a professional video production company is secured educational videos can be produced to share the essential information both locally and across all threatened areas of Coastal eastern Australia.

It is hoped that the NBRF again provides financial support to enable project leadership for the works outlined above. Works that will preserve and enhance the biodiversity and resilience across the entire shires Coastal strip long into the future.

Project Outcomes Summary

The earlier two reports contain information on survey outcomes and educational and collaboration outcomes. This report provides a summary of earlier outcomes, and relevant details of recent project outcomes as well as future direction.

Short Summary

Dieback intervention (leaf strip work): Over 100 Pandanus in Noosa Shire tenure received hands on dieback mitigation, and similar numbers in Noosa NP (in collaboration with QPWS staff).

Dieback prevention: Many dozens of wasp releases were performed during the project has certainly prevented leafhopper population increases and the onset of dieback.

Regeneration/ revegetation: 32 plants were planted during the project and over 1500 seeds direct seeded along parts of Noosa shires natural areas. QPWS staff have also directed seeded over 1000 seeds across Noosa NP with ongoing direct seeding planned.

Education/ Training: Hundreds of stakeholders and community members have learnt insights into the dieback process and management strategies, including the plight of Pandanus and restoration methods for natural areas.

Research: Many ecological observations have been documented and provided in reports and to multiple organisations and online sources. Notable findings include the discovery and documentation of unnamed insects and interactions, as well as host dependent species.

Baseline drone imagery and data collection has been collected which will contribute to future management considerations and justifications.

In kind Support

It is impossible to calculate the precise financial value of the in kind support provided during the duration of this project. Personal in kind contributions exceed 160 hours. Certainly, the last estimation provided to NBRF of \$70, 000 in kind contributions from other organisations is well below the actual amount of support the project has stimulated.

Over half a dozen QPWS staff have spent many weeks' worth of work within Noosa National Park at Noosa Heads and Peregrine section.

Noosa Council staff from Parks and Gardens and Natural Areas have collectively spent over a hundred hours at information sessions and while assisting with mitigation works. And providing contract arborists for important leaf strip works at Noosa Main beach and around Peregrine beach township.

Dozens of members from local Bushcare Groups have spent many hours assisting with project aspects, logistics and infield works.

University professors and research specialists from multiple government and non-government organisations have assisted with research and insect identification.

Education and Collaboration

Thanks to the funding provided through the NBRF, educational and training offers were met with open arms by the many collaborators. Outcomes that would have encountered logistical blocks if this effectively free service was not available.

Many “unofficial” training and education communications occurred throughout the project. Below is a tabled list of official training and education sessions.

| Education Work Shop and Field Work location and dates | | | |
|--|---|--|---|
| Date and Time | Location | Supporting Organisation | Event |
| Thursday 12th April 7:30-11:30 | Noosa Spit | Noosa Bush Beach and Creek Care | Weeding morning and pandanus dieback education session |
| Tuesday 17th April 2:00 pm – 3:00 pm | Noosa Council works depo Bartlet Street | Noosa Council Parks and Gardens Staff | PowerPoint slide education for Noosa Council Parks and Gardens Staff highlighting what, and where works are necessary |
| Friday 20th April 8:00am-12:00 pm | Noosa District Landcare Nursery Pomona | Noosa & District Landcare | PowerPoint slide education for Noosa District Landcare Conservation Trainees Staff highlighting what, and where works are necessary |
| Monday 7th May From 10:00am Q's & A's from 11:00am-2pm | Apex Park Gympie Terrace (opposite Robert Street) Noosaville | Heritage Park Bushcare Group | Heritage Park Bushcare Group Community Education Day |
| Saturday 12th May 8:00am to 10:00 | Beach Access 47, Tristania Drive Carpark, Marcus Beach | Marcus Beach Bushcare Association Inc. | *Weeding and Pandanus dieback and coastal vegetation education morning |
| Monday 15th May 7:00-4:00 | Noosa District Landcare-Noosa North Shore | Noosa & District Landcare | Onsite (Noosa North Shore) education, planting, and direct seeding with conservation team |
| Tuesday 15th, Wed 16th, Thurs 17th. 6:00am-3:00 pm | Noosa Main Beach and Peregrine Beach Township | Noosa Council, Northern Tree surgery | Dieback education and mitigation work with Council staff and Council contracted arborists (Northern Tree Surgery) |
| Wednesday 15th 10:00 am | Noosa Main Beach | Noosa Council Natural Areas | Met and discussed Shires natural Areas needs and future revegetation plans |
| Friday 18th May 10:00am to 12:15pm | Environment Centre 5 Wallace Drive, Noosaville | Noosa Parks Association Inc. | Friday Environment Forum PowerPoint slide demonstration |
| Thursday 24th May 8:00 am to 10:00 am | Peregrine Beach BA 65-66 | Peregrine Beach Community Association Inc. | *Weeding and Pandanus dieback and coastal vegetation education morning |
| 12th June 9:00-11:00 | Peregrine Beach BA 65-66 | Noosa Council Natural Areas | Toolbox workshop and mitigation work with Noosa Natural Areas Staff |
| Thursday 21st June 5:00pm to 7:00pm | Rural Futures Centre, 65 Pavilion Street, Pomona | Noosa District Landcare | THREATENED PLANT SPECIES, PANDANUS DIEBACK & COASTAL ECOLOGY with Liam Scanlan, Owen Snowden & Joel Fostin |

List of primary collaborators

Peregrine Beach Community Association Inc; The project would not have occurred without the support and collaboration with the PBCA and its passionate members. Rochelle and Ron Gooch have been exceptionally supportive, as have various other professionally and passionately driven members (Susan Francis and Barry Cotteral).

Noosa Council; The opportunity to share information and collaborate with Council management and staff from Parks and Gardens and Natural Areas has been invaluable. Staff were very supportive and appreciative for the information shared and infield mitigation leadership the project enabled. Follow up mitigation and revegetation work is required with plans unfolding. The interest and support from Parks and Gardens Dorene Di Bartolomeo, and Natural Areas Michael Lyons was fundamental to enabling collaboration with Noosa Council.

Kabi Kabi Conservation groups; Unfortunately, plans did not come to fruition during this project. Collaboration for future projects is keenly anticipated.

USC (University of the Sunshine Coast); USC professors Javier Leon, Gabriel Conroy and USC/DAFF research fellow Helen Nahrung have been exceptionally supportive. Many other Professors Laboratory staff and students have been supportive in small and large ways.

QPWS; As primary stakeholder of Noosa National Park (containing the most concentrated Pandanus population in the Noosa Shire) collaboration began in November 2017 and involved knowledge sharing, and joint involvement in performing mitigation works. Three highly detailed reports were produced (Health Assessment, IPM plan, and Final Report) and are available on request. Over 120 labour hours were funded by QPWS, with multiple staff learning and assisting during mitigation work and monitoring. Staff are autonomously growing seedlings and performing direct seeding throughout the National park. Senior Rangers Omar Bakhack, Nat Smith and acting RIC John McQueeney have been exceptionally supportive and proactive for mitigation and population enhancement work. Field rangers (Dave, Phil, Kristian and Matt) were enthusiastic, hardworking and have showed great personal initiative.

Various Bushcare groups across the shire; knowledge sharing, regen and reveg work and Pandanus education workshops have been conducted or planned with the following organisations:

Heritage Park Bushcare; performing a workshop and collaborating with Joan Heavey and passionate members NICA members was an unexpected bonus

Noosa Bush Beach and Creek Care; A weeding day was attended where Pandanus information was shared on the 12th April. Jill and Justin Cambell have been exceptionally supportive as with all members whom attended.

Marcus Beach Bushcare; Following an education session at Marcus Beach over 350 pandanus seeds were direct seeded in frontal dunes. Judy Tullock was exceptionally supportive and proactive organising and advertising an education morning.

Noosa Parks Association; Members from Noosa Parks Association have been long term supporters. Following from a "Friday Forum" delivery in early 2017, a Friday Forum was hosted on the 18th May to share local and wide-ranging Pandanus dieback information.

Noosa and District Landcare; Two education workshops have been organised, a community education evening June 21st and an education workshop on the 20th April for conservation and land management trainees. The staff are very proactive and supportive and potted pandanus will be

purchased to the value of the education workshops. Noosa District Landcare have recently performed revegetation work at Noosa North Shore Beach Camp Ground, and collaboratively an additional 32 potted Pandanus and direct seeding of 810 seeds were dispersed adjacent to regen sites utilising the assistance of supervisors and 7 conservation management trainees.

CSRIO; Entomologist and weevil expert Dr Rolf Obepreiler has provided in-kind support and collaboration, and identification and information regarding the crown boring weevils contributing to plant decline. He has provided valuable identification and information on the 3 little known weevils occurring on Pandanus within the Shire and others across SEQ. He has been very appreciative of samples sent and is quite eager to formally describe the undescribed *Diathetes* sp.

Queensland Museum (QM); As an honorary research fellow at the QM, with primary contact Dr Chris Burwell (Curator of Entomology) much in-kind support has been received and is available for performing research into insects contributing to Pandanus dieback. Dr Chris's expert guidance and assistance, access to the facility, equipment, and archives contribute to the project greatly, as well as pandanus protection objectives across eastern Australia.

DAF (Grow Help-mycology laboratory) The expert analysis of DAF laboratory staff regarding dieback and associated/contributing fungal and viral pathogens has been irreplaceable and been provided at a discounted rate or inkind. Various fungal pathogens and insects have identified to Genus or species level. Andrew Manners and former staff member Tony Cooke have been crucial supporters

Education and Collaboration



The education and training performed provided baseline Pandanus dieback and assessment skills, crucial to long-term knowledge-based monitoring programs. Four Bushcare groups were involved, Noosa District Landcare, QPWS and Noosa Council departments. Information covered included an overview of:

- Pandanus dieback background information
- Identification of *Jamella australiae* outbreaks and relative infestation levels.
- *Aphanomerus nr. pusillus* populations assessment and egg raft translocation techniques.
- Leaf stripping techniques and justifications.

- Identification of and recommendations to manage other factors contributing to Pandanus dieback (secondary insects, fire damage, climate, etc).
- Regeneration and revegetation methods
- Weed control methods and caution required with herbicides

Council Staff Education and Collaboration



A threatened young cluster population of 40+ plants were leaf stripped at Peregian Beach with during a toolbox workshop with Noosa Council Natural Areas staff. A fruitful combination of education and dieback mitigation. Natural areas staff welcomed the information and expressed a keen desire for further involvement and have already supported future regeneration works by enlisting Noosa and District Landcare to raise Pandanus seedlings for use by Bushcare groups and others at key locations.



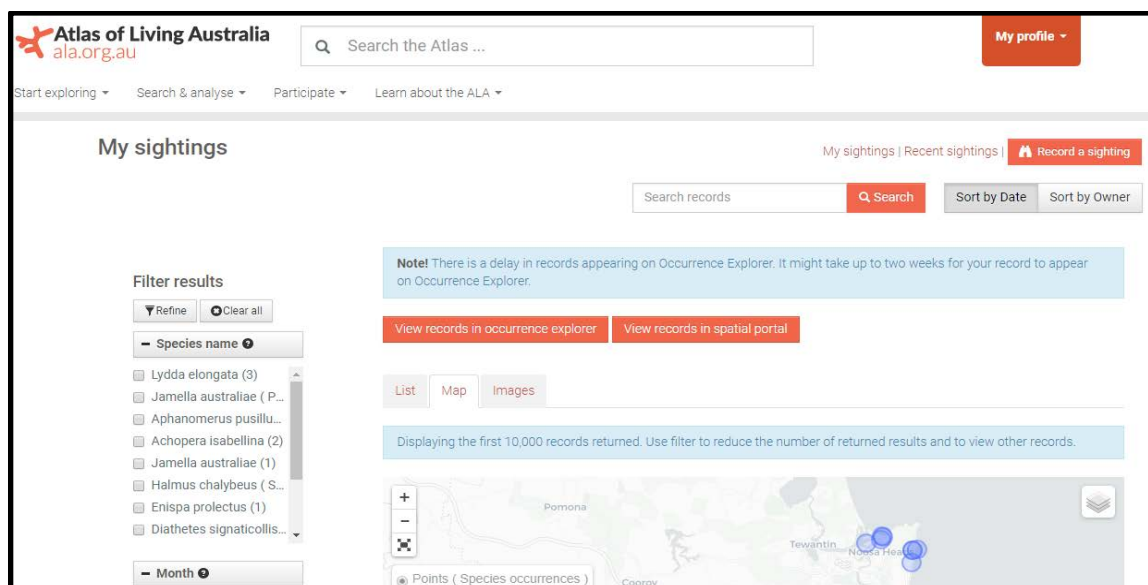
Noosa Council Parks and Gardens staff and Council preferred contract arborists collaborated to perform leaf strip works at Noosa Main beach and Peregian beach township. The skills and knowledge learnt will greatly aid any future mitigation work required.

