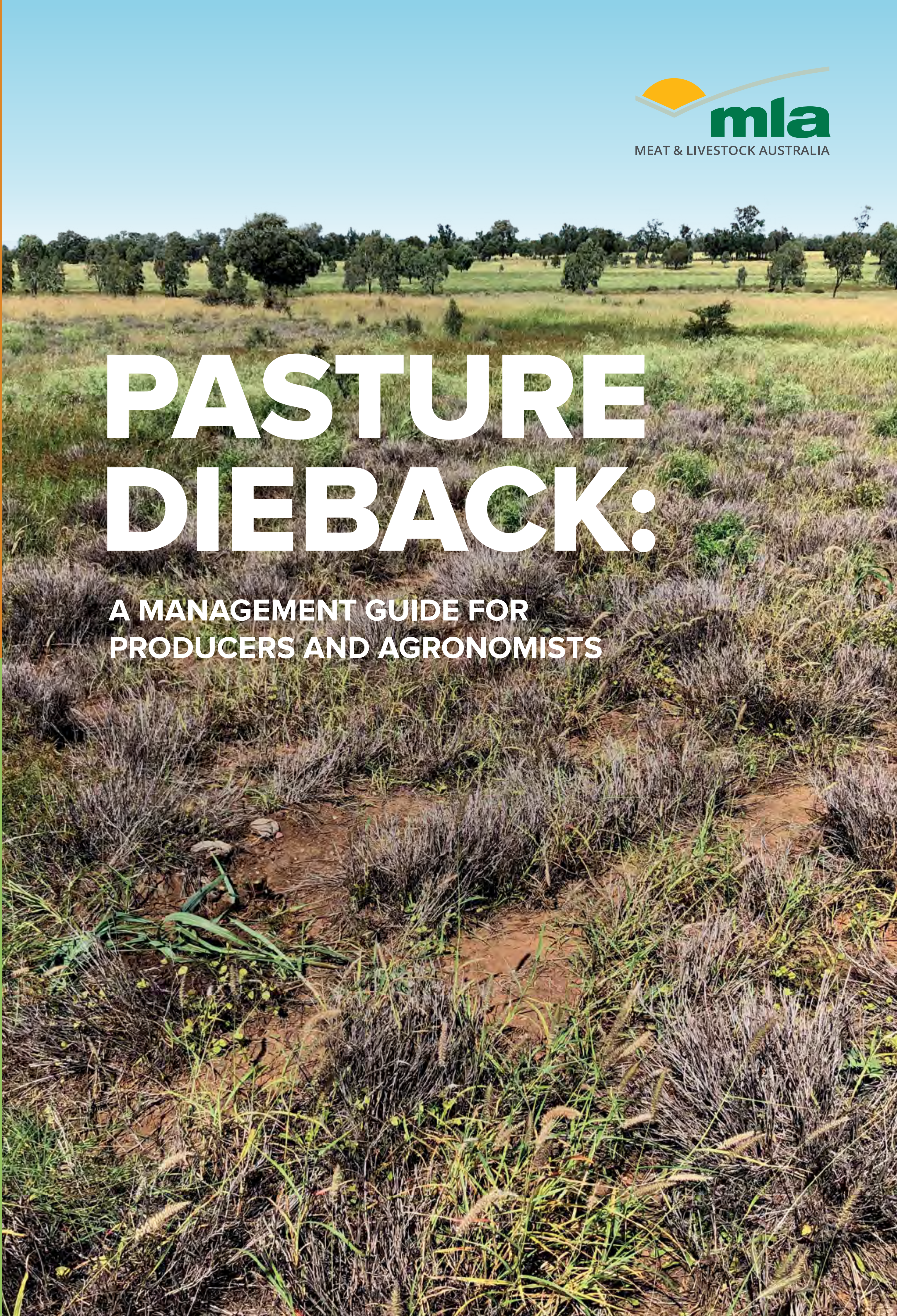

PASTURE DIEBACK:

A MANAGEMENT GUIDE FOR PRODUCERS AND AGRONOMISTS

MEAT & LIVESTOCK AUSTRALIA

CONTENTS

CONTRIBUTORS

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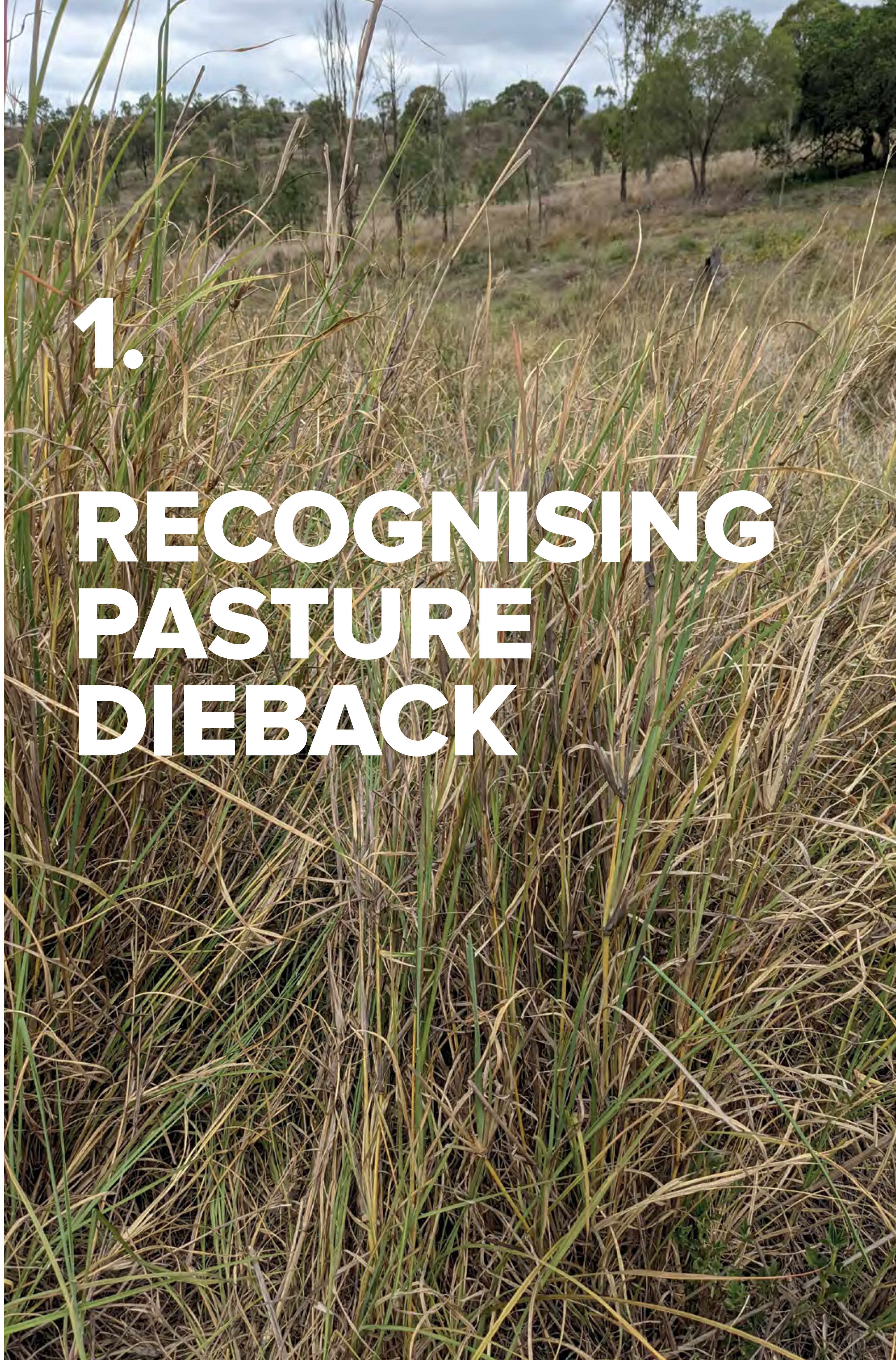


1. RECOGNISING PASTURE DIEBACK

WHAT IS PASTURE DIEBACK?

'Dieback' is a broad term referring to areas of plants dying without an obvious cause. Dieback is not unique to pasture grasses but occurs in plants ranging from giant Eucalypts to salt marshes and turf.

