Pasture dieback: Past activities and current situation across Queensland (2017).

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Summary

Over the last 5 years (2012-17), an increasing area of grass pastures, both sown and native, have been dying in patches across multiple districts in eastern Queensland. Symptoms are the same or similar to *buffel grass dieback* that was first observed in the early 1990's, that is yellowing and reddening of leaves, stunting and eventual death. Once the pasture has died, the area is typically colonised by a range of broadleaf plants, including weeds, small shrubs, legumes or other (generally undesirable) grasses. Graziers with pastures impacted by this condition have grave concerns about the progressive destruction of pastures, and are looking for answers to ensure the long-term profitability of businesses.

The term 'dieback' has been used to describe a range of conditions with unrelated causal agents across a broad range of plant types, including trees, shrubs, legumes and grass pastures. While an array of literature has been published about dieback in plant communities, there are relatively few publications specifically outlining dieback in pasture systems utilised by grazing animals (beef and dairy cattle, sheep). A range of pathogens have been identified as causes of dieback in other plants, including fungal root and leaf diseases, and a range of these have been isolated from plant samples affected by pasture dieback in central Queensland. Recent plant testing, and past research including a PhD study, have been unable to determine the causal agent or define the contributing factor(s) of dieback in central Queensland pastures. It is possible that the condition is a complex interaction of multiple contributing factors, for example plant pathogens, insects, soil fertility and moisture stress.

Approximately 120 landholders have reported pasture dieback on their properties, and about 35,000ha of pastures are known to be affected, spanning from south-east Queensland, Burnett, central Queensland, Mackay/Whitsunday and North Queensland (as of July 2017). While the entire 35,000ha is not completely affected as generally patches of pasture are affected across this area, the actual area affected is likely to be significantly higher than this due to not all reports being captured by Department of Agriculture and Fisheries staff and other industry organisations. Also, many graziers are unfamiliar with the disease and therefore don't realise they have pasture dieback, and anecdotal reports indicate some graziers are reluctant to tell authorities they have the disease due to biosecurity concerns, or the potential of land de-valuation by banks.

The development and funding of a research project to investigate pasture dieback is a high priority, due to the rapidly expanding area of affected pastures across Queensland being reported and the uncertainty of the cause. There has been relatively little research on pasture dieback in the past compared to the value of the sown grasses being affected. Past research relied on modest budgets, focussed on only a few sites and did not investigate all the possible causal agents. Future research needs to build on past studies where possible, however a coordinated, systematic approach using a multi-disciplinary team is required to provide a better chance of determining what the causal agent(s) are and what the best management practices are likely to be. In total, five priorities for future research, development and extension have been identified. These include: 1. Understanding the extent of the condition, now and into the future; 2. Determining specific details of outbreaks and commonalities across sites; 3 Determining causal factor(s); 4. Determining management solutions; 5. Engaging with industry. Currently, such as proposal that addresses these priorities is under consideration by Meat and Livestock Australia (MLA).

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Background

Over the last 5 years (2012-17), an increasing area of grass pastures, both sown and native, have been dying in patches across multiple districts throughout eastern Queensland. Symptoms are the same or similar to *buffel grass dieback* that was first observed in the early 1990's, that is yellowing and reddening of leaves, stunting and eventual plant death, creating expanding patches. Once the pasture has died, the area is typically colonised by a range of broadleaf plants, including weeds, small shrubs, legumes or other (generally undesirable) grasses. Graziers impacted by this condition have grave concerns about the progressive destruction of their pastures and the loss of productive capacity. Affected graziers are uncertain how to remedy affected areas/paddocks and are looking for answers to ensure the long-term profitability of their businesses.

Dieback in pastures was first observed in the Dawson and Callide valley regions of central Queensland in the early 1990's. Dieback was mainly limited to buffel grass (especially cultivars American and Gayndah), however small areas of Sabi grass (*Urochloa mosambicensis*) were also noted to be affected (Graham and Conway 1998). Therefore, at that time the condition was called *buffel grass dieback*, or *buffel ill-thrift*. Current observations (since 2012) indicate an increasing geographic spread of dieback in existing and new localities, and an increasing number of sown and native grasses are now being affected. Queensland Department of Agriculture and Fisheries (DAF) staff have received numerous enquiries from concerned graziers who are looking for answers about what to do. Despite two research investigations including a producer demonstration site (PDS) project by DAF (Graham and Conway 2000) and a PhD study by Central Queensland University (Makiela 2008), the causes of the condition are unknown, as are the management solutions.

What is pasture dieback?

Pasture dieback is a poorly understood condition that causes distinct symptoms, severely reduced plant growth, and eventual death of pastures across a range of sown and native grasses. Symptoms include vivid reddening and or yellowing of leaves and as the condition progresses, plant growth is severely retarded with plants dying in patches that range from less than 1m in diameter and up-to paddock scale of hundreds of hectares. Stock avoid grazing these areas making the affected zones completely unproductive, which causes negative impacts on livestock productivity. The symptoms of pasture dieback are very similar across grass species with symptoms occurring on pastures across a range of soil types and landscape locations. Patches of dieback are typically positioned randomly across paddocks, and once the pasture succumbs to the condition and subsequent rainfall occurs, broadleaf plants, usually weed species, legumes, and undesirable grasses colonise these areas. To summarise, symptoms include:

- Reddening and or yellowing of leaves of affected plants, starting with the oldest leaves first (see Image 1 and Image 3)
- Stunted, unthrifty plants with reduced biomass production (tillers, height, seed-head size)
- Reduced root system density
- Eventual death of plants, either individual, in small patches, or larger paddock scale patches (see Image 2 and Image 4)
- Decreased pasture density
- Dead patches are colonised by broadleaf weeds, legumes and (rarely) annual grasses.

Image 1. Reddening of leaves on Buffel grass.

Image 2. Dead patch of Buffel grass (on left)

Image 3. Reddening of leaves on Creeping blue grass.

Image 4. Dead Creeping blue grass patch.

The impacts of pasture dieback are the same across all affected grass species, including:

- severe reduction in pasture yield and quality
- reduction in palatability and stock acceptance
- lower cattle live-weight gain and overall beef production
- lower profitability
- reduction in ground cover
- decline in land condition (i.e. loss of desirable grass species) resulting in increased erosion risk.

The scale of these impacts varies across paddocks and properties. In some instances only a few, small areas (or patches) are affected; whereas on other properties or in other locations, much larger areas are affected. To date, there is no clear reason why some paddocks or properties have small areas affected, whereas others have much larger areas affected.

Report Objectives

The objectives of this report are to:

1. Review published literature about pasture dieback both nationally and internationally, including findings of past and recent research and field sampling.
2. Describe the current situation of pasture dieback across Queensland, specifically areas, locations and grass species impacted, climate, geographical and managerial impacts, and remedial management techniques being implemented, if any.

3. Compile the literature review and analysis of the current situation, and provide recommendations for future research, development and extension priorities.

Methodology

Production of this report was undertaken in three stages.