Research

Drone footage was collected with Dr Javier Leon at 5 dieback locations in Noosa National Park 17th January. A Special Research Project (SRP) was orchestrated and initiated yet was postponed due to high demands on my time to fulfil other high priority project aspects. The data was processed and examined and will serve as great baseline data for future comparative analysis.



Samples being sorted prior to mailing. Collecting, documenting, forwarding specimens to, and communicating with many different experts and researchers from multiple organisations requires much time and diligence. Contributing never before documented insects and/or ecological/behavioural information is both personally rewarding, and an important contribution to science, and provides Pandanus dieback management insights. A strong long-ranging contribution enabled through the support from NBRF.



Screenshot of some of the insects personally uploaded to the Atlas of Living Australia (ALA) to date. Having insects identified by experts and uploading to free to access online sources will help to fill in the many blanks surrounding the many insects of interest, and/or contributing to Pandanus dieback. Dozens of insects are yet to be added, when time permits. As insect species names are confirmed from data collected during the project, they will progressively be uploaded to online sources.



A close up of montage image of the parasitoid wasp (female) which is essential for control of the Pandanus leafhopper. It has not officially been named.

It has been referred to as *Aphanomerus nr. pusillus*. The “nr.” stands for near, indicating it is morphological similar to *Aphanomerus pusillus*. Samples collected locally during the project were sent to a researcher in OHIO, USA with a research focus on phylogenetics, stating “although we are also interested in describing new species. The wasps that you provide us with will have their DNA extracted and genome sequenced so that we can determine what it is most closely related to. We still don’t have a good understanding of platygastroid relationships, even though the first member of this superfamily was described over 200 years ago!”

This new collaborator may just help provide scientific evidence to help confirm the name of this poorly researched yet highly important micro wasp, which is perhaps the most important yet little known biological control success story to occur in Eastern Australia in recent decades.



Left; Two female parasitoid wasps parasitising a fresh egg raft pictured centre. With high wasp numbers parasitism levels will prevent the hatching of 80-95% of leaf hopper nymphs over the coming few months. **Right;** the larvae of the wasps devour the developing leaf hoppers, pupate then chew an exit hole and emerge as adults from the egg raft. The first instinct of female wasps is to go to the nearest freshly laid egg raft and deposit her eggs one by one in each of the 50-80 eggs and the cycle continues.



The yet to be named species of weevil in the genus *Diathetes*. Only previously known from specimens collected from Stradbroke Island and Indooroopilly in 2006. Multiple Specimens of this elusive weevil species were collected from Noosa National Park and activity and cocoons collected from the northern end of Sunshine Beach (see map pictured above). It occurs nowhere else in the Noosa Shire. Specimens were sent to DAFF Grow Help, weevil expert Dr Rolf Oberprieler (CSRIO) and will be personally taken to the Queensland Museum.

The feeding behaviour of this un-named weevil can be quite aggressive and damaging to the central crown, particularly of stressed Pandanus. Yet it may well be a rare and endangered species, and management work in Noosa National Park has been performed cautiously.



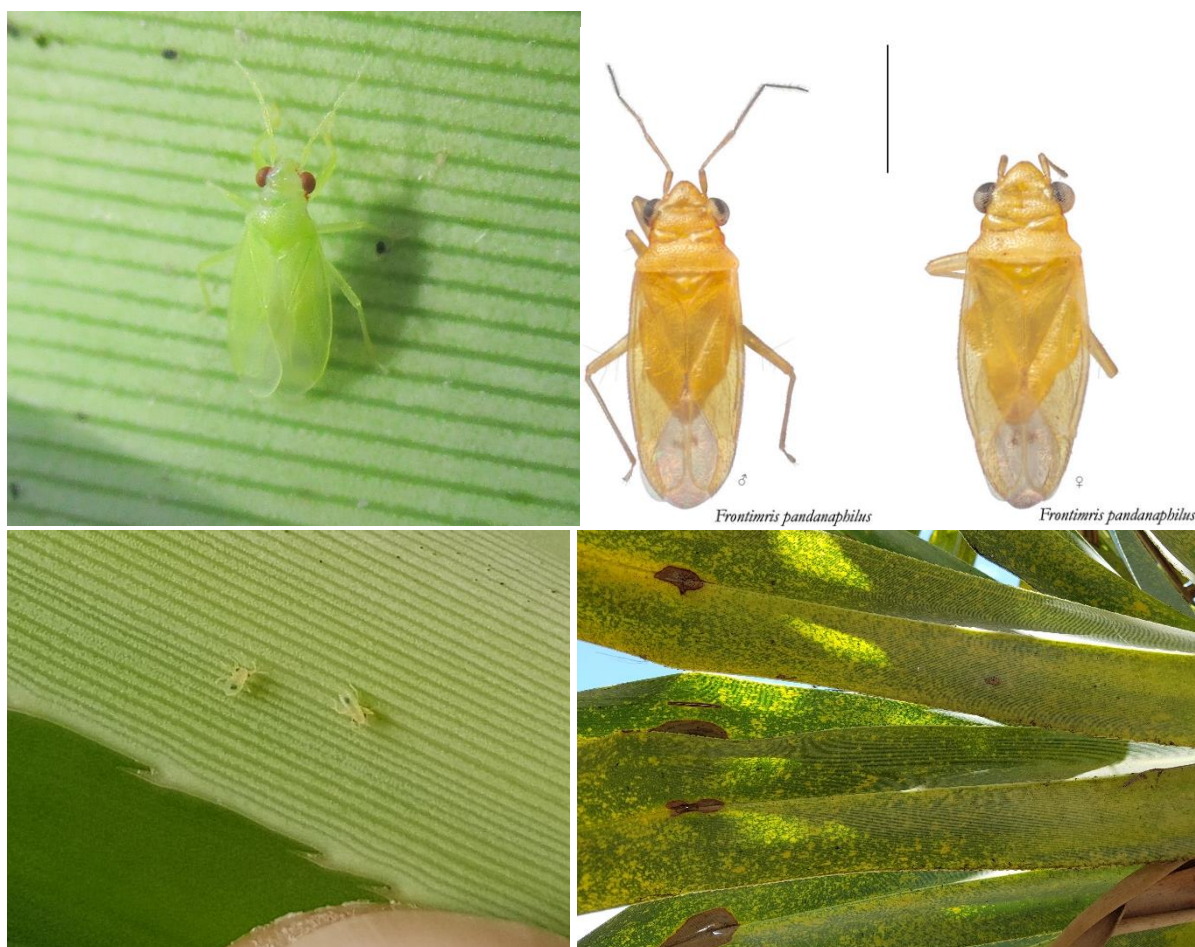
Figure 71. A male Pandanus flower with the naturally occurring *Diathetes morio* whose lifecycle is closely affiliated with male flowering. *Diathetes morio* was observed throughout the entire Shire and SEQ and beyond, only causing harm to the crowns of Pandanus which are in a state of stress.



*The commonly occurring weevil borer **Diathetes morio** (upper left) and damage to the crowns (upper right) usually on male Pandanus, yet also damaging the central growing point of female Pandanus. When **Diathetes morio** populations are elevated due to high numbers of stressed plants, plant reproduction is affected as they destroy male flowers prior to emergence (bottom left) and premature developing female fruits (bottom right).*

Diathetes morio is common in all Pandanus populations personally observed, almost the entire coast between the Town of 1770 south to the Gold Coast. It has been officially recorded across much of the southern pacific and appears to be entirely host specific on Pandanus spp. They have a close affiliation with the seasonal timing of male Pandanus flowers, aggregating on the strongly aromatic male flowers (likely as the cue for copulation). A single larvae feed on the terminal senescing flower, slightly boring into the starchy central apex, and feeding and tearing strips from the centre few leaves which it rolls into a cocoon and pupates from. Likely to have only one annual lifecycle, perhaps at times two in dieback areas. In areas undergoing prolonged and/or widespread dieback they also feed and pupate on stressed crowns, boring into the central starchy tissue, thus greatly exacerbating crown rot and subsequent plant mortality. Population abundance at a given cove or small stretch of open beach varies markedly from location to location.

The damage caused to an individual crown or leaf facilitates the feeding and a small scale localised population of *J. australiae*. When the central crown is attacked and damaged, a new central apex can be produced if the plant has adequate energy reserves.



Figures Upper left; adult photographed at Noosa of a likely undescribed *Frontimiris* sp. **Upper right;** newly described species from Western Australia *Frontimiris pandanaphilus*. **Lower left;** nymphs of the small insect pictured above (nymphs-1mm and adult-2mm). **Lower right;** Leaf yellowing symptoms of this unidentified sap sucking bug in the MIRIDAE family.

DAFF entomologists were not able to identify stating; “probably in the sub-family Phylinae or Deraeocorinae”-“entomologists present here may not have been able to identify it as they are not familiar with this family of insects.” Queensland Museum curator of entomology Dr Chris Burwell was not familiar with this insect either, which is likely an undescribed “true bug” host specific to Pandanus (personally observed in Noosa and across SEQ).

Researchers in Northern Australia have recently described *Frontimiris Carvalho* from Australia for the first time and named 3 new *Frontimiris* species including *Frontimiris pandanaphilus* pictured above. Personal observations and research into the morphological similarities and host specificity of the specimens personally photographed, and the newly described species strongly suggest they share the same genus. The long geographical distance between Western and Eastern Australia would almost certainly suggest a separate species level classification. Communication with experts continue, and hopefully soon to result in identifying this overlooked insect and likely the naming of a new species.



Figures Hundreds of a plant hopper near Noosa groin were observed, not observed elsewhere in the Shires natural areas, nor throughout SEQ. A possible garden escapee likely originating from northern Australia where all documented records appear to be... Only observed elsewhere in urban Pandanus near Agnes Water and one nearby coastal location. Derbidae family, genus *Lydda*, species very likely *elongata*.. Research continues into origins and natural distribution (No ALA records in SEQ).



Upper Left; An adult weevil borer *Achopera isabellina*. **Upper Right;** the damage caused to a live prop root. **Lower;** Larvae collected from root. Despite few documented records of this insect, adults commonly observed across SEQ feeding in stressed crowns, roots and branches of *Pandanus*.



Adult forms of two very commonly seen fly (species of the Order Diptera) whose larvae appear to feed in and on necrotic tissue in dieback affected crowns (leaf heads) of *J. australiae* infested *Pandanus*. The 'skinny wasted hover fly' on the left is a 15mm long-yet to determined genus and species in the Syphidae family. It may be predatory.. The 2mm fly belongs to the Drosophilidae family. Queensland museums Diptera specialist examined photographs of both species and stated the difficulty in identifying these barely documented insects even to genus level.



*The adult moth of the root boring larvae pictured above. Collected from the Gold Coast, captive reared and sent to DAFF and CSIRO Lepidoptera experts for positive ID. Feedback suggests it may not be identified to species level as the genus is poorly described, understood and not previously recorded on Pandanus. Identified so far as “Probably *Erechthias deloneura*”..*



Left and right: the larvae of the root boring moth occurring in large numbers destroying prop roots and greatly reducing plant health which in turn favours Leaf hopper and other secondary insect proliferation. They also feed on Pandanus crowns and upper branches as pictured right.

Pathogens

Many samples of suspected fungal/viral/phytoplasma pathogens from across SEQ have been personally sent to mycologists at DAFF Growhelp laboratories. Although this department is primarily focussed on agricultural pests and diseases, the support from expert staff has helped to create a more complete picture of the role certain pathogens play in the dieback process.

Two fungal species have been linked to the crown rot process; *Fusarium sp.*, *Marasmiellus sp.*

A *Colletotrichum sp.* was found active on samples with rust like leaf spotting. An entomopathogenic fungi (*Beauveria sp.*) was confirmed from samples at Noosa National Park which had interestingly controlled both leafhopper adults and nymphs, and the undescribed crown weevil borer *Diathetes sp.*

A phytoplasma has been identified in Teewah township by a researcher affiliated with DAFF Grow Help. The effect of this pathogen on Pandanus is unknown.



A snapshot of the various pathogen symptoms observed on Pandanus. Certain pathogens play a major role in dieback

A suspected entomopathogenic (insect killing) fungi occurring on one specimen of the undescribed *Diathetes sp.* which was also covering tens of deceased adult *J. australiae* was sent to DAFF Grow Help. DAFF specialists confirmed the presence of an entomopathogenic fungi species (*Beauveria sp.*) which has great implications, influencing dieback management decisions for the National Park (and surrounding dieback areas), and for future Pandanus dieback management and treatment options. One species of *Beauveria*- *B. bassiana* is already commercially available for control of a broad range of arthropods, sold as BotaniGard® ES and is being reviewed for approval in Australia by the APVMA.

Documenting animals utilising Pandanus



During leaf strip works an impressive number of animal species were encountered in the urbanised areas. With more accessible crowns various bird species immediately started feeding on leaf hopper adults and nymphs, and still continue to feed, which will contribute to leaf hopper control.



Various species of animals regularly utilise the unique habitat that Pandanus provide in coastal areas. Native rodents, possums, native and Asian geckos, carpet pythons, and multiple bird species including raptors are commonly observed in or on Pandanus. Raising awareness of the many living organisms that directly rely on Pandanus supports the importance of Pandanus population restoration work.