Pasture dieback is different from pasture rundown, although this condition can also affect pastures in northern Australia. Sown pastures are initially very productive when planted after clearing or in fertile cropping soils. However, productivity typically declines over time. This is not due to loss of nutrients from the soil, but the 'tying-up' of available nitrogen in the crowns, roots and organic matter of old grasses.

Aside from a single report of pasture dieback in paspalum caused by mealybugs in 1928 (Cooroy district), pasture dieback first emerged as a serious problem in central Queensland in the 1990s. Initially described as "buffel grass dieback", the cause was never established (Makiela and Harrower, 2008). As Biloela buffel did not appear to be strongly affected, many graziers adapted by moving to that variety. After a period of good growth, dieback re-appeared in 2015 (Buck, 2017). Most tropical and sub-tropical sown grass species, including some natives are affected, and it has become a major cause of loss of pasture production over large areas. It affects areas from Atherton, through north and central Queensland, and west as far as Roma and Injune and down into Northern NSW (Figure 1).

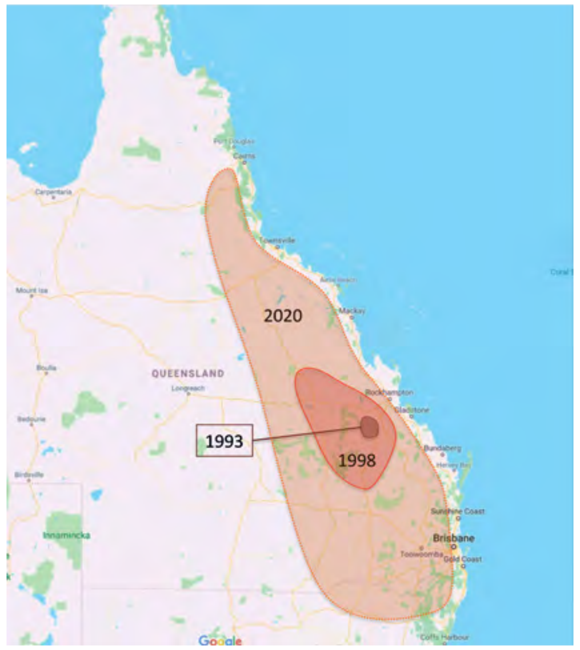


Figure 1. Area potentially affected by pasture dieback

HOW TO RECOGNISE PASTURE DIEBACK?

Pasture dieback is characterised by a series of symptoms that occur over time. Early symptoms are most obvious in actively growing pasture and may be hard to differentiate from nutrient deficiency, grazing stress, or from drought under very dry conditions. The first symptom of 'dieback' in most pasture species is a yellowing or streaking of the leaves, which may be followed by patches of red or purple along the leaf margin or in solid blocks on the leaf (Figure 2)

Figure 2. Early symptoms of dieback include yellowing then red or purple streaking of the leaves (Photo: N. Diplock, AHR)

The colour may vary in different species. It can also appear as a series of dots and patches. Green panic simply yellows, Rhodes grass tends to turn orange instead of red, while broadleaf paspalum, creeping bluegrass, setaria and signal grass may be dark red or purplish (Figure 3).

Figure 3. Dieback symptoms on: (a) American buffel; (b) Gayndah buffel; (c) creeping blue bisset; (d) green panic; (e) broadleaf paspalum; (f) Setaria; (g) Rhodes grass; (h) bluegrass (Photos: C. Hauxwell, QUT (a) S. Buck, DAF (b-d) S.J. Baker, NSW DPI (e-g) and N. Diplock ,AHR (h))

Affected plants have stunted root systems lacking fine feeder hairs, sometimes with blackened and dying root tips (Figure 4). Symptoms progress until the whole plant is affected and dies. Compared to dried pasture, which is golden, dieback affected grass becomes grey and brittle, and cattle avoid eating affected plants (Figure 5).