1. The first stage was to source literature about dieback, both nationally and internationally. This was initially conducted by a broad subject search using the internet, however specific searches were conducted through international science journal databases which also included conference proceedings. This search was conducted by staff at the DAF Research Information Service.
2. The second stage was to undertake an analysis of the current situation, this included:

- Collecting and recording information provided by graziers from phone call and email discussions. Due to the concern and the publicity generated at the time, many graziers called the DAF Customer Information Centre (13 25 23) to report dieback incidences and discuss management options with a DAF officer. This concern also prompted Meat and Livestock Australia (MLA) to release a media statement in April 2017 (MLA 2017) which outlined their action plan for addressing pasture dieback. This statement also included details of an on-line survey that provided another opportunity for graziers to report outbreaks and outline their situation.
- Two focus group meetings in March 2017 (one at Moura (Dawson Valley) and one at Biloela (Callide Valley)) with graziers and industry representatives. At these events participants filled out a survey (before information was presented) which collected information on the current situation including area and grass species impacted, seasonal, geographical and managerial impacts, duration of impact and if symptoms are getting better or worse, what management techniques are being used to remedy the situation, how much support there is to fund a research program, and what should be investigated.
- Pasture dieback information was delivered at two AgForce grazier meetings in May 2017, one at Moura and the other at Gin Gin. Feedback from participants was collected and compiled with that collected from the earlier focus group meetings.

3. The third stage comprised of compiling this information into a report, together with images, a map of known dieback occurrences in Queensland, and recommendations for future research, development and extension.

Additionally, a forum was held in Brisbane in December 2016 with DAF staff that developed and refined a project proposal on pasture dieback for the 2016/2017 MLA R&D project annual call.

Results

Literature review findings

The term ‘dieback’ has been used universally across the world to describe unthrifty growth and or death of plants. Dieback has been noted in a range of plant types, including trees, shrubs, temperate legumes and grass pastures. An array of literature has been published about ‘dieback’ in plant communities, however, there are few publications specifically about dieback in pasture systems utilised by grazing animals (beef and dairy cattle, sheep).

Internationally, dieback type symptoms in pastures have been identified in both legume and grasses. In China, dieback symptoms of stunting and root rot in vetch pastures have been noted to be caused by root fungi including *Embellisia sp., Fusarium sp*. and *Conostachys rosea* (Li *et al.* 2007). In South America, a wilt and eventual dieback disease has been reported in *Stylosanthes guianensis*. The causal agent of the wilt disease was identified as *Lasiodiplodia theobromae*, which is a virulent, unspecialised, facultative wound pathogen commonly found worldwide (Kelemu *et al.* 1997). Symptoms include complete dieback of branches and brown discolouration of vascular cells in adult plants, and in susceptible genotypes the entire plant dies.

Dieback has been reported in turf grasses in Canada where *Pythium* root rots were reported as the cause of dieback in creeping bent grass and annual blue grass that resulted in diffuse blighting or yellowing of turf in small patches during cool, wet weather (Hsiang *et al.* 1995). Dieback in a range of pasture grasses (Johnson grass, yellow foxtail and broadleaf signal grass) has been reported in the United States, with symptoms including dieback of leaves, stems and root stunting, and plant death. A range of pathogens were identified however fungi across six species of *Bipolaris sp., Curvularia sp*. and *Exserohilum sp*. where frequently observed (Pratt 2006). In an earlier study the same author reported necrotic lesions and dieback symptoms in Bermuda grass where pathogenicity testing confirmed the cause as *Bipolaris sorokiniana* (Pratt 2003). Leaf lesions on other pasture grasses have been reported elsewhere in the United States. In southern Texas, a blight on buffel grass was reported to be caused by *Pyricularia grisea* (Rodriguez *et al.* 1999). The same blight was also reported to be found during a survey of buffel grass pastures in central Queensland (Perrott and Chakraborty 1999), at the same time and localities where buffel grass dieback was reported (Graham and Conway 1998). The authors of the buffel grass blight study concluded that more extensive surveys are necessary to establish the extent and severity of this disease and its possible links with buffel grass dieback. It is highly probable these findings are coincidental, in that it is unlikely this blight causes dieback in these pastures due to symptom expression differences. Blight causes round-to-elliptical lesions or blasts with light brown centres and dark red to dark brown borders (Perrott and Chakraborty 1999), whereas dieback presents as reddening of the leaves starting from the tip and progressively moving, sometimes unevenly, towards the ligule (Makiela and Harrower 2008). A possible explanation why blight and dieback have been recorded in the same pastures is because buffel affected by dieback could be weakened and therefore pre-disposed to attack by other parasitic organisms.

Other pests affecting buffel grass have been recorded. These include Spittle bug insects (*Aeneolamia albofasciata*). These insects are reportedly the most economically important insect pest of buffel grass pastures in Mexico, where damage can increase establishment failure of new pastures and decrease productivity of established stands (Martin *et al.* 1995). Spittle bug nymphs feed on sap from around the base of the plant, whereas adults feed on stems, crowns and young leaves causing chlorotic areas around puncture sites and inject a toxin which disrupts plant nutrient transport and respiration (Martin *et al.* 1995). While these symptoms are different to buffel grass dieback in central Queensland, it highlights the probability that other pests such as insects could be playing a role in this condition so must be considered when investigating causal agents.

In Australia, dieback has been noted in a range of plant types, including trees, shrubs, temperate legumes, and grass pastures. Dieback in eucalypt trees in southern Australia has been commonly reported and a review on the topic (Jurskis 2005) outlines attribution to a range of issues including an exotic pathogen(s), native organisms, climatic factors and agricultural and urban pollution. This review states episodes of dieback can be associated with natural climatic extremes, and that a variety of pathogens and pests can take advantage of trees that are stressed by environmental changes. The author also outlines that *Phytophthora cinnamomi* is generally accepted as the cause of dieback in eucalypts (Jarrah trees) in Western Australia. The expression of this disease varies with environmental conditions, such as very wet/or dry seasons on poorly drained sites affected by human management. However other studies indicate there is no conclusive evidence that *Phytophthora* is killing Jarrah trees, but attribute the cause to similar environmental conditions, that is waterlogging (as a result of human activities) rather than a pathogen (Davison 1997). The rationale being *Phytophthora* can also be found in healthy stands. These studies, while in different plant communities and geographic locations to pasture grasses in Queensland, indicate the difficulties to determine 'cause and effect', and that biological organisms found in dieback situations can be either primary or secondary causes, or are merely coincident with other contributing factors.

Also in southern Australia, a survey determining the decline in annual subterranean clover (*Trifolium spp*.) pastures reported the cause being a complex of soil-borne root pathogens (Foster *et al.* 2017). These include *Aphanomyces trifolii*, *Phytophthora clandestine*, and one or more *Pythium, Rhizoctonia* and *Fusarium* species. Typical leaf symptoms of the root disease was reddening and or purpling which is indicative of nutrient or moisture stressed plants. The authors report the root disease was independent of the highly variable complex of pathogens associated with diseased roots, geographic location and rainfall zone (from low, 330mm to high, 1000mm).

In northern Australia, dieback has been observed in non-native invasive shrubs. A study, which characterised the fungal communities from stems and soils from both dieback affected and healthy plants of five exotic invasive plant species (including *Parkinsonia* and *Mimosa*), failed to find fungi that were either unique or relatively more abundant in dieback affected than healthy plants (Raghavendra *et al.* 2017). The authors added there were no significant differences in fungal amount, diversity or community structure between dieback-affected and healthy plants, and that future investigations of biotic factors other than fungi (such as bacteria) may provide more insights into the dieback mechanisms affecting these species.