Survey Summary

Urban areas

The extensive use of Pandanus as landscape specimens throughout the urban areas of the Shire has favourably influenced the persistence of the primary bio control agent the parasitoid wasp *Aphanomerus nr. pusillus* (a safety in numbers principle). This for the most has prevented large scale leafhopper (*Jamella australiae*) population peaks and subsequent Pandanus dieback in suburban areas.

However, a thorough examination of leaf hopper egg rafts across the shires Coastal foredune strip revealed that in some cases localised extirpation of the parasitoid wasp *A. nr. pusillus* has resulted in heavy infestations of *J. australiae*, which has caused current cases of Pandanus die back, and in previous years.

Coastal Natural Areas

In summary most older original Pandanus communities across the Shires coastal foredune areas (excluding Noosa NP) are decimated/ reduced/ compromised. Older plants often have lost multiple limbs and the resulting stress greatly reduces the reproductive capability, subsequent viable seed production and natural germination rates.

Most of the alive and healthy plants have been planted by Bushcare groups. The majority of these planted Pandanus are mostly found along and adjacent to Beach Access tracks and have not reached re-productively maturity (under 15-20 years of age).

The work of local Bushcare groups and others spanning decades, controlling weeds and planting Pandanus and other coastal floral species is not to be undervalued, with many areas containing Pandanus only due to their environmental care and hard work.

A stroll through many of the Shires Beach Access tracks, displaying aesthetically pleasing-high floral diversity and weeds partially controlled, is a mis-representation of the actual state of the Shires Coastal ecosystems. Stepping into the untouched areas away from Beach Access tracks show the actually state of affairs...

Invasive Introduced Weeds such as Broad leaf pepper, Basket asparagus fern, Gloriosa Lilly, Siratro, Singapore Daisy and multiple invasive grass species (to name a few) have caused drastic changes to ecosystem function and assemblage, and the abundance of native plant species, including Pandanus.

Pandanus Leafhopper induced dieback (reducing natural reproductive capability), coupled with competition with weeds has notably reduced natural germination rates, with low and unsustainable juvenile counts a common theme across the Shire.

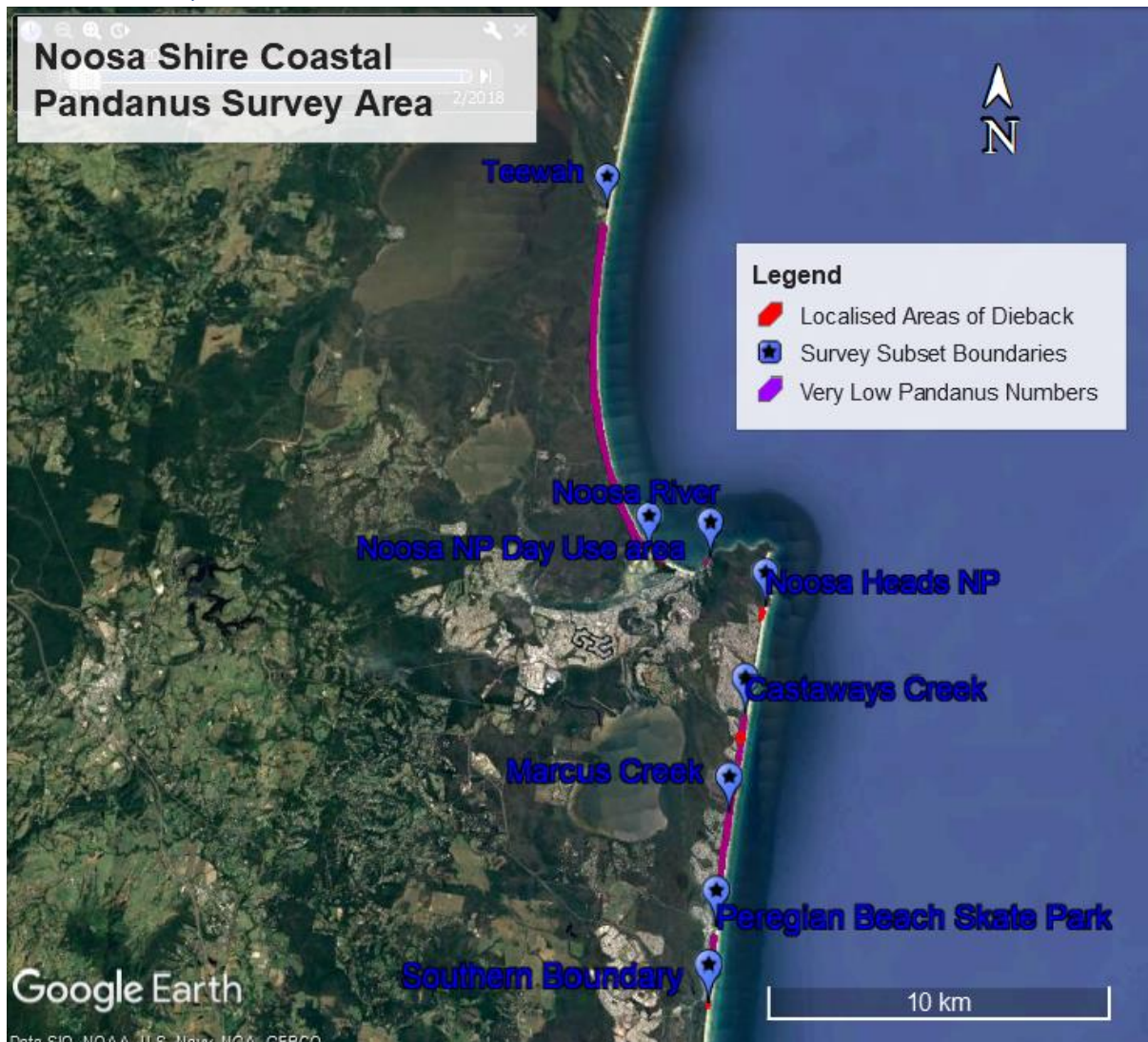
High fuel load weed grass species has increased the fire intensity in parts of Noosa North Shore, and isolated areas south of Noosa National Park, and subsequently increased mortality rates of Pandanus and other native plants.

The population growth and spread of existing and newly emerging weed species exceeds the amount that is currently being controlled.

For the sustainability of Pandanus and our precious Coastal Ecosystems, it is abundantly clear that more directed hands are needed to repair/protect/maintain these extraordinary yet threatened ecosystems...

Summary of all works all sites

Entire site map



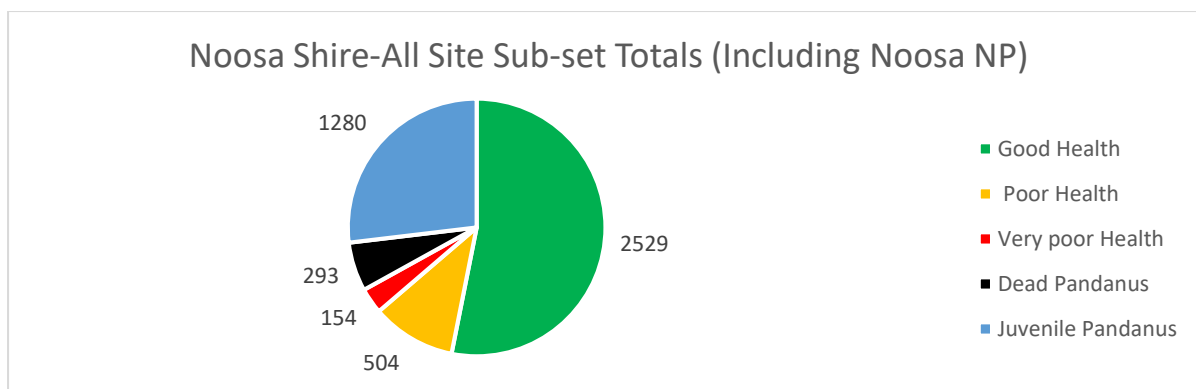
Map of the entire survey area with subset boundaries from the Southern boundary at Peregrine Beach north to Teewah. Red polygons encompass areas of recent dieback, purple polygons encompass areas of foredune with very low pandanus dieback where small scale dieback has continued to reduce Pandanus populations.

Pandanus Health Rating and Population Count

Piecharts of count data visually illustrate trends that reveal the health status of each subset.

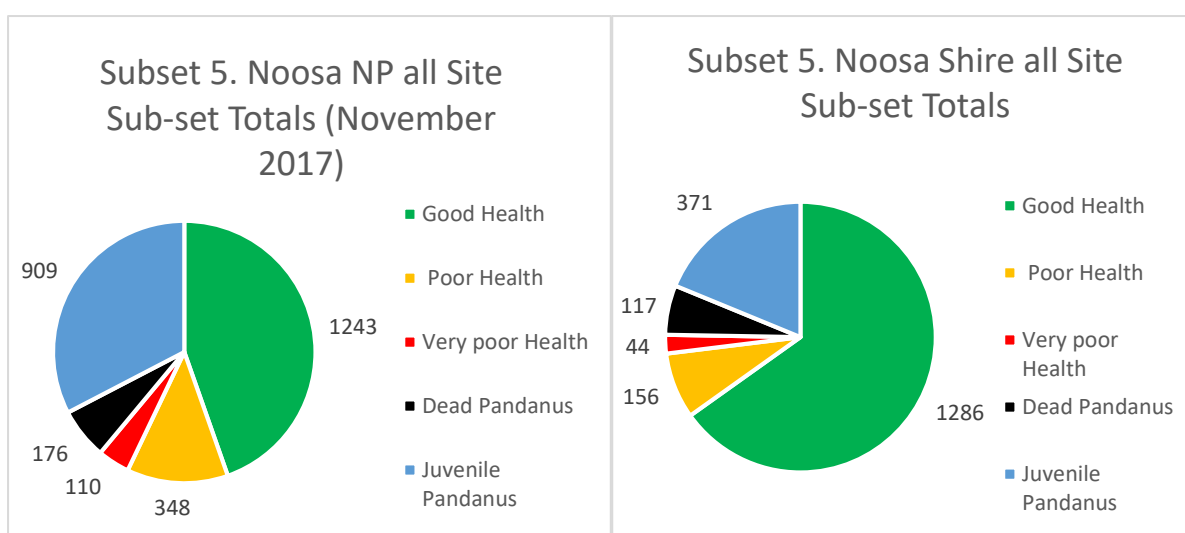
Juvenile plant (under 1m tall) counts are well below what should be found in a healthy population. Ideally juvenile counts should be roughly equal to mature plant counts. Many kms of coastline would benefit greatly from regeneration and revegetation works.

Counts of Poor, Very Poor and Dead plants are well higher than expected and observed in healthy comparable coastal areas of SEQ.



*Pie charts of Pandanus population count and health rating all site subsets inclusive of Noosa National Park from Noosa Shires Southern boundary to Teewah in the north. *Plant counts in all categories may be up to 5-20% higher than those recorded.*

Noosa National Park accounts for over half of the Pandanus found within Noosa Shires Southern and Northern boundary's.



Pie charts of Pandanus population count and health rating of all site subsets In Noosa Heads National Park (NP) November 2017 and all site subsets with Noosa Shire tenure.

Throughout Noosa Shire the majority of plants counted have been planted (plants in Good health and the juvenile plants). Throughout Noosa NP most plants are naturally occurring.

Pie charts of Pandanus population count and health rating all site subsets In Noosa Shire tenure were produced from surveys in March 2018. Survey efforts were focussed along the entire coastal strip approximately 50-150 metres from the high tide mark. Pandanus in the urban interchange of the coastal strip and parks and gardens were not counted.