Figure 4. Roots of dieback affected (left) and healthy (right) grasses. Note the lack of feeder roots and yellow to red leaf tips on the dieback affected plant (Photo: N. Diplock, AHR)

Figure 5. Late stage dieback in buffel grass (Photo: C. Hauxwell, QUT)

DEVELOPMENT AND LONG-TERM SIGNS OF DIEBACK

Early signs of pasture dieback are often most obvious where grass is actively growing. Symptoms may be more severe in areas with long, thick grass and a dense understory of organic matter, such as un-grazed areas (roadsides, fenced areas), under fence-lines in well managed pastures or under trees, where large amounts of low palatability grasses can build up over time. Affected areas spread from roughly circular patches to paddock scale areas of dead pasture.

Pasture dieback can occur repeatedly over long periods, re-invading grasslands seasonally and resulting in poor pasture production. Expansion occurs both up and down slopes and on a wide range of soil types, although sometimes with a tendency to spread in the prevailing wind direction. Dead areas are often colonised by a range of broadleaf plants including weeds, small shrubs and legumes, or by undesirable annual grasses.

The NSW and Queensland Departments of Agriculture are developing a guide to identification of pasture dieback. This will include a diagnostic key and comparison with other types of damage.

More information on identifying dieback is also available at futurebeef.com.au/wp-content/uploads/2018/05/2.-How-to-identify-pasture-dieback.pdf

Identifying pasture dieback

The site is affected by pasture dieback if grass displays the following symptoms:

- Yellowing and/or reddening of the leaves
- Root systems in poor condition with few feeder roots and dead areas
- Plants become grey and brittle, breaking off easily at ground level when pulled
- Dead patches of pasture expand over a period of weeks
- Broadleaf weeds and legumes, instead of pasture, dominate after rainfall events.

You may also observe:

- Severe symptoms along fence-lines and other areas with thick grass
- Insects e.g. mealybugs, on the leaves and/or in the soil

Dieback is not:

- Characterised by leaf fungal diseases that cause yellow or red spots, lesions or blight
- Yellowing and/or reddening of older leaves due to drought or cold
- Natural senescence of annual grasses.

RECOGNISING PASTURE DIEBACK

DEVELOPMENT AND LONG-TERM SIGNS OF DIEBACK

Pasture dieback symptoms

1. Leaves become yellow and/or red, often starting from the tips of the older leaves

2. Root systems are stunted and lack fine feeder roots

3. Symptoms progress until the plant dies, becoming grey, brittle and easily pulled out

4. Dead patches appear and spread, particularly where grass has grown thickly, such as un-grazed or fenced areas

5. Broadleaf weeds colonise the areas of dead pasture

Mealybugs may be visible on the plant leaves and/or in the soil

GRASS SPECIES AFFECTED

While initial reports in 2015 focussed on buffel and creeping bluegrass, numerous tropical and sub-tropical grasses are now also affected by dieback, including some native species. Susceptibility of different species were summarised in the 2017 review by S. Buck (Table 1). However, local environmental factors also affect susceptibility. For example, a grass grown outside its natural range may be more affected by dieback than one growing under more ideal conditions. Susceptible species may be repeatedly attacked and die out, being replaced by less desirable pasture such as Bahia grass. However, such tolerant species may still provide useful fodder.

Table 1. Grasses reported as potentially susceptible to pasture dieback. Those at the top of the list are believed to be more susceptible than those near the bottom of the list. Note that the ordering of species is **NOT EXACT** but represents approximate susceptibility within a range.

	Species	Common name	Cultivar
More Susceptible	*Cenchrus ciliaris*	Buffel grass	American, Gayndah
	Bothriochloa insculpta	Creeping blue grass	Bisset
	Digitaria eriantha	Pangola grass	Pangola
	Paspalum spp.	Paspalum	
	Pennisetum clandestinum	Kikuyu	
	Chloris gayana	Rhodes grass	
	Panicum coloratum	Panic	Bambatsi
	Panicum maximum	Panic	Petrie, Gatton
	Urochloa mosambicensis	Sabi grass	Nixon
	Urochloa decumbens	Signal grass	
	Setaria sphacelata	Setaria	Kazungula
	Brachiaria mutica	Para grass	
	Panicum maximum	Panic	Green
	Dichanthium aristatum	Angleton/bluegrass	
	Bothriochloa pertusa	Indian couch	
	Setaria incrassata	Purple pigeon grass	Inverell
	Paspalum notatum	Bahia grass	
	Cenchrus ciliaris	Buffel grass	Biloela
	Heteropogon contortus	Black spear grass	(Native)
	Bothriochloa bladhii	Forest blue grass	(Native)
Less Susceptible	*Chrysopogon fallax*	Golden beard grass	(Native)

Legumes, including fodder species, are not affected.