In Queensland, dieback has been more commonly reported in turf-grass, however there are reports from extensive pastures utilised for grazing. In turf-grass, a range of soil-borne diseases have been documented, including Kikuyu yellows, *Helminthosporium* disease complex, Spring dead spot, *Pythium* and *Fusarium* diseases, *Rhizoctonia* and *Anthracnose* (Bransgrove 2017). Of these Kikuyu yellows produces very similar symptoms to pasture dieback, and 'yellows' can occur where kikuyu is used in grazed situations. Kikuyu yellows results in small patches of dead grass where the leaves turn yellow, the roots deteriorate and rot, resulting in plant death in patches up to 1-2m in diameter (Nuturf 2017). Kikuyu yellows is caused by the fungus *Verrucalvus flavofaciens*, and despite thriving in the presence of high soil moisture and infecting the roots causing rot, the condition is often more noticeable in dry weather. Once the pasture has been killed, other grasses and or broadleaf weeds generally invade the affected area. No known chemical control is available for Kikuyu yellows as fungicides are largely ineffective; resistant varieties are deemed as the only viable long term solution (Bransgrove 2017). Despite some similarities, it is unlikely the fungus causing Kikuyu yellows is implicated in pasture dieback due to the differences in leaf symptoms and the absence of kikuyu pastures in the most commonly affected districts with dieback (i.e. central Queensland).

In pastures used for grazing in Queensland, dieback or death of pastures has been rarely documented. One case was the death of paspalum pastures in patches in the Cooroy district, where mealy bugs were noted as the cause (Summerville 1928). This report outlined that initially dieback was confined to a small patch in one paddock however the insect spread rapidly and a subsequent inspection 12 months later confirmed several more farms and at least six paddocks were affected. The symptoms reported included leaves turning purple at the tips and along the margins, which then extended to the entire leaf and sometimes the leaf-stalk as well. Eventually the plant becomes completely withered and brown and the whole upper part of the plant dies. Insect pests could be playing a role with the current incidences of pasture dieback in Queensland and interestingly the symptoms reported in this publication are similar to those being noted in a range of grasses affected by dieback across Queensland i.e. reddening and purpling of leaves, starting from the tips and moving towards the stem.

Dieback in central Queensland pasture grasses was first recorded around 1993 (Graham and Conway 1998). At that time buffel grass, specifically cultivars American and Gayndah, were affected; while the taller cultivar Biloela was unaffected. Dieback symptoms were also noted in Sabi grass (*Urochloa mosambicensis*). A number of reports of affected pastures were received between 1994 and 2000 from graziers in a range of districts including the central highlands (Emerald, Capella, Blackwater), Dawson valley (Duaringa, Baralaba, Moura, Wandoan) and Callide Valley (Biloela, Harrami). By the mid to late-1990's, graziers were highly concerned about the potential impact on the local beef industry. Buffel grass is the dominant sown grass species in central Queensland and across northern Australia, covering an estimated 26 million hectares (Peck *et al.* 2011). Due to this concern, one industry forum and two research investigations were conducted at that time to collate information about buffel grass, try to isolate a casual agents and investigate what could be done about it.

Industry forum: Buffel grass symposium (Kyte *et al.* 2001).

Due to the length of time buffel grass has been established in central Queensland and emerging issues such as dieback, the Buffel grass symposium during February 2000 was convened for invited participants to discuss the many issues associated with buffel grass. Participants included experienced extension officers, scientists, land resource officers, botanists and conservation officers from across Queensland. Discussion topics included:

- History and development of buffel grass pastures in Queensland,
- Soil properties, nutrient cycling, paddock/pasture renovation, legume options, nutritive value of buffel grass pastures,
- Diseases (including dieback), successional changes, herbaceous weed invasion, environmental concerns, impact of introduced plants in northern Australia and
- Future management options for sustained production including nutrient inputs, and alternatives to buffel grass.

Participant discussion recorded at the forum stated that dieback had reduced beef production in affected areas to about one third of what was possible previously. Affected graziers were not wanting any more publicity, they just wanted answers as to what was causing the condition and what management practices could be used to mitigate the impacts. Affected graziers, researchers and extension staff thought that government and research organisations needed to do more because the problem may have been reported locally, but it may be more widespread and could still be spreading. Seventeen years later dieback is now affecting a larger number of graziers across larger areas, including existing and new districts, and graziers are saying the same things, i.e. we just want answers to the problem and research organisations need to more thoroughly investigate the problem.

Research investigation nos 1: Producer demonstration site (PDS) project (Graham and Conway 2000).

This project aimed to identify the cause of dead patches in buffel grass pastures near Baralaba in the Dawson valley. This project undertook chemical analysis of plants, soil nutrient, plant and root pathology, and soil insect (nematode) testing.

When: Between 1997-2000

What happened:

- Two field trials (three reps and six treatments) to test the outcomes of different management strategies on the biomass growth of buffel grass. Treatments were applied on 3-4 December 1997 and included:
    1. complete fertiliser (230kg/ha Fertica®/ha + 160kg Nitram®/ha) ,
    2. nitrogen only fertiliser (220kg Nitram®/ha)
    3. tyne renovation,
    4. systemic soil insecticide/nematicide only (Aldicarb 150g/kg (Temik® 150G)),
    5. systemic soil insecticide/nematicide with complete fertiliser,
    6. untreated control.
- Root nematode studies
- Disease presence on plant tops and roots
- Diseased plants analysed for phytoplasmas (specialised bacterial organisms)
- Root fungus investigations
- Chemical analysis of plants and soil
- One field trial to test the disease tolerance of nine pasture species

What was found:

- Neither root nematode nor soil nutrient deficiencies, imbalances or toxicities were seen as the cause of the problem
- Soil insecticide did not improve plant growth nor diminish the symptoms of discolouration
- No evidence of phytoplasmas were detected
- The root fungus *Fusarium oxysporum* was isolated, but pathogenicity tests were yet to demonstrate similar symptoms and causal effects on unaffected plants
- The field trial to evaluate disease tolerance of pasture plants was initially hampered by dry weather and needed to continue over a number of growing seasons before outcomes were generated. Results from this trial were never reported.

Outcomes and conclusion:

- The investigations of soil nutrient deficiencies, root nematodes, phytoplasmas, and soil chemistry didn't provide clear evidence of any causal relationship.
- It was suggested a soil-borne disease organism may be involved.

Research investigation nos 2: PhD study by Sandrine Makiela, Central Queensland University (Makiela 2008).

A PhD study was undertaken which aimed to describe the condition, outline the effects that dieback has on host plants, and investigate possible causes, transmission mechanisms, and control options. The field components of this study were conducted on the same or neighbouring properties as the PDS project (near Baralaba in the Dawson Valley). After extensive laboratory, glasshouse and field experiments a causal agent(s) was not identified. This study concluded '*more work is needed to conclusively identify the primary causal agent of this potential costly condition',* and further surmised '*the condition was likely to be caused by soil borne fungi and or viruses, and that several other factors such as water and nutritional stress may contribute by weakening the plants and increasing susceptibility to the condition'*. While a definitive causal agent(s) was not found, this study did provide insights as to what the potential causes might or might not be. These are summarised in **Table *1***.