Southern Boundary to Peregian Beach Skate Park

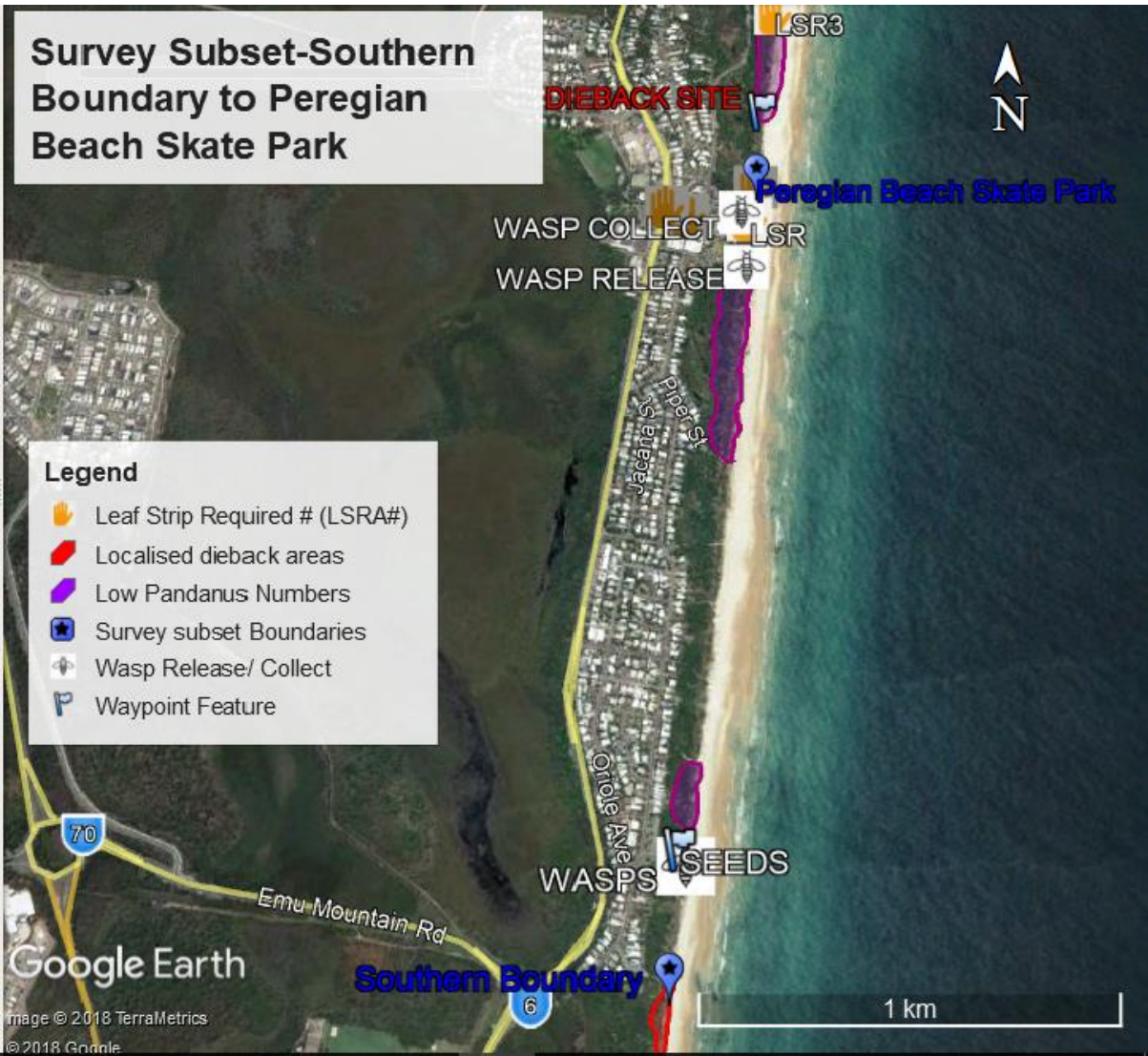
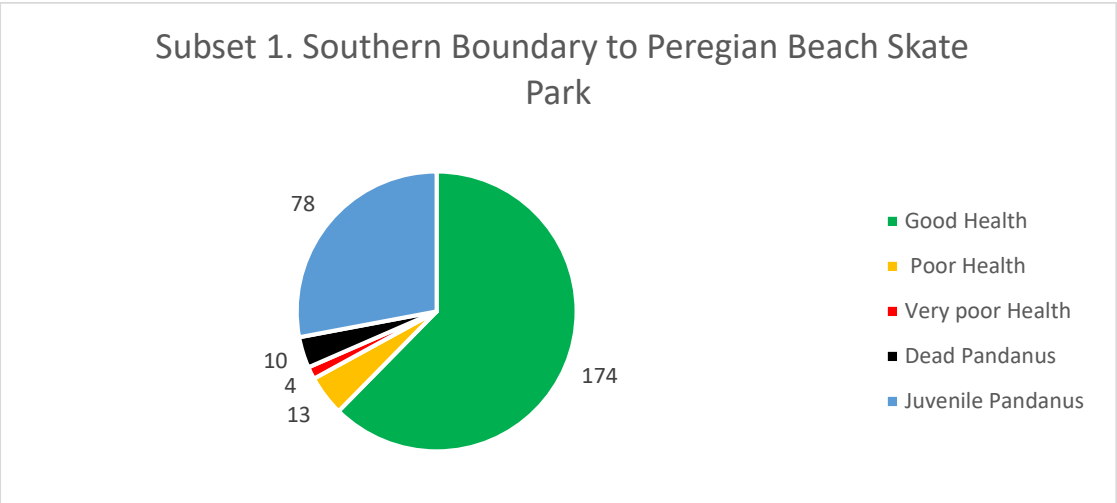


Figure 6. Survey Subset- southern Boundary to Peregian Beach Skatepark with polygons and waypoint markers of significant survey findings and works performed or required. The purple polygons highlight the primary areas that future population restoration work should be targeted.

Subset Findings



Survey Summary

Persistent Leaf Hopper infestations on mature compromised plants were observed throughout the subset.

Multiple wasp releases were performed throughout project duration.

Low numbers of reproductively mature plants were observed, most of these were compromised from previous dieback events.

Low natural germination has occurred, with most of the juvenile plants and reproductively immature plants observed having been planted within the last 15-20 years.

Very low Pandanus numbers occur particularly between Beach Access (BA) tracks 64-65 and 59-60.

South of Peregrine Beach township most infestation levels are low.

Moderate to heavy infestations on 6-8 plants throughout Peregrine Beach township require leaf strip intervention (mitigation plans have been made with Council Parks and Gardens Staff).

Some isolated plants in the rear dunes display damage and decline due to fire damage (approximately 10+ years B.P.).

Summary of works

A community workshop was held at Victory Park Peregrine Beach hosted by PBCA. Direct seeding of over 400 seeds was performed with volunteers between BA 64 & 65.

A hands on education session was held at Victory Park with Council Natural Areas staff where over 40 young infested Pandanus were leaf stripped.

Leaf strip work on Pandanus around Peregrine township and adjacent natural areas (10+ plants).

Multiple wasp releases around Peregrine Township and 2 in natural areas.

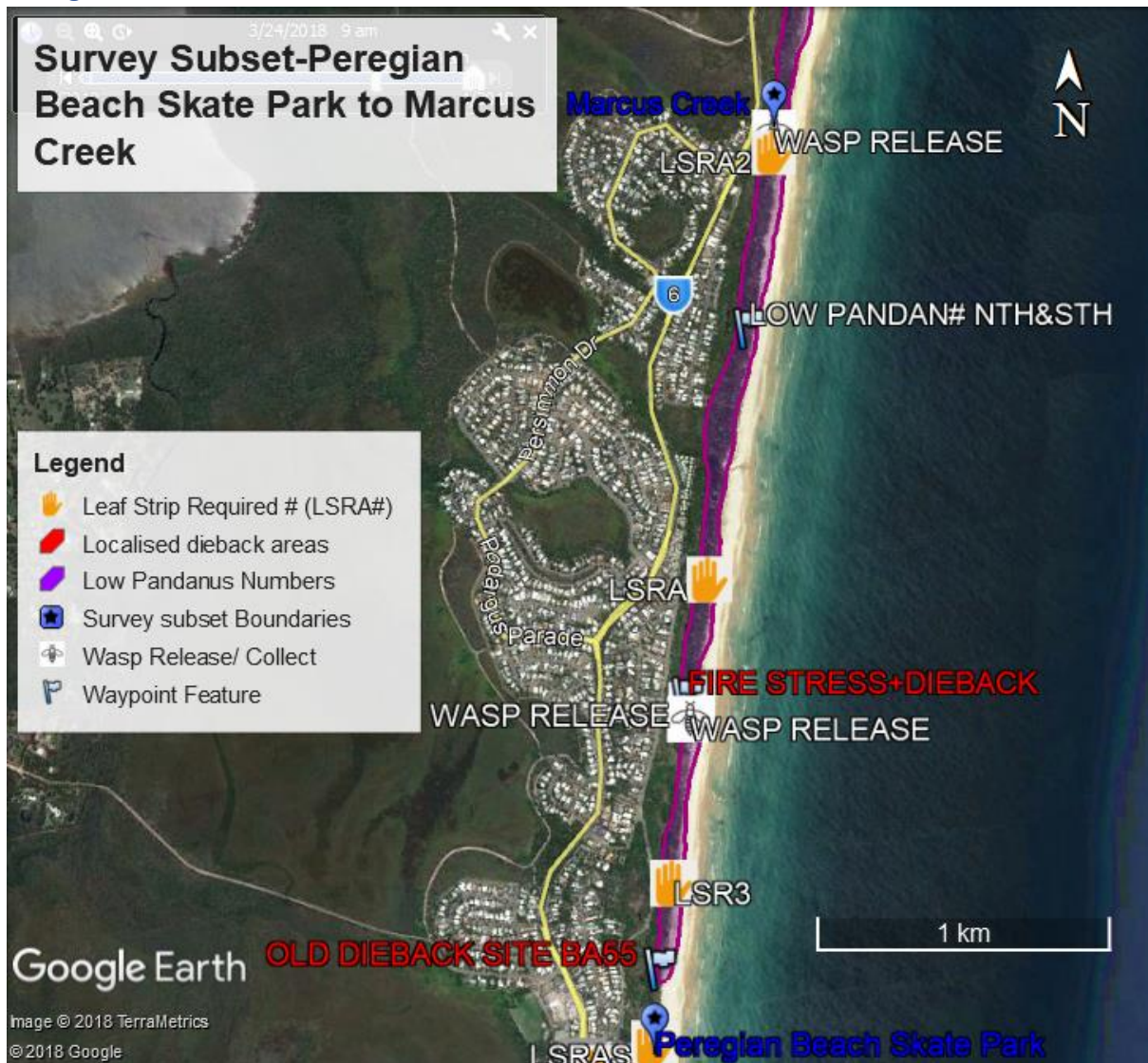


Collaboration with Council Parks and Gardens and Council contractors enabled safe dieback mitigation work in high profile areas. Literally hundreds of thousands of leafhoppers at various lifecycle stages were removed from heavily infested plants at Peregrine Beach alone. A safe and chemical free form of dieback prevention.

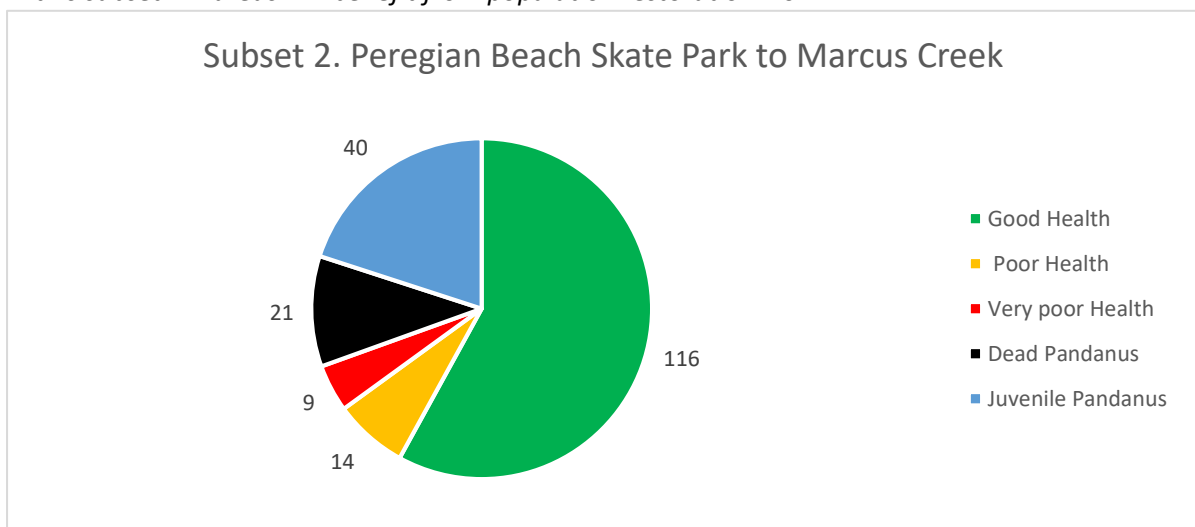


Follow up inspections at Peregrine Beach revealed healthy plants, low leaf hopper numbers and high level wasp parasitism. No further work is required until around September 2018 when plant health, Leaf hopper and wasp population monitoring is prudent as temperatures warm and insects become increase activity.

Peregian Beach Skate Park to Marcus Creek



Survey Subset- Peregian Beach Skatepark to Marcus Creek with polygons and waypoint markers of significant survey findings and works performed or required. Note that low pandanus numbers occur in this subset. All areas will benefit from population restoration work.



Note the low count numbers.

Survey findings

Very low plant counts for both mature and juvenile plants were observed. Almost all juveniles have been planted.

Most plants occur adjacent to Beach access tracks.

Very low numbers of plants reproductively mature, most observed are compromised by previous dieback events and are only capable of low level seed production.

No seeds were observed throughout the entire subset.

Leafhopper numbers were at low level throughout.

Four wasp releases were performed on plants with increasing Leaf hopper numbers.

Fire has damaged older plants in some areas and contributed to a proliferation in certain weed species.

Very high levels Basket Asparagus Fern were observed throughout. Gloriosa Lily was more prevalent in the south of the subset (Biocontrol moth was present). Broad leaf Pepper trees increased towards the north of the subset. Only low-level Lantana was observed.