CAUSE OF PASTURE DIEBACK

Is it a disease?

The symptoms of pasture dieback, particularly the spread of dead patches and the total destruction of affected plants, broadly resemble a disease. There are many diseases of pastures, and a number of different fungi including *Rhizoctonia, Fusarium, Bipolaris, Cladosporium, Nigrospora, Gaeumannomyces* and others have been isolated from improved pastures affected by dieback.

However, no pathogen species has been consistently found on dieback affected pasture, and attempts by pathologists to produce symptoms of dieback by deliberately infecting pasture grass with these fungi have so far failed. Diseases usually impact a limited range of species, whereas pasture dieback symptoms have now been observed in a wide range of different grasses (Rogers, 2017).

A detailed study by Dr Sandrine Makiela (2008) investigated the hypothesis that buffel grass dieback was caused by a disease. In total, 65 fungal isolates from dieback affected buffel grass were re-inoculated into young plants using five different inoculation techniques. None of the inoculated plants developed symptoms of dieback. The study also found that, unlike many diseases, pasture dieback could not be transmitted through seeds or by leaf contact alone. Microscopic examination of dieback affected plants revealed that the xylem (water and mineral carrying) vessels contained tyloses – growths produced by the plant in response to stress. However, no fungal hyphae or bacterial colonies were visible in association with these blockages.

These results together suggest that fungi are likely to be secondary infections growing on decaying plant tissue. While they may contribute to the severity of symptoms, they are unlikely to be direct causes of pasture dieback.

Is it nutrition?

Most Australian soils are low in phosphorus. Availability of this element is often considered to be a key limitation on pasture growth. The symptoms of phosphorous deficiency in plants include poor root development and development of reddish-purple tips and striping, particularly on the older leaves. Not only are these symptoms consistent with the early stages of pasture dieback, buffel grass leaves with dieback are frequently lower in phosphorus than normal leaves.

There is some evidence that dieback is worse if soil phosphorous is very low (Rogers, 2018). However, paired sampling indicates little correlation between dieback and soil fertility. While many patches affected by dieback have low phosphorous, so do the unaffected pastures in neighbouring paddocks.

Poor nutrition also does not explain the spread of pasture dieback in expanding patches, its sudden appearance in previously healthy paddocks, or the increased prevalence of dieback in areas with the best pasture growth. Trials inducing phosphorous deficiency in buffel grass produced some of the symptoms of dieback (leaf reddening) but, even when combined with drought stress, did not result in grey and brittle dead plants.

The explanation for the apparent correlation between phosphorous deficiency and dieback may lie with sap-sucking insects. While such insects mainly feed on the phloem vessels (carrying carbohydrates to the roots), they also extract nutrients from the xylem vessels (carrying minerals to the leaves). Feeding on the plant can therefore induce symptoms of nutrient deficiency in the leaves, particularly if availability is low.

Nutrient deficiency is therefore associated with pasture decline, rather than dieback, it likely reduces resilience, making plants more vulnerable to damage.

Is it an insect?

Insects are a key suspect in the pasture dieback mystery. Mealybugs, nematodes, ground pearls and other soil dwelling insects have all been investigated as potential causes of pasture dieback.

The key insect associated with dieback has been identified as the pasture mealybug *Heliococcus summervillei* (Schutze et al., 2019). It is found across many areas affected by pasture dieback, with high mealybug density frequently associated with more severe symptoms. Pasture mealybug feeds on both leaves and roots. The species is known to have caused major dieback of paspalum in Queensland during the 1920s (Summerville, 1928), then again in 1938 (Brookes, 1978). In New Caledonia, a major infestation resulted in widespread pasture dieback in 1998 (Brion et al., 2004).

The mealybugs are covered in fine waxy filaments, giving them a floury or 'mealy' appearance. They are very small and require a hand lens to observe them. Even the adult females are only a few millimetres across (Figure 6).