Table 1. Potential causes of buffel grass dieback as outlined in Makiela (2008)

<table>
<tr><th>Finding</th><th>Reason</th></tr>
<tr><td rowspan="4">Dieback is likely to be caused by a biological soil pathogen.
Fungi could be a possible cause.
Viruses could be a possible cause, together with fungi.
A disease complex (e.g. fungi and virus together) is the most likely cause of dieback.</td><td>The condition is disrupted by soil disturbance; requires a host plant to survive and spread.</td></tr>
<tr><td>Fungi commonly cause patches in pasture; can spread rapidly through the soil; can cause symptoms analogous to those of dieback; application of a fungicide reduced symptom severity.</td></tr>
<tr><td>Viruses can cause stunting and colour changes to leaves; a virus needs to be spread by a vector, which could include fungi or insects.</td></tr>
<tr><td>Explains the difficulty in reproducing the condition in shade-house conditions; why the condition is disrupted when soil it disturbed; all involved pathogens need to be present for symptoms to occur.</td></tr>
<tr><td>Unlikely that soil nutrient deficiency is the direct cause; likely that a soil pathogen is interfering with nutrient uptake and/or translocation in the plant.</td><td>Same nutrient level in soil yet different in the plant in affected and unaffected pasture in close proximity.</td></tr>
<tr><td>Unlikely the causal agent is soil insects.</td><td>Nematicide had no apparent effect on dieback symptoms or spread. However nematodes may act as a vector and help spread the condition.</td></tr>
<tr><td>Unlikely the causal agent is bacterial.</td><td>Bacteria do not usually cause patches; move slower than the observed spread of dieback; cause wilting and/or abnormal growths which is inconsistent with dieback.</td></tr>
<tr><td>Unlikely the causal agent is a phytoplasma.</td><td>Phytoplasma are transmitted by sap sucking insects; it's unlikely sap sucking insects are involved.</td></tr>
</table>

The PhD study also discusses potential control measures for dieback. Firstly, it outlined that chemical control of dieback is possible, specifically the fungicide *Amistar®,* however more research is needed to identify what concentrations are effective, or if other similar products provide better outcomes. Secondly, it was found that soil disturbance disrupts the condition, however cultivation might only temporarily stop progress, and also spread the pathogen(s) into unaffected areas. And finally, the application of fertiliser might also assist to alleviate soil nutritional deficiencies and improve pasture health, and in turn 'aid' in the control of this condition. Another potential option not discussed in the PhD study could be to remove the existing pasture and re-seed the paddock to a resistant species or cultivar, such as 'Biloela' buffel. This could be relatively time consuming and costly but possibly more economical compared to repeat applications of chemicals or ameliorants (e.g. fungicides, insecticides, biological formulations) over large areas. However, recent observations (2017) are indicating cv. Biloela buffel is now being affected by the condition which could rule out this option. But if all of these options could be utilised concurrently i.e. fully remove the existing pasture through cultivation, apply appropriate fungicide and fertiliser, and re-sow the paddock to resistant grasses or a different pasture type such as legumes, these might be options for graziers to consider implementing now while research is being conducted to definitively determine the cause(s).

Other possible causes of pasture dieback

A range of factors have been reported to cause dieback and death in temperate, sub-tropical and tropical pastures nationally and internationally. Due to the focus of this report being on the causes of pasture dieback in Queensland, other factors that have been suggested to cause dieback by technical and industry specialists, and graziers, will only be discussed.

1. Pasture rundown - nutrient (N) tie-up

Pasture rundown is the reduction in pasture growth over time due to nutrient, mainly nitrogen, tie-up in organic matter (Peck *et al.* 2011). Pasture rundown occurs slowly, where it takes years for pasture and animal performance to noticeably decline, as opposed to dieback that occurs over a significantly shorter time line, i.e. within weeks or months and so the impacts are noticed within one summer growing season. Leaf colouration differences also occur, with dieback causing prominent reddening, and yellowing starting from the leaf tips. Whereas the leaves of plants affected by rundown show classic nitrogen deficiency symptoms of a general paler green and eventually yellow colour across the whole plant which is more pronounced on older leaves, less seed production, and less vigorous growth especially of higher N demanding grasses which can lead to pasture composition changes. Pasture rundown symptoms can be completely reversed by application of N fertiliser, whereas fertiliser has shown to be ineffective on pastures affected by dieback. Dieback causes localised plant death in patches, whereas pasture rundown affects whole paddocks. There could be however, a secondary link between rundown pastures and dieback, in that rundown pastures are relatively unthrifty, so could be predisposed to being affected by a pathogen or insect. Nevertheless the observation that dieback is relatively uncommon in paddocks where the pasture is shorter, or more severely rundown, means that any direct link between the two is likely tenuous.

2. Other diseases

A range of other pathogens have been implicated in pastures affected by dieback. These include crown rot in *Sporobolus* grasses (*Nigrospora oryzae*), leaf spots in turf (*Helminthosporum* disease complex) and Yellow canopy syndrome in sugarcane.

Nigrospora oryzae is a naturally occurring (endemic) saprophytic fungus that can cause crown rot in weedy *Sporobolus sp*. grass plants. It has been recently promoted as a biocontrol for giant rats tail and giant parramatta grass in New South Wales (Officer 2012; Lawrie 2011). The fungus invades the roots, reduces tussock size and eventually kills the plant. Affected plants are characterised by pale orange leaves and affected tillers are easily removed from the crown and have a brown coloured base. Symptoms are obvious after the first effective rainfall event after winter, and the amount and rate of disease spread can be dependent on rainfall (Officer 2012). It has been speculated that *Nigrospora* could be the cause of dieback in creeping bluegrass pastures in the northern coastal Burnett region. This claim has never been verified, nor does it seem feasible due to the claims that *Nigrospora* only has parasitic impacts on grasses within the *Sporobolus* genus. Further, due to *Nigrospora* being an endemic fungi it would be impossible to determine if affected plants are impacted by introduced or naturally occurring *Nigrospora*.

Helminthosporum disease is a complex of fungi (commonly *Drechslera spp., Bipolaris spp.* and *Exserohilum spp.*) that causes spots and lesions on leaves and stems of turf grasses such as kikuyu and couch (Syngenta 2017). The symptoms vary according to the dominant pathogen at the time. Spots can be reddish-brown, dark brown or purplish-black, and plant tissue around the spots can turn yellow after infection. Infected leaves eventually wither and die, and severe infestations can lead to plant death however mature plants usually overcome the disease during favourable growing conditions. Infection occurs during mild-warm temperatures and moist-wet conditions, and moisture on the leaf surface is necessary for extended periods (>10hrs a day for several days) for infection to occur (Bayer 2017; Syngenta 2017). It's unlikely *Helminthosporum* disease is the actual cause of dieback in grazed pastures due to the specific requirements for infection and differences in symptom expression, however similar fungi (*Bipolaris spp*.) have been found on plants collected in central Queensland that were affected by dieback.

Yellow canopy syndrome (YCS) is a condition of an unknown cause that is affecting sugarcane in coastal Queensland. Sugar Research Australia (2016) outlines symptoms generally include yellowing of the crop where young leaves show faint yellowing at the tip, and older leaves show uneven coarse mottling with developing areas of uneven green and yellow tissue. Leaves in the lower canopy are more uniformly yellow, and show areas of brown-black necrotic spots. Once affected, yellow leaves do not recover. While there is speculation and concern that the two issues might be related, there is no definitive evidence of any linkages between dieback in pasture grasses and YCS in sugarcane, despite field observations (**Error! Reference source not found.**) in the Mackay district that pasture grasses (Guinea and Para grass) on sugarcane headlands displayed dieback symptoms adjacent to sugarcane crops affected with YCS (J. Hughes pers. com).