Seven plants of various sizes require leaf stripping

Summary of works

4 wasp releases

Small scale leaf stripping

Educational workshop with Marcus Beach Bushcare Association.

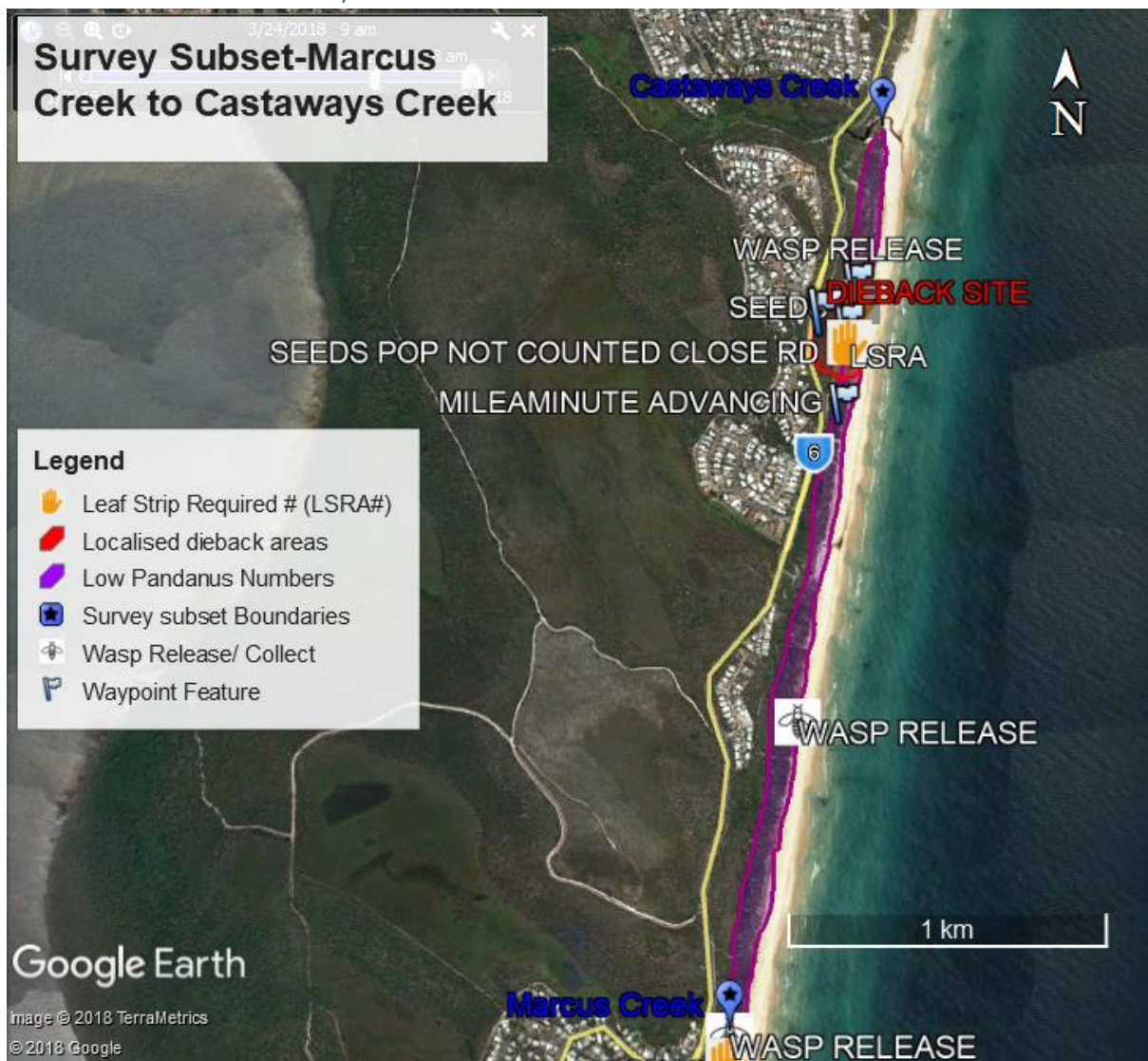
Direct seeding of over 350 seeds in frontal dunes

Future Direction

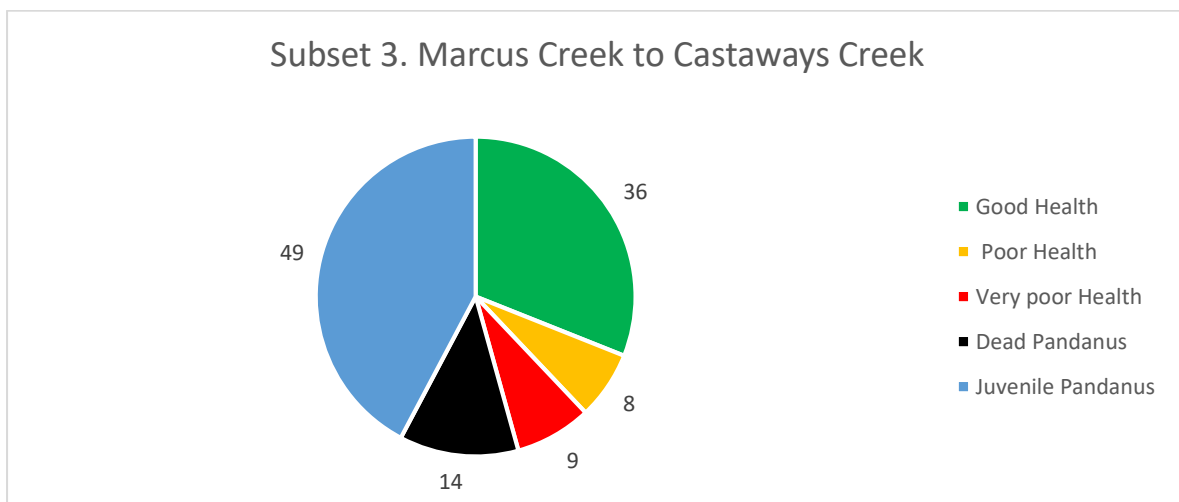
Leaf hopper and wasp monitoring and any small scaled leaf strip work required.

Population restoration work through plant outs and direct seeding.

Marcus creek to Castaways Creek



Survey Subset- Marcus Creek to Castaways Creek with polygons and waypoint markers of significant survey findings and works performed or required.



This subset contained very low numbers of Pandanus. A legacy of past sandmining and dieback events

Survey summary

Pandanus numbers were exceptionally low throughout this subset. Only 102 mature plants (over 1m) and juvenile plants combined for 4km of Beach.

Less than 15 plants were observed in the km's between BA 45-41. Most of these have been planted. The remaining original Pandanus are in Very Poor condition. Trends that occur across the entire subset.

Three plants require leaf stripping

Rehab areas with dense stands of Casuarina and some Pandanus (performed approximately 10 -15 years BP) have multiple instances of Casuarina branches inhibiting the growth of Pandanus. Thoughtful and careful trimming Casuarina branches to prevent the damage caused to Pandanus is a valuable practice and should be seen as follow up on earlier plant efforts.

Two wasp releases were performed

High levels Basket Asparagus Fern were observed throughout. Gloriosa Lily was in low concentration yet sporadic throughout subset. Broad leaf Pepper tree infestations were moderate. Mile a minute vine is increasing at one main location. *Passiflora suberosa* is sporadically distributed and increasing throughout the subset.

Summary of works

Small scale leaf stripping

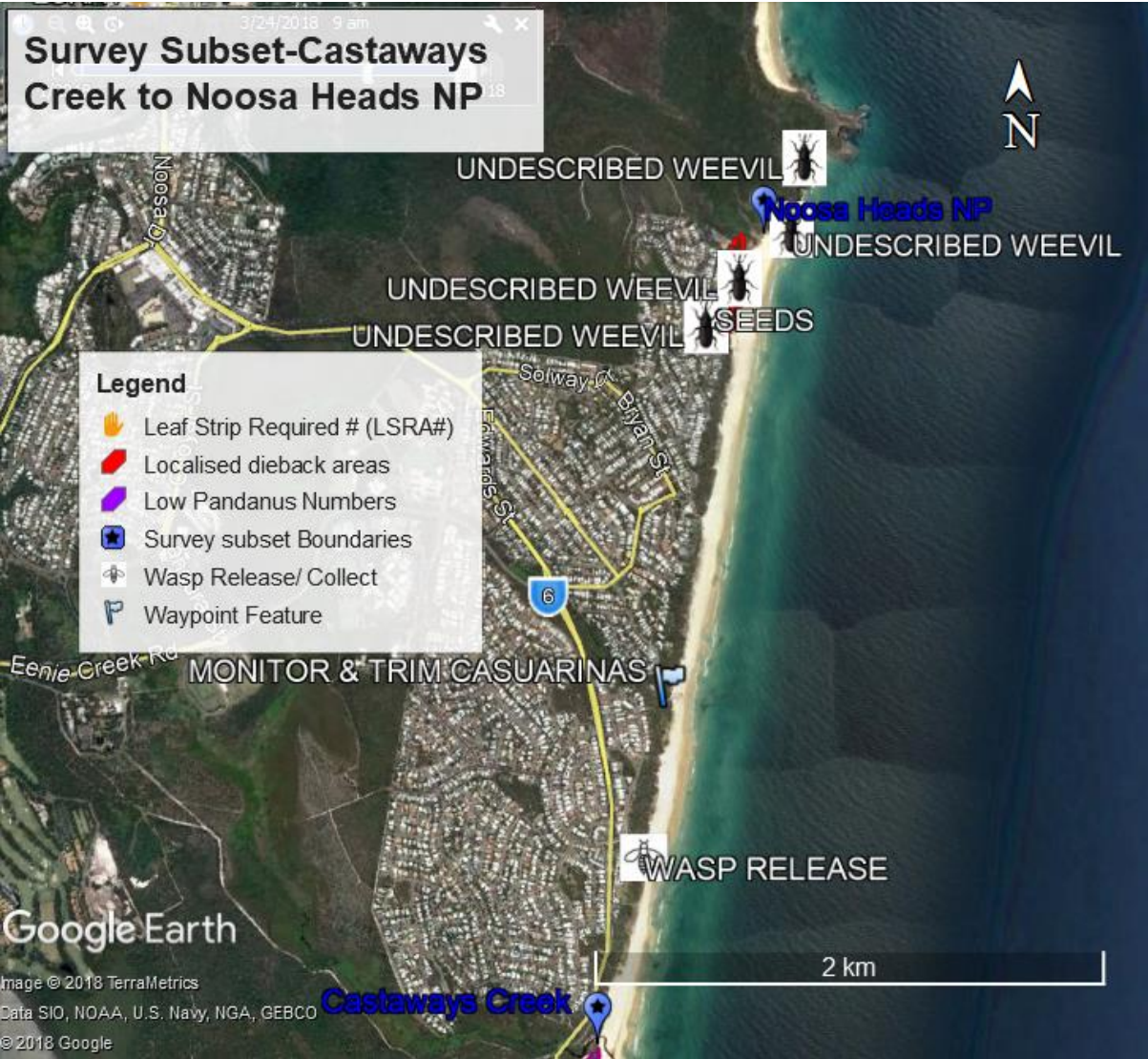
3 wasp releases

Future direction

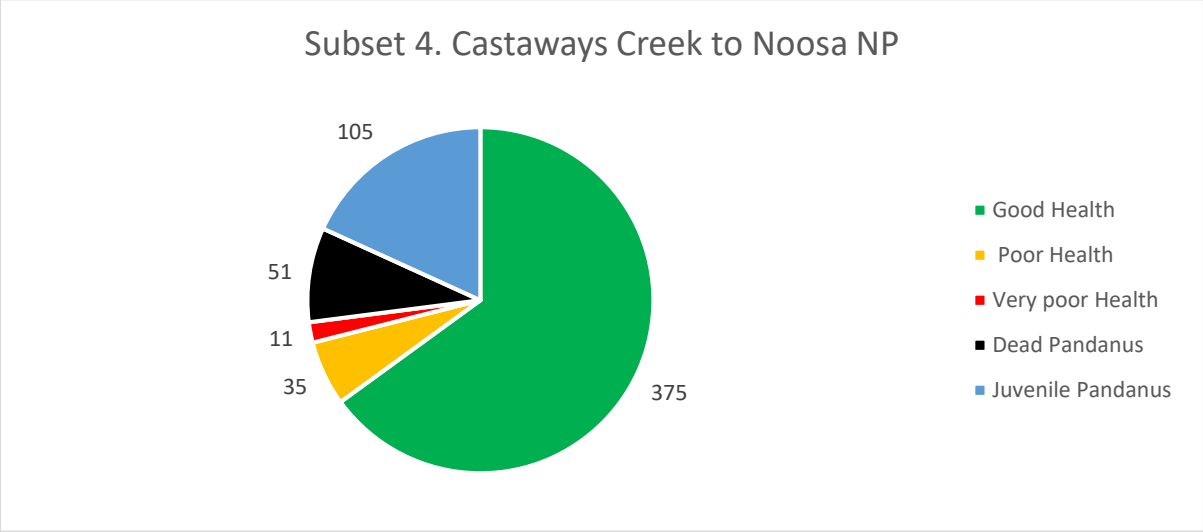
Trimming of Casuarina branches interfering with Pandanus growth at dune rehab sites.