Glasshouse trials have found that introducing mealybugs onto apparently healthy buffel grass caused plants to develop symptoms consistent with dieback, while plants have also been observed to recover when treated with insecticides (Hauxwell and McNichol, 2018).

Field inspections have found young mealybugs several metres from dieback patches, with higher populations at the outer edge of the affected area. The expansion of dieback in paddocks is therefore consistent with an increasing and spreading population of mealybugs (Hauxwell and McNicholl, 2018).

Extensive surveys have shown that pasture mealybug is found mainly in the dense crown of the plant, as well as on leaves and in the soil. The early life stages of mealybugs – crawlers – move in search of food, both underground and on the soil surface, while adults will move through the soil profile in response to moisture. Pasture mealybugs can reproduce underground (Figure 7) as well as under logs and cow pats and in dense grass thatch .In these protected locations, they can survive extended dry periods as well as extremes of heat and cold, re-emerging when conditions become more favourable.

While winged male mealybugs do occur, female mealybugs do not need to mate to reproduce. This means a single female can give rise to a large and increasing population. Females cannot fly but can readily disperse by wind, water, vehicles, animals, equipment and on infested hay. This long-distance travel may explain the sudden appearance of dieback on previously unaffected properties.

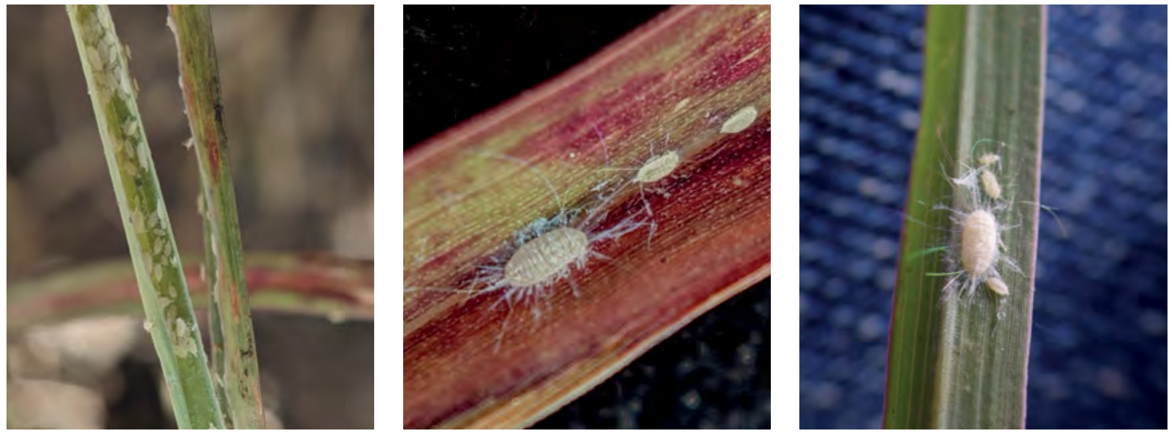


Figure 6. Early and late instars of pasture mealybugs on leaves (Photos: N. Diplock, AHR and C. Hauxwell, QUT)

Figure 7. Pasture mealybugs can be found on the soil (Photo: N. Diplock, AHR) and reproduce within it (Photo: E. Bryans, QUT)

Young pasture mealybug nymphs (crawlers) are virtually invisible to the naked eye, being less than 0.3 mm long. Their small size means they are easily dispersed by wind and water. Adults are pinkish, 2mm long with a waxy appearance and disperse within a paddock by crawling (Figure 8). Mealybugs can also disperse in water, on infested hay and through transfer on vehicles and animals.

Figure 8. Pink reproductive adult female mealybug (left) juvenile female (centre) (Photos: N. Diplock, AHR) and winged male mealybug (right) (Photo: A. Dickson, QUT)

Other insect pests that have been associated with pasture dieback include Rhodesgrass mealybug (*Antonina graminis*) and ground pearls (*Margarodes australis*).