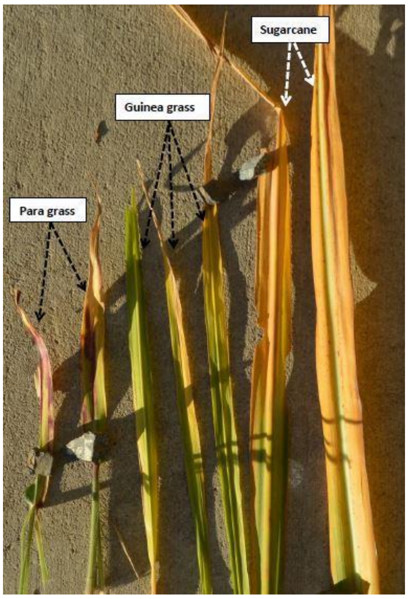

Image 5. Dieback symptoms in Para grass, Guinea Grass and YCS symptoms in sugarcane.

(Image courtesy of John Hughes DAF Mackay).

3. Insects

A range of other insects have also been implicated in pastures affected by dieback. These include Chaffers similar to those that have affected Mitchell grass (*Astrebla spp*.), African black beetles that can be commonly found in irrigated grass hay production systems, and nematodes. Due to the consistent lack of insects found on above ground or under pastures affected by dieback, it is unlikely that insects are the primary cause. However, and as mentioned previously, the role insects might play and the potential interaction between other pathogens cannot be dismissed. Further, this highlights the critical need for a range of trained technical staff to be involved during field visits, as not everyone has expertise in all areas of plant pathology and entomology.

A range of factors have been attributed to causing dieback-like symptoms in plant communities across Australia and other countries. These factors have depended on a range of aspects including plant type, soil and weather conditions, and management practices. While the literature provides some insights into the possible causes of dieback in Queensland pasture systems, the inability of two research studies to determine the cause(s) of dieback conducted on pasture in central Queensland indicates this condition may be complex or other potential causes need to be investigated. A range of pathogens including fungi, bacteria, viruses and soil insects need to be considered along with abiotic factors such as soil fertility dynamics, weather conditions and managerial practices. Interactions between pathogens and contributing factors also need to be considered.

Current situation

Dieback is still evident in districts (central Queensland) where it was identified some 25+ years ago, while ‘new’ outbreaks have been identified in other districts and in a broader range of grass genera over about the last 5 years. A significant number of sown species are now being affected, including some native grass species (**Table *2***).

Table 2. Grasses reported being affected by dieback in Queensland (2017).

Species name	Common name	Cultivar(s)	When affected
Cenchrus ciliaris	Buffel grass	American; Gayndah	Recently and up to 25 years
Urochloa mosambicensis	Sabi grass	Nixon	Recently and up to 25 years
Bothriochloa insculpta	Creeping blue grass	Bisset	Recently (~5years)
Chloris gayana	Rhodes grass	Various	Recently (~5years)
Panicum maximum	Green panic	Petrie	Recently (~5years)
Panicum maximum	Gatton panic	Gatton	Recently (~5years)
Panicum coloratum	Bambatsi panic	Bambatsi	Recently (~5years)
Paspalum dilitatum	Common paspalum	-	Recently (~5years)
Paspalum plicatulum	Paspalum	Rodds bay	Recently (~5years)
Brachiaria decumbens	Signal grass	Basilisk	Recently (~5years)
Brachiaria mutica	Para grass	-	Recently (~5years)
Digitaria eriantha	Pangola grass	Pangola	Recently (~5years)
Setaria sphacelata	Kazungula setaria	Kazungula	Recently (~5years)
Heteropogon contortus	Black spear grass	(Native)	Recently (~5years)
Bothriochloa bladhii	Forest blue grass	(Native)	Recently (~5years)
Chrysopogon fallax	Golden beard grass	(Native)	Recently (~5years)

Localities of where dieback has been recently reported in pastures include:

- North Queensland (Atherton tablelands),
- Coastal and inland central Burnett (Gin Gin, Bundaberg, Biggenden, Gympie),
- Dawson and Callide valleys (Bauhinia, Moura, Biloela),
- Coastal Fitzroy (Marlborough, Rockhampton district, Mt Larcom)
- Central Highlands (Emerald district),
- Mackay/Whitsundays (Eaton, Homebush, Habana, Mia Mia), and
- South-east Queensland (Brisbane and Lockyer valleys).

This indicates dieback has spread geographically and is impacting a greater number of grass species across multiple genera then previous studies have reported.

Approximately 120 landholders have reported pastures with dieback symptoms. These landholders have affected pastures that range in size from less than 1ha to up to 12,000ha, with the total area affected estimated to be around 35,000ha as of July 2017 (Table 3 and **Figure 1**). It is important to note this area of 35,000ha is not completely affected by dieback, as dieback occurs in patches, some small and others large, throughout an area of 35,000ha. This information was collected via direct communication with graziers (phone calls, emails) and through four industry focus meeting events held at Moura, Biloela and Gin Gin between March and May 2017. It is likely the reported affected area is biased towards the localities of these focus meetings, however, the main regions across Queensland affected by dieback are likely to be captured. In reality the actual area affected is probably significantly higher as not all incidences have been reported, and many landholders may not know they have dieback. During focus meeting events some graziers stated only seeing affected pastures once they knew what to look for. Also, anecdotal reports indicate some graziers have been reluctant to inform authorities about outbreaks due to fears of potential biosecurity restrictions or land de-valuation (equity concerns) by banks.

Table 3. Reported Queensland regions with areas affected by pasture dieback at June 2017.

Region	Area known to be affected (Ha)	Predominant grass (and cultivar) affected
Nth Queensland (Tablelands)	81	Signal (cv. Basilisk)
Mackay / Whitsunday	460	Digitaria sp. (cv. Pangola)
Central Highlands	6,345	Buffel (cvv. American, Gayndah)
Dawson and Callide Valleys	26,787	Buffel (cvv. American, Gayndah)
Coastal Fitzroy	481	Creeping blue (cv. Bisset)
Burnett	423	Creeping blue (cv. Bisset)
Brisbane and Lockyer Valleys	44	Creeping blue (cv. Bisset)
Total	**34,621**	