Increasing Pandanus numbers through plantings and direct seeding. (this will help protect existing plants through aiding natural wasp permanence).

Castaway Creek to Noosa Heads NP



Survey Subset- Castaways Creek to Noosa National Park with polygons and waypoint markers of significant survey findings and works performed or required.



Note low juvenile counts (due to weed suppression of natural germination and previous dieback events)

Survey Summary

This subset had the highest numbers of original naturally occurring Pandanus. Even so most of the plants counted have been planted in recent decades and most have not yet reached reproductive maturity.

Rehab areas with dense stands of Casuarina and some Pandanus (performed approximately 10 -15 years BP) have multiple instances of Casuarina branches inhibiting the growth of Pandanus.

Trimming Casuarina branches to prevent the damage caused to Pandanus is a valuable practice and should be seen as follow up on earlier plant efforts.

One wasp release was performed

No fire damage was observed

High and concerning levels of the common major invasive weeds were observed (Gloriosa, Basket Asparagus Fern, Singapore daisy, and various weed grass species). Broad leaf pepper was common but in low concentration. Many other weed species were well established.

Around a third of a dense/ mature population between BA 27 and 26 have been lost to dieback in the last ~4~ years.

Damage and cocoons of an undescribed crown weevil borer (*Diathetes sp.*) was observed in the northern corner of this subset. Live larvae and adults were collected from pandanus in the adjacent Noosa National Park in previous months.

Summary of works

One wasp release

Low level leaf stripping

Extensive surveys of individual plants to establish the range of the undescribed *Diathetes Sp.*

Future direction

Pandanus population restoration work

Trimming of Casuarina branches overhanging and interfering with Pandanus growth at rehab sites.

Monitor the activity of the undescribed *Diathetes sp.*

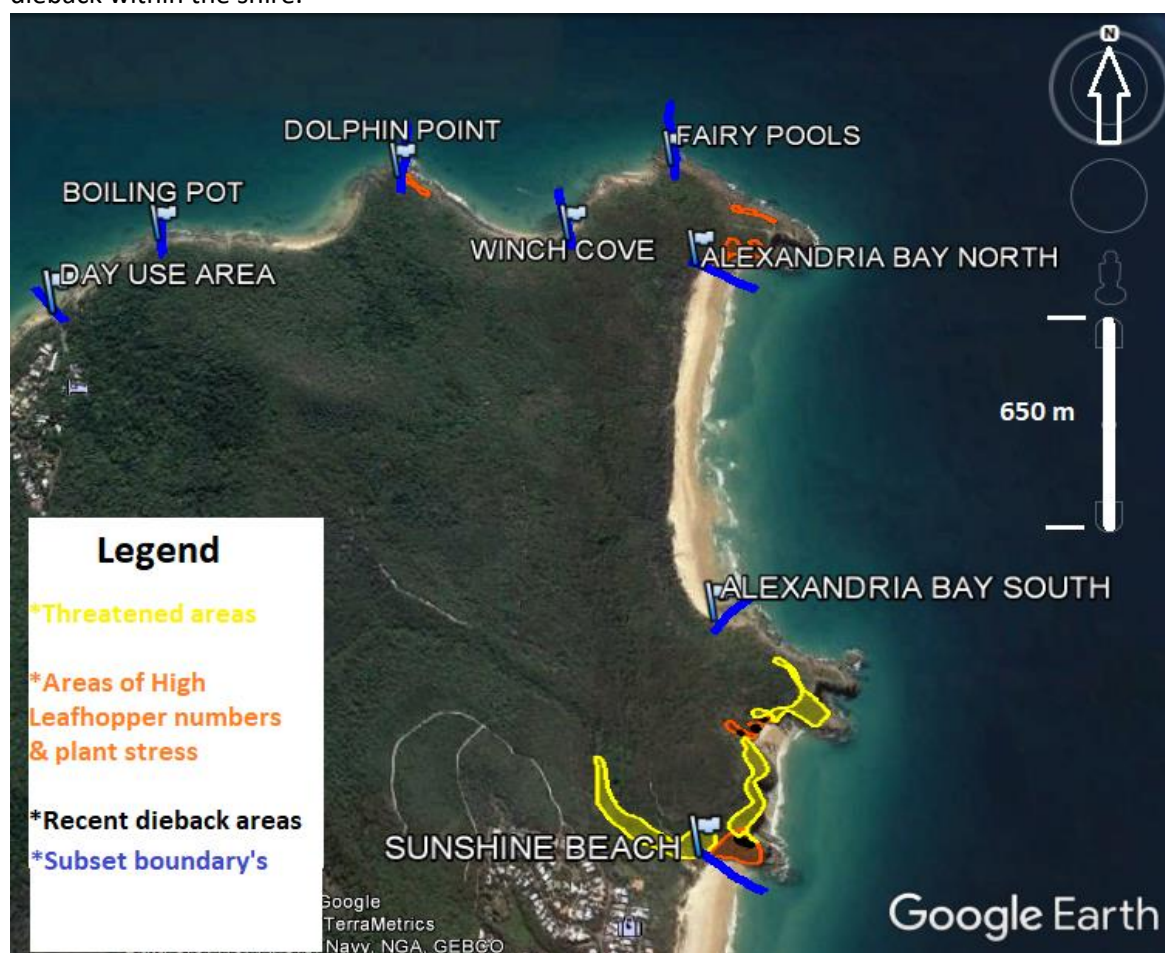
Noosa Heads National Park

After contacting Noosa National Park QPWS Senior rangers seeking permission to perform Pandanus dieback works under the NBRF funded project, management staff secured funding to undertake contract work directly for QPWS. From November to March, dieback mitigation works, ranger training, research, and three highly detailed reports were produced: “Noosa National Park Pandanus Population Health Assessment”, “Noosa National Park Pandanus Dieback IPM Plan-short, mid and long-term management recommendations”, and a “Final Report on treatment success and ongoing mitigation works necessary to increase the fecundity of the pandanus population in Noosa NP”.

**These reports contain highly detailed ecological information and are available upon request.*

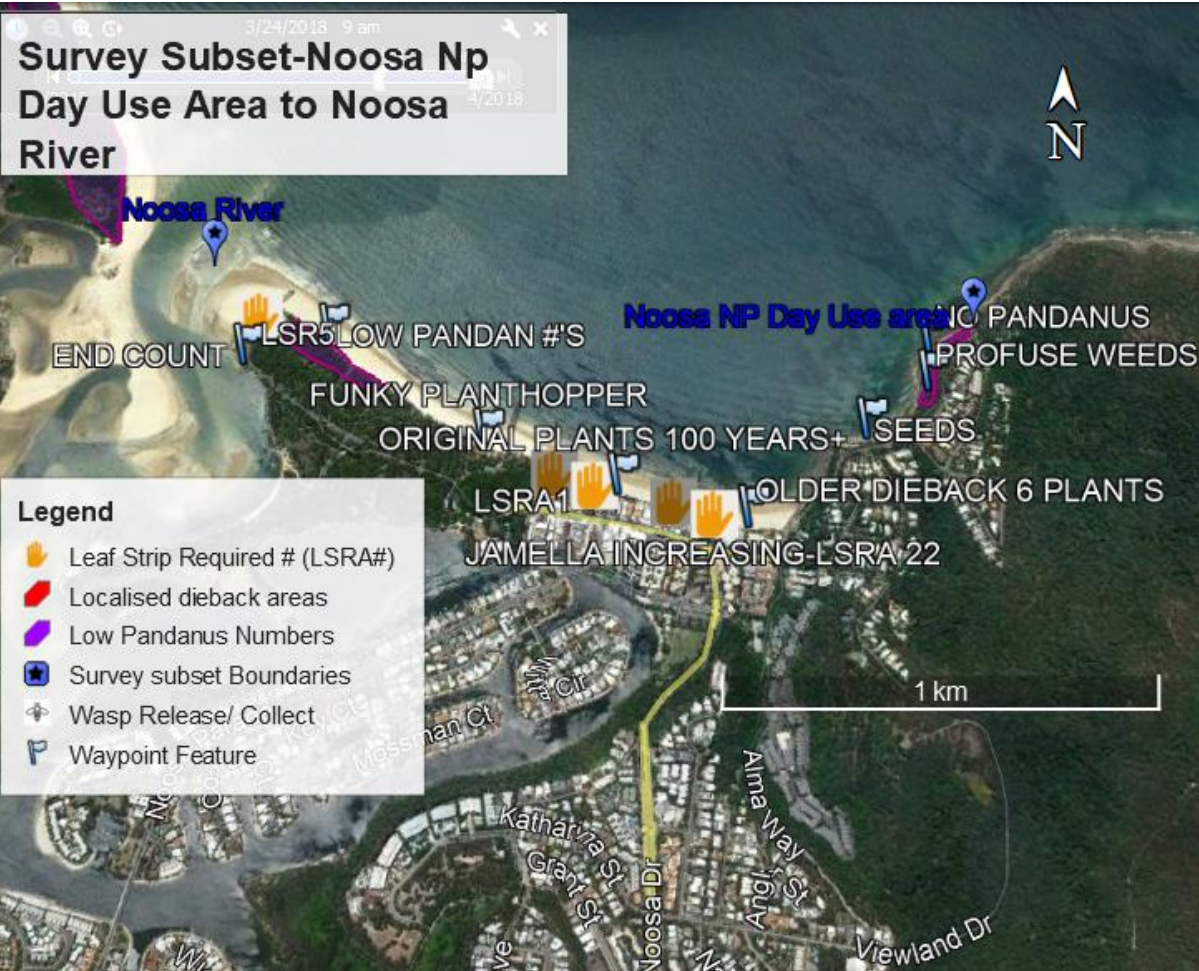
Local QPWS upper management staff have been exceptionally supportive and proactive for the immediate dieback mitigation work, ongoing monitoring and population recovery. Departmental funding allocated for pest and weed management throughout Coastal Queensland National Parks is appallingly low and hard to secure, their efforts are commendable. The collaboration with local Bushcare volunteers has produced great results, is a merit to all involved, and a partial solution to the increasing issue.

The field staff enthusiastically learnt methods and assisted mitigation work, and have individually taken initiatives to better the Pandanus populations within Noosa National Parks. Rangers are continuing monitoring, mitigation work and direct seeding, and staff from all levels have expressed keen support, and a desire for continued collaboration for a wholistic approach for Pandanus dieback within the shire.

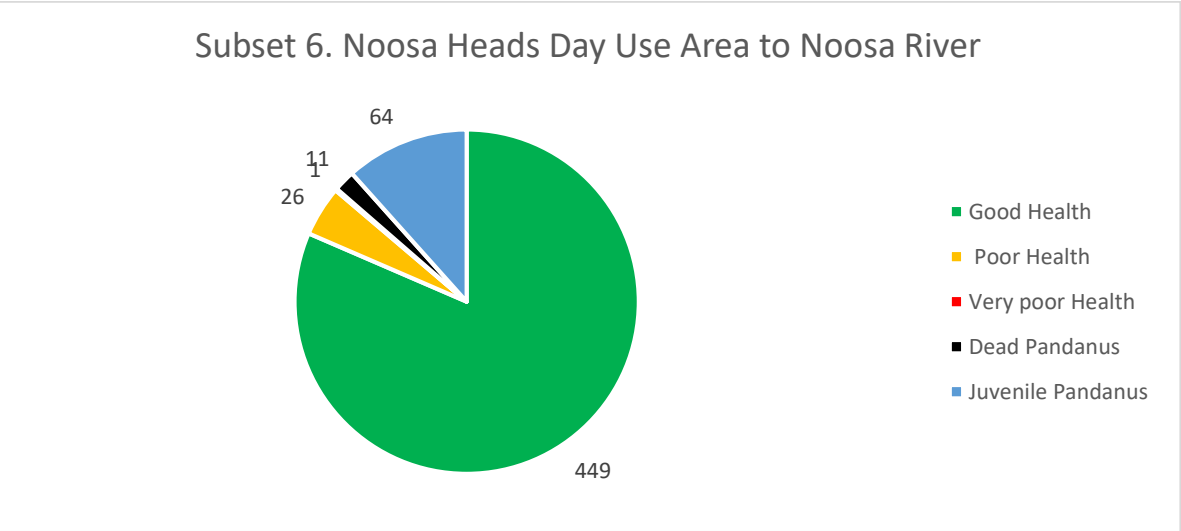


Map of Noosa Heads National Park subset boundaries with polygons, produced November 2017 for a QPWS funded report: “Noosa National Park Pandanus Population Health Assessment”

Noosa heads NP Day Use Area to Noosa River



Survey Subset- Noosa National Park Day use Area to Noosa River with polygons and waypoint markers of significant survey findings and works performed or required.



High mature plant numbers due to high levels of vegetation work can be observed in this subset. Low juvenile numbers highlight the opportunity for future plant out work at key areas.

Survey summary

In the few hundred metres nearest Noosa NP, no Pandanus occur, and weeds are profuse, particularly weed grasses. Regeneration would be ideal in this location.

Leafhopper infestations and contributing pathogens have caused dieback of limbs and were in elevated numbers either side of Noosa Main Beach surf club. Leaf hoppers have caused Mild dieback of limbs of around 5 plants (occurring since infestations began around one year ago). 22 plants were moderately infested, and required treatment to prevent dieback of infested plants and spread to other non-infested plants. Wasps were active. Non-chemical IPM is possible to mitigate dieback at this stage (as plant health declines pesticide intervention becomes more of a necessity). Plans were made with Parks and Gardens staff to perform the necessary works. 8 plants also require leaf stripping between the Groin and river.

A fortuitous meeting with long-time resident Bill Watson revealed the planting of Noosa Main Beachs Casuarinas, Coconuts and the existing Pandanus (as mature specimens) occurred in the late 70's early 80's. Two mature male plants were pre-existing estimated at over 100 years old.

Between Noosa groin and Noosa River good numbers of Pandanus occur with some now reaching reproductive maturity. Further planting or direct seeding is required at a few areas nearer the river. A little known plant hopper was observed in high numbers on a few Pandanus.

Summary of works

Education and training for Council staff and council arborists during leaf stripping works

19 Mature Pandanus leaf stripped at Noosa Main Beach.

Multiple wasp releases and monitoring after leaf strip work

Trimming of dead branches overhanging foot path for public safety

A Pandanus dieback educational workshop with Noosa Bush Beach and Creek Care members at the Noosa Spit.

Future direction

Monitor leaf hopper numbers and wasp parasitism along Noosa Main Beach

Monitor fungal pathogen activity posing risk to Pandanus under previous stress

Chemical intervention would be prudent for the highly stressed plants along Noosa Main Beach to prevent health decline, favoured conditions for leaf hoppers, and spread of existing fungal pathogens evident. Communications with Parks and gardens staff continues.

Population enhancement near Noosa groin in the few areas with low canopy cover and high weed occurrence

Synopsis of leaf strip work performed at Noosa Main Beach

From three infested plants observed in early 2017, around 1 year later 22 plants were infested at time of survey-March 2018. In May 2018, 19 of the 22 earmarked plants were leaf stripped in collaboration with Noosa Council Natural Areas and the highly professional Council contracted team from Sunshine Tree Surgery. Because leaves had to be removed from site, a method to retain high numbers of parasitised egg rafts on site was developed. The method has been successful and wasp parasitism is currently high and leaf hopper numbers low. However, around 5-6 plants have

compromised vascular function due to pre-existing pathogen attack, and the use of pesticide would be prudent to protect those plants affected and surrounding plants. Details will be discussed in detail with Parks and Gardens Staff.



Three of the 5 'wasp plates' used at Noosa Main Beach. A method newly developed was extremely successful! The removal of all leaf litter during leaf strip works posed a risk of decreasing wasp numbers which could potentially result in a resurgence of leaf hopper numbers. To overcome this parasitised egg raft were stapled to disposable plates and hung from branches of leaf stripped plants. An estimated 3-8 thousand wasps have subsequently emerged which has certainly increased the parasitism rates of egg rafts laid by any remaining leaf hoppers.



Close up of a 'wasp plate.' High percentage of wasp parasitism is evident by the emergence holes made in egg rafts (wasps are still to emerge from the 2 central egg rafts displaying no emergence holes)



Every egg raft on this leaf at Noosa Main beach has been 100% parasitised



Blue faced honey eaters, wattle birds, and various other species were highly active feeding on leaf hopper adults and nymphs during leaf strip works and during the 4 monitoring visits carried out after the works.



Pictured left; March 2018. Yellowing of leaves and dead limbs at Noosa Main Beach-signs of previous leaf hopper infestations. **Right; May 2018.** Trimming of dead branches and leaf stripping.



The same plant as pictured in photographs above-June 28. Although leafhopper numbers are now low level this plant and around 4 others is still showing yellowing of the leaves due to the pathogens (likely fungal) which are compromising vascular function.

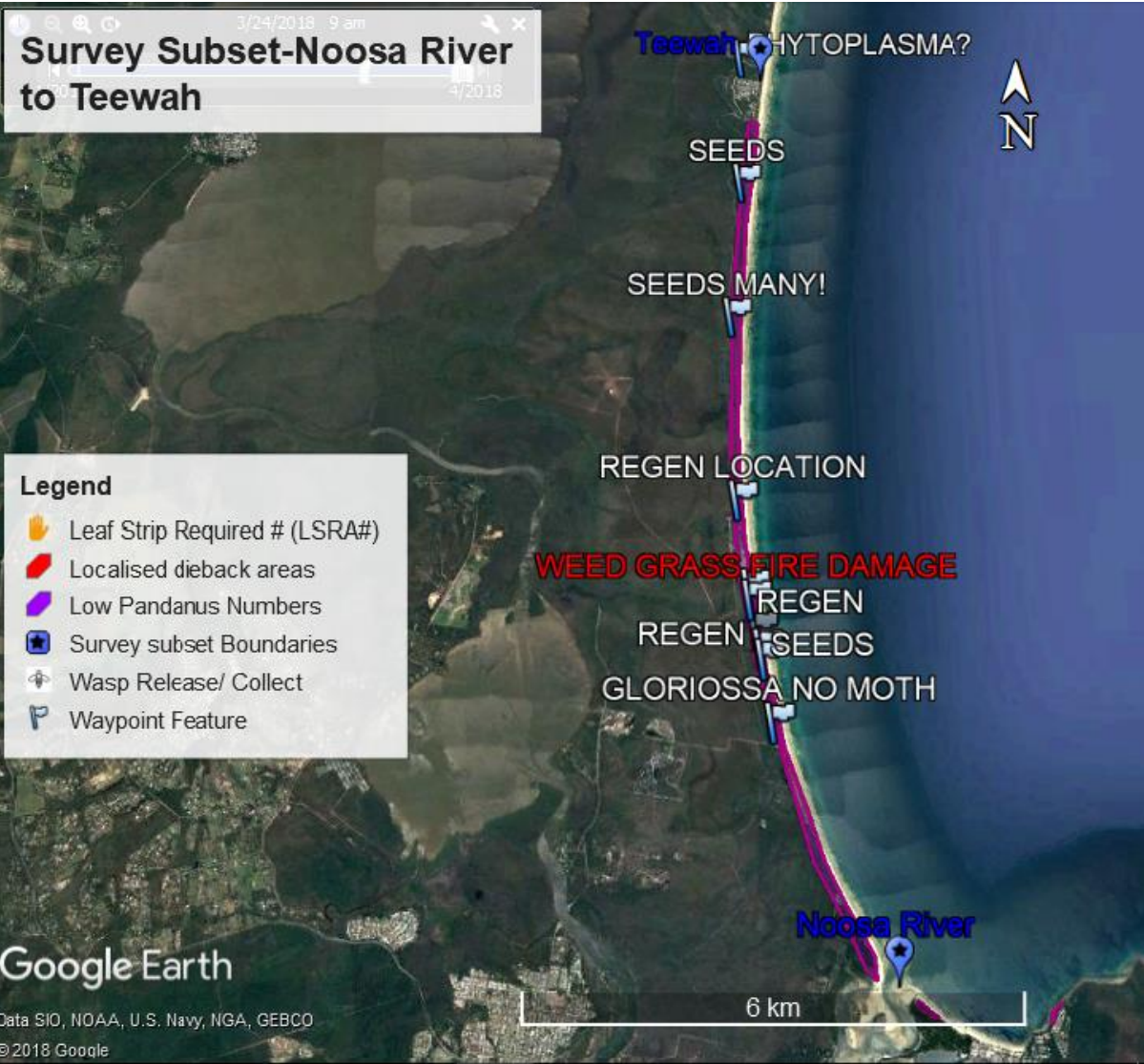


Obvious signs of advancing crown rot were observed during leaf strip works, with some crowns still green in colour yet falling off in the hands of leaf strip personal due to the pre-existing fungal damage.

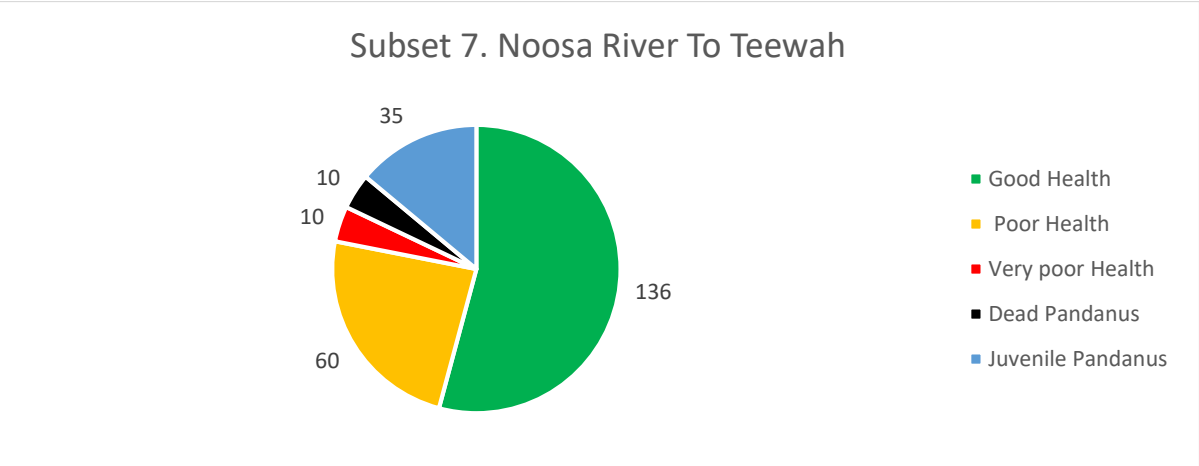


Further deterioration occurring on some crowns with pre-existing fungal pathogens active. Pesticide intervention would be prudent to reduce further health decline and a potential spread to nearby currently healthy plants.

Noosa River to Teewah



Survey Subset- Noosa River to Teewah with polygons and waypoint markers of significant survey findings and works performed or required.



Low plant counts occurring across the coastal length of mixed Council and QPWS managed tenure

Very Low Pandanus numbers occur in approximately 12 kms of beach from Noosa River to Teewah. Less than 200 mature individuals were observed. A legacy of past sandmining and the receding and advancing of a compromised dune complex.

Some of the surviving mature Pandanus have been compromised by fire and have low reproduction capability.

Fire intensity has in parts been greatly increased by the presence of high fuel load weed grass species. Naturally germination of Pandanus and other flora is also impaired.

Photos and waypoints were taken of a Pandanus at Teewah displaying symptoms of phytoplasma damage congruent with information shared by DAFF Grow help analysts, and perhaps warranting further research.

Many other weed species were observed many in low but increasing numbers; Singapore daisy is establishing at various locations after being washed up on large tidal surges. Gloriosa and Asparagus fern are increasing their range and density aided by bird seed dispersal. Lantana is well established in most parts. Brazilian nightshade, Mossman burr and many roadside grass spp. are extending their range and concentration.

Waypoints were taken of ideal regeneration areas adjacent creek outlets, although much of the subset would benefit from Pandanus population enhancements, and any level of revegetation or regeneration work.

Noosa District Landcare have recently performed revegetation work at Noosa North Shore Beach Camp Ground and plans have been developed to collaboratively plant 33 Pandanus and perform direct seeding at nearby regen sites utilising the assistance of supervisors and 7 conservation management trainees.

Summary of works

In field education session with Noosa District Landcare trainees

32 Pandanus collaboratively planted in at existing rehabilitation site at North Shore camp ground

Collaborative direct seeding of over 810 seeds

Future direction

Ongoing leaf hopper and wasp population monitoring

Population restoration work

Treatment and Prevention of Pandanus Dieback

With the lack of parasitism by *Aphanomerus* *nr. pusillus* of *Jamella australiae* egg rafts, *J. australiae* numbers will increase to deleterious levels (often to over 100's of thousands on a single mature plant).

This in turn causes a rapid decline in plant health which facilitates the increase of deleterious secondary insects (primarily weevils and Lepidoptera spp.-moths), and deleterious fungal, bacterial pathogens and potentially viral pathogens. As time passes, and with increased plant mortality and increased numbers of highly stressed plants, these deleterious factors increase exponentially and spread to nearby individual Pandanus and Pandanus populations.

To prevent the mortality of highly stressed mature, and highly susceptible juvenile plants in areas suffering late stage dieback, wasp release alone is insufficient.

To prevent plant losses Leaf stripping and/or chemical intervention is required.

Consistent Biannual Monitoring-Detailed Localised Pest and Predator Assessment

Pandanus leafhoppers occur on virtually every mature Pandanus throughout the Noosa Shire.