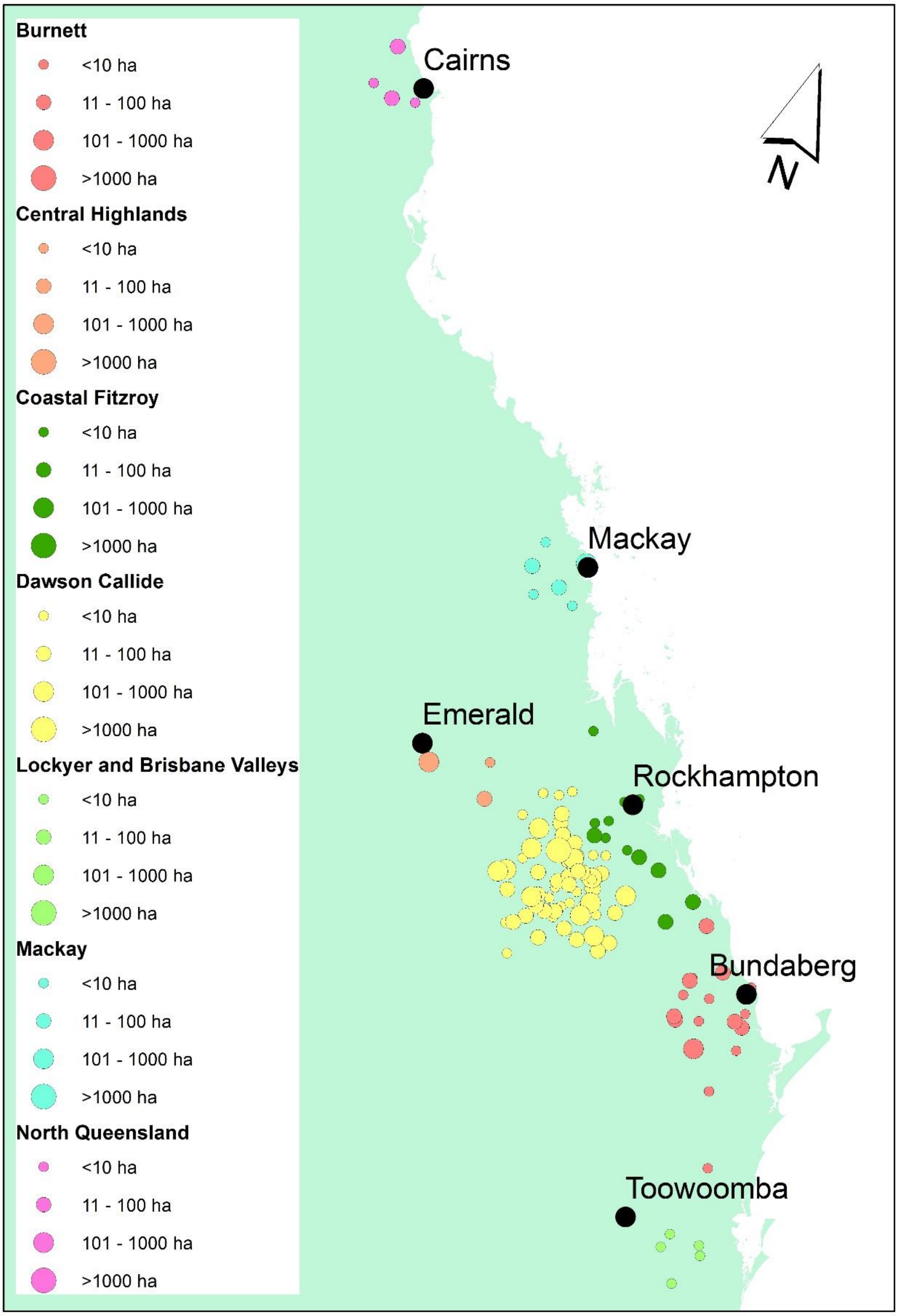

Figure 1. Known pasture dieback locations across Queensland, and size of area impacted (as of July 2017).

The dieback focus meeting events held in March-May 2017 also provided a range of other observational information from graziers on the current situation. This information is summarised in the following points:

- Generally recent incidences of dieback have been observed between 6 months (~September 2016) and 2 years ago (~April 2015), even in the districts (Dawson and Callide valleys) where dieback has been evident for >25 years.
- Most pastures have quickly succumbed to the condition, dying within weeks of noticeable symptoms (reddening and yellowing of leaves).
- Generally once affected, pastures have not recovered. However, in a few cases the pasture has recovered.
- Buffel grass (cvv. American and Gayndah) and Creeping bluegrass (cv. Bisset) are the main grass species affected, however many other sown grass species are impacted. Some native grasses have been affected including important productive species such as Black spear and Forest bluegrass.
- Pastures are being affected across a range of soil types, but more commonly affects are observed on the more fertile and therefore more productive soils e.g. Brigalow scrub, scrub, or productive alluvial soils.
- Dieback has been reported at multiple, random locations across the landscape.
- Dieback was reported as being more prevalent and having more impact on pastures with higher amounts of standing biomass.
- Most graziers believe the area affected by dieback is expanding.
- Most graziers' state dieback was observed after a period of dry weather, which was then followed by a wet break/period late in the growing season (e.g. autumn 2017).
- Most graziers did not offer an opinion on what might be causing dieback. Of the respondents who offered their opinion on a likely cause, most suggested a soil pathogen (e.g. fungi) as the most likely culprit. Soil insects were only mentioned once.
- Most graziers are not doing anything about dieback.
- Of those graziers who are trying remedial options, renovating (only), renovating and re-seeding, altering stock numbers (both reducing and increasing), burning, fertilising, spraying with fungicides, insecticides or biological formulations, are being tried.
- All graziers supported the development of a research project; the vast majority wanted a project to find out what the causes are, and what can be done about it.
- About 15 graziers have indicated they would be interested in hosting on-farm research trials.

From the direct communication and focus meeting events, two types of observations by graziers have been consistently reported; that is the impacts of management practices and seasonal factors. Management impact primarily revolves around grazing management (Table 4). The climatic factors are based on rainfall, either lack of, or high amounts. These observations have not been systematically confirmed or evaluated by technical experts, therefore limited cause and effect interpretations or conclusions can be based on this information. The significance of this information however is that consistently similar messages are being generated from individual observations that are independent from each other.

Table 4. Grazier comments about impacts of management and climate on dieback incidence.

Management impacts	Climatic factors
Less dieback where grass is kept short, from for example heavy grazing pressure, recent fire.	Less dieback where the grass is short due to extended dry or drought conditions.
Less dieback in younger sown pastures, or where sown pastures have been fertilised.	Dieback more evident after a wet winter.
Dieback commonly observed under fence lines.	Dieback more evident after a dry summer, followed by a wet autumn.
Dieback more severe in pastures with high legume content, for example leucaena.	Dieback more evident during / after a wet summer season with high humidity.
Dieback can be seen on one side of a fence, and not the other (possibly due to a grazing pressure difference).	

While affected areas are either completely destocked, or stocking rates are significantly reduced based on the lower pasture production, most graziers are not actively undertaking remedial activities and are effectively waiting to see what happens to their pasture. This approach seems questionable in the longer term as productivity can be severely reduced in paddocks where dieback occurs. However, multiple contributing factors may explain why few graziers have invested in remedial management practices to date, including:

- The cause of the condition is unknown.
- Patches appear randomly across the landscape.
- In many cases the impact area is currently quite small (<100ha) compared to total land holding, however the affected areas are increasing and therefore cannot be ignored in the longer term.
- Weather conditions have not been conducive to renovating or re-sowing pastures i.e. many localities have been very dry during the 2016/17 summer.
- Management practices have not been tested in research trials. Trials need to be conducted to test production responses to analyse likely economic returns before graziers have the confidence that an investment in remedial management practices is worthwhile.

A small number of graziers are implementing strategies to reduce and or remove the cause of the condition and restore pasture growth and productivity. Strategies implemented are borne out of frustration of not knowing what to do, a lack of research activity, and can be described as being “a stab in the dark”. There has also been a lot of speculation about likely management options based on information from limited grazier experience, past research which failed to convincingly provide solutions, current thinking of agronomists/industry personnel, all wrapped together with ‘gut feel’! Current strategies reported being implemented, and the main rationales for these practices are outlined in Table 5.

Table 5. Rationale of known strategies being implemented by graziers to combat dieback.

Strategy/management technique	Rationale for implementation
Burning with a hot fire or a series of fires.	Some graziers observed less dieback where there has been a recent fire; fire reduces pasture biomass and might kill the soil pathogen(s) causing the condition.
Fertilising.	Fertiliser will improve soil and pasture health and perhaps resilience to ward off pathogenic organisms.
Cultivate and re-sow new pasture.	No growth anyway so take the opportunity to renovate the paddock and re-sow with fresh seed and or new species.
Utilising heavy grazing pressure for short time periods.	Utilise existing pasture biomass, open up pasture canopy, stimulate soil microbiology and encourage fresh re-growth.
Reducing grazing pressure with resting or instigating longer rest periods.	Encourage improved pasture condition and hence resilience from pathogenic organisms.
Spraying the pasture with fungicide.	Past research indicated the condition could be caused by a soil fungus.
Spraying the pasture with insecticide.	Insects (mealy bugs) have been observed in high numbers (however only in one or 2 cases).
Spraying the pasture with biological formulations (eg bacteria).	Enhance soil microbial activity and plant health, and so resilience and ability to ward of pathogenic organisms.

Whether any of these strategies actually work is unknown at this point in time. In most, if not all cases, insufficient time has passed or weather conditions have not been conducive to determine if any of these strategies work in the short or longer term. However, these graziers are not prepared to wait until their pasture is completely decimated, nor are they willing to wait for research to find the answer(s) especially in the absence of research funding to investigate the issue over the last 20 years. This is despite the potential high risk of incurring cost and wasting time undertaking activities that might not have any benefit or may even exacerbate the condition.

Diagnostic analysis of pasture affected by dieback between 2015-2017

A small number of graziers have tried to determine what is causing the condition by communicating and engaging with government or university plant pathologists and soil experts, or with private agronomic firms. A small number (<50) of plant and/or soil samples have been analysed to determine the presence of pathogenic organisms, such as bacteria, fungi, insects, or soil nutrient deficiencies, imbalances or toxicities. DAF plant pathologists have analysed approximately 40 plant samples that were submitted directly by graziers between 2015 and 2017, or were collected during a pathology survey trip during May 2016. During the survey trip, plant samples (leaves, nodes, basal stems and roots) of three grass species from four properties (three near Gin Gin, and one near Yandaran) were collected, and isolations were identified. A large number of fungi were isolated, however, the most common were *Penicillium sp*., *Curvularia sp*. and *Nigrospora sp*. (Table 6). Fungi in the genus *Penicillium* are mostly saprophytic and responsible for common moulds. That is, they primarily decompose dead plant and organic material therefore are highly unlikely to be the cause of dieback. Of the other common fungi isolated, these can be both saprophytic and parasitic, causing leaf spots and blights, and or crown or root rots in grass plants.

Table 6. Fungi isolated from grass samples during an on-farm survey trip in May 2016.

Grass	Plant part	Fungi isolated (in order of most to least common)
Creeping blue	Roots	*Penicillium, Nigrospora, Alternaria*
	Basal stem	*Penicillium, Nigrospora, Curvularia, Alternaria*
	Stolon	*Curvularia, Penicillium, Nigrospora, Alternaria, Fusarium, Diaporthe*
	Nodes	*Nigrospora, Penicillium, Curvularia, Bipolaris*
	Leaves	*Curvularia, Penicillium, Nigrospora, Exserohilum, Cladosporium*
Rhodes	Roots	*Penicillium, Nigrospora, Fusarium*
	Basal stem	*Penicillium, Nigrospora, Curvularia, Fusarium, Rhizopus*
	Stolon	*Curvularia, Penicillium, Nigrospora*
	Nodes	*Curvularia, Nigrospora*
	Leaves	*Curvularia, Nigrospora*
Giant Rats tail	Roots	*Penicillium*
	Basal stem	*Penicillium*
	Stolon	*Penicillium*
	Leaves	*Curvularia, Penicillium*

Of the samples submitted directly by graziers between 2015 and 2017, seven samples were creeping blue grass and five were buffel grass. Isolations were conducted on all samples and fungi identified were similar to those found on plant samples collected during the May 2016 survey trip (Table 7).

Table 7. Fungi isolated from grass samples submitted directly by graziers between 2015 and 2017.

Grass	Fungi species isolated
Creeping blue	*Fusarium, Bipolaris, Curvularia, Nigrospora, Penicillium, Alternaria.*
Buffel	*Fusarium, Bipolaris, Curvularia, Nigrospora, Penicillium, Alternaria, Phoma, Diaporthe*.

Almost all plant samples directly submitted or collected during the survey trip in May 2016 were fully affected (some even dead) by the condition at the time the samples were taken. This was most likely due to the time taken by graziers to realise what was happening in their pastures and to collect and submit samples. Also, the field survey trip was conducted when technical staff were available between other project activities therefore the sampling occurred late in the pasture growing season (May) after the symptom expression had occurred for some time, and plants were either dead or dying. These time constraints and a lack of dedicated personnel meant that additional diagnostic testing on these samples, such as confirming Koch’s postulates, have not been conducted. It is difficult to ascertain whether any of these fungal pathogens have actually caused the plant death. It is possible that most, if not all, fungi isolated are only present because something else caused the initial setback. More targeted sampling during the initial or very early stages of the condition is required to enable a reliable prospect of isolating and confirming causal plant pathogens.

Current situation in historical pasture dieback areas

Recent (2017) discussions with landholders who were originally impacted by pasture dieback in the 1990’s have indicated that dieback is still evident in their pastures today, and that the condition is managed together with the myriad of other resource issues on their properties. Some graziers have attempted to re-plant affected areas or paddocks with varying success. Generally buffel grass struggles to grow in these areas, if at all. Other grasses and some legumes are now growing in the affected areas. In some cases these properties have also been impacted by waterlogging during recent floods, with pastures currently being more affected by recent climatic events rather than pasture dieback.

Possible management options

Many graziers are wanting to implement solutions now, before the causal agent(s) is identified. In light of not knowing the causal factors and the observation that sown tropical legumes are not currently affected by this condition, one option could be to remove remaining pasture and sow an adapted legume (only). This could be achieved by cultivating the whole paddock multiple times with a chisel or offset plough, fallowing to store soil moisture and provide multiple opportunities to remove successive grass and weed germination, then sow either an annual legume such as Lablab, or a suitable perennial legume (only) such as desmanthus, stylos, butterfly pea or leucaena. This concept provides high quality forage for animal growth, while removing the host (grass) of the condition for a period of time. Grasses could be re-introduced after sufficient time for the pathogen/causal agent(s) to die out. This technique will mainly suit situations where the paddock can be cultivated and the majority is affected by dieback. In situations where machinery access is an issue, aerially spraying the remaining pasture and seeding could be an option. The uncertainty of the cause(s) of this issue make these suggestions speculation, however the broad concept is to use this situation as an opportunity to renovate and introduce legumes into the paddock to boost longer-term nitrogen supply and hence pasture health, vigour and beef production.

Another, albeit longer term, solution is to discover a resistant cultivar(s) from existing available sown pasture germplasm. For example, anecdotal evidence indicates the buffel grass cultivar *Biloela* has shown 'tolerance' to this dieback condition. While only three cultivars of buffel grass (*American*, *Gayndah* and *Biloela*) are predominantly utilised in Queensland, an additional 31 cultivars have been released around the world with a further 15 lines being identified as promising accessions that have not been commercialised (Tropical Forages 2017). In the first instance these recognised cultivars and promising accessions should be screened for tolerance and or resistance, which could be released as a resistant variety or identified as possible parent lines for breeding programs. If useful resistance was not found in this screening, then further work would be required to identify resistant lines. If a causal agent is isolated, these initial screening studies could occur within a relatively short timeframe. More time and investment would be required if broader screening is required, and a similar process could be followed for other grass species. These activities would require research investment. However, replacing affected pastures with a tolerant or resistant line might be a more economical solution for the industry compared to intensifying pasture management or regularly applying amendments (e.g chemicals, biological formulations) in these low input extensive grazing systems.