Understanding the health status and pest and predator levels of each individual plant within a dieback area will dictate the need for treatment, and which treatment method is applied.

Understanding real time levels of constantly fluctuating pest and predator species utilising *Pandanus tectorius* as host is crucial to applying efficacious, environmentally considerate, and economically prudent mitigation works.

Assessing *J. australiae* and *A. nr. pusillus* populations in relation to individual plant health is fundamental to management decisions.

Other predators notably contributing to the control of *J. australiae* infestations are numerous including; numerous Arachnid species, MERYLIDAE beetle commonly observed feeding on egg rafts, Lizards (Asian geckoes & skinks), Lacewings, birds (Blue faced and Lewins Honey eaters), etc.



A small subset of the many Arachnid species observed to undergo population increases, greatly contributing to reducing *J. australiae* numbers during and post infestation.



Leaf stripping also displaces and reduces many of the dieback contributing secondary insects

How it is performed

Leaf stripping requires a hands-on approach, and involves the removal of the lower (older) leaves occurring in on each growth head, until all damaged and necrotic leaves are removed. The amount of leaves removed will differ depending on stage of dieback, relative leafhopper infestation levels, and time since dieback began. It can only effectively be performed on plants containing a trunk (over ~1 m~ tall).

To safely and efficiently be performed on larger individuals, skilled arborists with climbing equipment are required. To prevent plant damage, no climbing spikes should be used.

Prior to, and after leaf stripping is performed, the surrounding flora should be noted. Leaves should be removed from significant vegetation (to prevent smothering effects of fallen leaf matter and regeneration potential), and from approximately 1-2m from the base of each Pandanus (to mitigate damage caused by the existence of high fuel load in the event of fire).

When is it beneficial

Leaf stripping is only necessary on plants which have persistent elevated leafhopper numbers, heavy infestations, or after heavy infestations when secondary insects, *J. australiae* and fungal/bacterial pathogens are actively decreasing plant health or preventing plant recovery. Performing leaf strip work on healthy plants is an unwarranted strain on valuable and limited human resources, and potentially result in damage to crowns and predator prey dynamics. The removal of dead leaves from healthy Pandanus also unnecessarily removes habitat of native rodents, birds, and insects.

Competitive shading of Pandanus

Careful pruning of surrounding native vegetation overshadowing Pandanus will benefit multiple Pandanus within the site, without having an adverse effect on the plants requiring pruning.

Weeds of Concern

Various weeds of concern were observed within the survey site. Some of these have become established and the competition is preventing natural germination of Pandanus and other coastal plant species. Others are vigorous growers and prolific seed producers and are currently occurring in low to high numbers throughout the sub sets. Their presence is affecting natural processes and biodiversity and if control measures are not performed, a weed seed-bank will build within the site. There is also a risk of these weeds spreading into adjacent National Park tenure.

Marcus Beach Bush Care Association Inc's website has a brilliantly succinct and informative list of local weeds most prevalent throughout the Noosa Shire. <https://mbba.org.au/our-worst-weeds/>

Revegetation

Revegetation is possible by planting nursery raised plants and through direct seeding.

To achieve successful regeneration in dieback areas, efforts will need to remain focussed on protecting remaining Pandanus populations from heavy leafhopper infestations that result from wasp extirpation.

In areas suffering notable dieback of mature Pandanus high juvenile Pandanus mortality occurs. The loss of juvenile Pandanus and reproductive mature Pandanus effectively causes a break in regenerative succession.

Noosa council natural areas staff have made steps to support future revegetation works by enlisting Noosa District Landcare to raise Pandanus for coastal plant out work.

With high numbers of plants required to restore the entire Noosa Shires coastal strip (more than local nurseries with endemic stock can supply), I hope orchestrate the raising of 2000 plants as part of a very directed and specific revegetation project. Funding and support is currently being sought.

Another effective way to increase Noosa Shires Pandanus populations is through a technique termed direct seeding.

Direct seeding

Direct seeding is by far the most time efficient and economically favourable method for increasing or maintaining Pandanus populations. It also decreases the chance of inadvertently introducing fungal root and other pathogens into natural areas, which is a risk inherent in revegetation plantings.

It simply requires the collection of viable Pandanus "keys" (seeds) of suitable maturity and directly placing them into ideal locations, sideways orientated at a soil depth of around 0-2 cm from the uppermost surface. Seeds of optimum maturity can remain viable for years and will naturally germinate when soil moisture levels remain suitable for a few months. Germination can occur in as little as 3 months, and as multiple embryos are contained in each key, multiple opportunities exist for plant establishment. When keys are placed in ideal locations a very high chance of plant establishment can be expected.

Selecting keys from mature plants exhibiting a notable level of resistance to *J. australiae* infestations will aid the long-term fecundity of Pandanus populations, as it is likely that any genetic morphological or behavioural resistance to *J. australiae* attack will be passed on to offspring.



Kabi Kabi descendant Torie performing direct seeding methods.

Natural Regeneration

Very low levels of natural germination is occurring throughout Noosa Shires natural Pandanus populations. This is due to decreased plant health of mature plants, and the young age and reproductively immaturity of planted Pandanus.

Natural unaided germination frequently occurs in dieback affected sites. However, when leafhopper numbers are high in surrounding mature Pandanus, juvenile mortality rates are high. This emphasises the need for consistent diligent leafhopper and wasp monitoring and translocations as required to prevent a complete break in plant succession.

In dieback areas the existing Pandanus seed bank under deceased female plants will expire after a few years and the reproduction of surviving compromised plants is greatly decreased. With recently germinated plants taking at least 15 years to reach reproductive maturity.

Conclusion

Surveys of the entire coastal strip revealed low and decreasing Pandanus population numbers, a legacy of past sandmining, damage from fire events, high weed competition, and almost two decades of dieback resulting from Pandanus Leaf Hopper infestations.

Multiple individual plants and localised populations were infested with leafhoppers. Wasp releases and translocations were performed to prevent new or advancing dieback cases.

Educational workshops and leaf strip work was performed in collaboration with many stakeholders managing Noosa coastal areas, have immediate and future positive repercussions, and has initiated a unified approach to managing this ongoing issue.

Extensive media coverage of educational events and works performed provided a high level of advocacy for both the plight and importance of Pandanus in our coastal areas, and the positive role the NBRF plays for protecting Noosa Biodiversity.

The direct seeding of 1500 Pandanus seeds, and 32 potted plants will enhance Pandanus numbers and resilience at multiple localised coastal areas.

Research into and documentation of a long list of insect species and ecological interactions many have already been uploaded to online sources with further works personally planned as species names are revealed.

The support from every collaborator has been expressed for all future works outlined in this report and required to protect and enhance the shires Coastal Pandanus populations.

The primary future works required are:

- Twice yearly monitoring of the entire coastal strip to identify emerging cases of dieback and performing wasp translocations and any small-scale cost saving preventative mitigation work.
- Follow up monitoring and works required at pre-existing dieback sites.
- Further Community engagement to empower residents with knowledge on how to manage their Pandanus, as well as to provide more hands for revegetation and regeneration works required.
- Pandanus population restoration work. Rearing plants for revegetation, and direct seeding regeneration work throughout many kms of degenerated coastal foreshores. *A personal goal to mitigate all existing or emerging cases of dieback, and boost Noosa Shires pandanus population by 2000 plants by June 2019 can be achieved with further support and collaboration.
- recognising a need for sharing the important information relative to Noosa Shires an educational video was drafted with the self-funded aid from an amateur videographer yet was of inadequate quality for release. If funding and collaboration with a professional video production company is secured educational videos can be produced to share the essential information both locally and across all threatened areas of Coastal eastern Australia.

It is hoped that the NBRF again provides financial support to enable project leadership for the works outlined above. Works that will preserve and enhance the biodiversity and resilience across the entire shires Coastal strip long into the future.

Thank you for your interest in the preservation of our local Pandanus tectorius populations. I hope that the ecological information and logic based foundational concepts included in this report has provided insights into some of the many factors occurring and influencing the dieback process

I look forward to providing further collaborative assistance to protect these iconic plants, having such high socio-economic and cultural importance, and providing such incomparably high service to coastal ecosystem function and biodiversity.

I wish to express a heartfelt thankyou a long list of supporters, each who have played an essential role an achieving the objectives of this projects.

In respect and commitment,

Joel Fostin :-).

Manager- Ecosystem Management and Biosecurity Solutions "Protecting life, saving money"

Email: pandanus.joel@gmail.com

Appendix

Photographic Survey Summary



Many of the older original Pandanus have perished due to fire damage and Leaf Hopper induced dieback. The recent dead are still standing and observable, evidence of previous mortality goes unnoticed as Pandanus decompose quite rapidly.



Fire damage and Leaf hopper induced dieback has compromised the health of most of the older originally occurring plants and no seed production was observed. High concentration of competitive weeds further inhibits germination from previous seed production. Thick stands of Basket Apsaragus Fern is prevalent as pictured beneath the Pandanus in right of bottom photo.



Dieback and reproductive inability due to stress and reduced crown size and health, a common site of the larger plants that were found within this subset, and most of the Shires coastal strip. As a result very low levels of natural germination is occurring.



Blady Grass contains devolopes far less fuel load than concerning weed grass species present, yet still burns at an intensity that damage or destroy Pandanus



Noosa Northshore: Fire damaged Pandanus suffer decline due to continual rotting of trunks, roots, and lower branches. Asparagus Ferns (pictured at base) and other weeds build in numbers post fire inhibiting the natural germination of pandanus and other native flora.



Noosa North shore: The presence of weed grasses over 60cm tall (*Chloris* sp.) increases fuel load and fire intensity is greatly increased resulting in damage and loss of Pandanus, Casuarinas and other native species across broad areas on Noosa North Shore. Weed grasses must be taken into consideration during back burning operations



The ground under dead and dying Pandanus frequently is inundated by weed species (Gloriosa and Asparagus fern in these cases) and if any seeds are present they are unable to germinate and penetrate through the weeds thick cover.



Dense stands of Gloriosa, Basket Asparagus Fern and Broad Leaf Pepper trees were a common scene throughout the Peregrine to Sunshine Beach stretch.



Singapore Daisy smothering 1,000 + square metres at one location. Multiple stands many tens of metres square occurred throughout this subset.



Noosa Northshore: *Gloriosa* did not occur in heavy concentrations in this subset, yet if left unmanaged will increase in numbers to match the dense stands occurring in the south of the shire.



Noosa Groin: Dieback of *Casuarinas* and some *Pandanus* may have been the result of inadvertent root uptake of herbicides applied to thick weeds. Regardless of cause such open areas are ideal for *Pandanus* plantings to bolster localised population and out compete weeds.



Noosa Boardwalk (near Little Cove): Dense stands of broadleaf Pepper Tree, Molasses grass, Panic grass, Painted Spurge, Asparagus Fern and other weeds occur in an area devoid of Pandanus nearest Noosa Heads National Park.



Two young 5-8 year old planted Pandanus near Marcus Creek that succumbed to leaf Hopper infestations. When infestations go unchecked old and young plants perish.



A close up taken during leaf stripping of the plant in the above photograph. Persistent Leaf Hopper adults (upper left), egg rafts (lower centre) and nymphs (centre and throughout) continue to cause plant health decline.



Four leaves from the plant in the round about at Peregrine Beach displaying moderate infestation levels. Over 120 egg rafts are present. Between 6,000 and 10,000 Leaf hopper nymphs would emerge in the absence of wasp parasitism. With only recent wasp arrival many hundreds of nymphs have emerged most of which will reach maturity, from these five leaves alone. By removing dead and infested leaves, infestations can be reduced and contained.



Plants with increasing Leaf Hopper numbers display many fresh egg rafts on underside of leaves. Wasp translocations performed where no wasp activity was observed.



A successful wasp release on the young threatened Pandanus pictured above. Two weeks after wasp translocation was performed wasps were observed actively parasitising fresh egg rafts (3 wasps can be seen on the egg raft upper middle right of picture).



Long stretches of beach contained no Pandanus, an uncharacteristic site in undisturbed beaches of Eastern Australia in Pandanus natural range. Apparently, a legacy of damage caused by sandmining.



Examples of three of the creek outflow areas which are ideal for Pandanus reveg/regen sites.



Most of the juvenile and mature Pandanus found in the foredune have been planted by Bush care volunteers and NRM groups.



An example of an excellent cluster planting of Pandanus. Plantings such as this make up the majority of the plants in healthy condition.



A Casuarina branch overhangs a mature 25 + year old Pandanus causing damage and eventual death

of its growth heads (crowns). The simple act of trimming a single branch is a valuable service particularly when populations are so low and in poor condition.



Top photo: view looking south of a regen area consisting of highly concentrated Casuarina plantings. Bottom photo: Pandanus planted under dense casuarina stands are well established and would benefit greatly from trimming Casuarina branches now causing damage to individual crowns and restricting growth.



*The majority of juvenile plants observed have been planted by hardworking forward-thinking Bush Care members. Five in a row on the high point of foredune swales are pictured here. *Planting in low portions of swales improves survivorship and growth rates.*