What has DAF done recently (2016-17) about this issue?

DAF has noted the importance of this issue to the Queensland beef industry and in December 2016 submitted a research project proposal to the 2016/17 MLA open call for projects. This proposal outlined a two stage approach, where the first stage aimed to identify the causal agent(s), and the second to undertake glasshouse and on-farm trials to identify management solutions. To enable diagnosis of the cause(s), stage one included a survey of up to 50 paddocks affected by dieback to verify symptoms, record the current situation (pasture types, soil types affected etc.), benchmark seasonal and managerial conditions, and set up sites to determine future rate of spread. An expert scientific team was then to collect plant and soil samples for diagnostic analysis, and replicate the symptoms in the glasshouse to ensure confidence in identification of the cause(s). These findings were to guide and direct what treatments to be trialled in the second stage. Through formal notification received in March 2017, the application didn't progress, however since that time MLA have continued to communicate with DAF about future activities and have released a 'Pasture dieback action plan' in April 2017 (MLA 2017). This action plan outlines key activities MLA wish to see undertaken, including:

1. Understanding the spread and extent of dieback.
2. Ascertain what short term measures can be deployed to reduce, and ideally halt, the spread of dieback.
3. Undertake activities to understand what has caused the onset of dieback.
4. Expert panels to guide the research response, including:
    a. Forming a short-term producer panel/group to provide data, information and first hand stories.
    b. Forming an expert panel of scientists for the next six months to assess the issue.

A meeting in June 2017 was convened by MLA and included the stakeholders in the DAF proposal as well as other industry representatives and graziers i.e. an expert panel. Presentations and discussions at the meeting concluded that the issue is highly complex, and that a soil pathogen is the most likely cause of the condition. MLA also outlined their intention to contract a project with DAF later on in the 2017 calendar year, and that another meeting would be held around October 2017 to progress this point. It is DAF's position to continue discussions with MLA about the formulation of a research project, to ultimately undertake activities and determine the cause, management solutions, and remedial actions to manage dieback and reduce the impact on the grazing industry.

Conclusions

The current occurrence of pasture dieback across Queensland is a serious concern for a large number of graziers. Around 120 graziers and 35,000ha of previously productive pastures are known to be affected by pasture dieback as of July 2017. However, the actual area impacted is likely to be a lot higher, potentially several times higher as not all outbreaks of pasture dieback are reported to DAF, and many graziers don't know how to identify the disease and therefore may not know they have patches of dead pastures on their property. Further, anecdotal reports indicate other graziers have been reluctant to inform authorities for fear of biosecurity restrictions, and or property devaluation by banks (i.e. equity concerns).

Dieback in Queensland pastures is not new. Pasture dieback has been experienced for >25 years in central Queensland buffel grass pastures. However, the difference between the historical and current incidences is that pasture dieback is now impacting an increased range of grass species and is occurring in new locations including both southern and northern Queensland.

Nationally and internationally, dieback in pasture systems has been identified in both legumes and grasses. The most common cause reported across a range of grass and legume species are parasitic fungal pathogens typically found on plant root systems. Similar fungi have been found on grass plants affected by pasture dieback in central Queensland. Pathogens affecting leaves of grasses have also been recorded both overseas and in pastures affected by dieback in central Queensland. Whether any or a combination of these pathogens are contributing to causing pasture dieback in Queensland is unknown. Limited research conducted on affected buffel grass in central Queensland in the late 1990's and early 2000's was unable to determine the cause of dieback. These studies concluded that the condition was likely to be caused by a soil borne pathogen, possibly fungal and or viral, and that other factors such as water and nutritional stress may also contribute by weakening the plants and increasing their susceptibility to the condition.

Due to the rapidly expanding area of pasture dieback being reported across Queensland and the uncertainty of what is causing it, the development and funding of a research project is a high priority. Without an effective research and development effort into the future, the impact of the condition will most likely continue to spread and affect more of Queensland's productive grazing lands.

Where to next

The development and funding of a research project is a high priority. While research into pasture dieback was conducted previously, it was not systematic, did not investigate all plant pathogen types and was limited in both geographic extent and management options tested. Future work needs to build on this research, but conducted in a coordinated manner with a multi-disciplinary team to investigate a wider range of plant pathogens and management options. In total, five priorities for future research, development and extension have been identified. These are:

1. Understand the extent of the condition, now and into the future.

   While many graziers have reported dieback on their property, many more haven't. A coordinated mechanism for landholders to report outbreaks is required, together with a process to document and interpret information about the overall extent, area and species affected, whether the condition is spreading, seasonal, management and landscape factors etc.

   Remote sensing should be investigated to test whether these systems can aid in mapping the current extent and determine the rate of dieback spread over time. This will require piloting in areas with known outbreaks to test methodologies and determine whether they can be extrapolated in localised or regional areas. A range of remote sensing technologies, such as high resolution satellite imagery, time-series datasets, and imagery from aeroplanes, helicopters or novel devices such as drones, should be investigated for their applicability of mapping and monitoring outbreaks of pasture dieback.

2. Determine specific details of outbreaks and commonalities across sites.

   An on-farm systematic analysis performed on as many known dieback sites as possible is needed to determine commonalities across sites and situations. Factors such as pasture species affected, soil types/landscape position, climatic and management influences, past history need to be analysed. This process should involve technical experts with knowledge in, but not limited to, grazing land management (GLM), soil chemistry/nutrition, plant pathology, and entomology. A thorough and detailed plant and soil sampling regime is required with a range of technical experts on-site. This approach will ensure all characteristics of each situation are documented.

3. Determine causal factor(s).

   Due to the current lack of understanding of what is causing the condition, a multidisciplinary team needs to systematically investigate all possible causes, including fungi, bacteria, viruses, phytoplasmas, insects including macro and micro biota, soil nutrient and water stress interactions, in a coordinated approach. Specialised laboratory and/or glasshouse studies are required, including replicating symptoms (satisfying Koch's postulates) to ensure the causal agents are identified.

4. Determine management solutions.

   Once the causal factor(s) are known, management solutions or treatments tested in glasshouses and in the field, to determine appropriate on-farm practices to reduce or remove the causal agent(s) and restore pasture and beef productivity. Determining tolerance or resistance via detailed screening processes, in currently available grass pasture species or possibly in non-released accessions, would also be a high priority due to the potential cost savings these could provide, compared to regular application of chemicals or other amendments over large areas.

5. Engage with industry.

   Pasture dieback has impacted graziers for decades and more recently a significantly higher number are being affected. There is frustration amongst graziers and advisors because of the uncertainty of what is causing the condition. Investment in pasture research by research organisations is now needed. Some graziers are 'trialling' treatments without knowledge of what the cause(s) is. None of these treatments are being trialled in a coordinated way that will inform others in the industry, and it is possible that these activities might actually be spreading the causal agent(s). A meaningful RD&E program that will achieve outcomes and results while engaging industry throughout the process is needed to ensure knowledge of the condition, awareness of program activities and progress, and an ability to adequately assess which solutions to implement (and how) when results become available.

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Melina Miles (DAF Toowoomba) undertook a review of the known literature on mealy bug presence and impact in pasture systems. This information was utilised in the literature review.

Almost 200 graziers across Queensland have called, emailed and attended grazier forums at multiple locations. Without the willingness of local graziers who are dealing with dieback to provide their time and their insights, the collected information on the current situation would be significantly less.

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