Rhodesgrass mealybug caused major pasture dieback in southern Texas and Florida after it was introduced in the 1940s (Chantos et al., 2009). It feeds on a wide range of pasture species, particularly Rhodes, kikuyu and bermudagrass. The insects are often found at the base of the plant and under the leaf sheaths at plant nodes. Once established in a suitable feeding site, the adults shed their legs, so cannot move to new hosts. They also differ from *H. summervillei* in that the dark insect often protrudes slightly from the centre of its waxy coating, giving a 'halo' effect (Figure 9).

While mealybugs are strongly suspected of playing a major role in pasture dieback, other insects have also been identified at multiple sites, and their potential role is under investigation.

Figure 9. Rhodesgrass mealybug, *Antonina graminis* (Photo: C. Hauxwell, QUT)

RECOGNISING PASTURE DIEBACK

Ground pearls are tiny, soil-dwelling insects related to scale. Pink ground pearls (*Eumargarodes iaingi*) are a major pest of sugarcane and turf grasses. However, it is white ground pearl (*Margarodes australis*) that has been found in areas affected by pasture dieback. Nymphs form spherical cysts up to 3mm diameter. The adults appear similar to mealy bugs, but without their waxy coating (Figure 10).

Figure 10. Ground pearl cyst (left) and adult (right) (Photos: N. Diplock, AHR)

Nematodes, such as the root knot nematode *Meloidogyne* spp., have also been found in pastures affected by dieback. Although nematodes can impact pasture establishment and reduce productivity (Mercer et al., 2008), they rarely kill plants.

While mealybugs are a likely cause of pasture dieback, simply feeding on the plant does not fully explain why dieback affected plants become distinctly grey and brittle, or why low insect populations appear able to kill previously healthy plants. It is possible that a toxin is involved, being introduced into the sap during feeding. This would also explain the observation that dieback affected plants develop xylem blockages, a reaction designed to prevent pathogen transmission through the plant. If a toxin is involved, it may explain the severity of symptoms as well as the lack of recovery in dieback affected areas. Current research work is investigating whether pasture mealybugs introduce a toxin into dieback affected pastures.

Are mealybugs the primary cause of pasture dieback?

FOR	AGAINST
• Mealybugs are often found on symptomatic plants. They are not found on dead plants, on which they cannot feed. • It is more common for insects than diseases to attack a range of host plants • Patterns of spread are consistent with an increasing mealybug population spreading from an initial infection point • Long distance spread is consistent with movement of mealybugs on vehicles, animals, equipment and fodder as well as in wind and water • Affected plants have stunted root systems lacking fine feeder roots, consistent with mealybug feeding damage • High levels of nitrogen may benefit mealybug reproduction; dieback is often worse in areas with higher nitrogen • Moisture increases mealybug activity; dieback is often worse along fence lines and roadways, where dew and runoff allow grass to grow thickly • Mealybug feeding makes plants more susceptible to disease and drought stress • Introducing mealybugs to healthy plants can cause dieback symptoms • Plants may recover if treated with insecticide • *Heliococcus summervillei*, has caused pasture dieback before in Australia and overseas	• Mealybugs are not always found on dieback affected plants and pastures • Pasture mealybug is known to have been present in Queensland for more than 100 years – what has changed?

It seems likely that more than one factor is involved in creating pasture dieback

RECOGNISING PASTURE DIEBACK

SUMMARY OF CURRENT INFORMATION ON THE CAUSE(S) OF PASTURE DIEBACK

Dieback does not appear to be caused by disease or nutrient deficiency, although both do occur on affected pasture and may make symptoms worse. Mealybugs, especially the pasture mealybug *H. summervillei*, are strongly associated with pasture dieback. However, pasture mealybug has been present in the affected area for at least 100 years. Unless a new mutation has increased virulence, such as by injection of a toxin during feeding, it seems likely that a combination of mealybugs with other environmental stresses is responsible.

The factor that has changed most in the last 10 years is the climate. Drought, high temperatures, soil compaction, waterlogging and other stresses make plants far more susceptible to attack by insects and diseases. Other factors include the biological, physical and nutritional qualities of soil. Any or all of these may be increasing the effects of insect pests which have always been present.

There are currently several active projects aimed at conclusively identifying the cause(s) of pasture dieback in Australia. These projects aim to clarify the importance of each of these factors, as well as better defining the different symptoms included under the general description "pasture dieback"

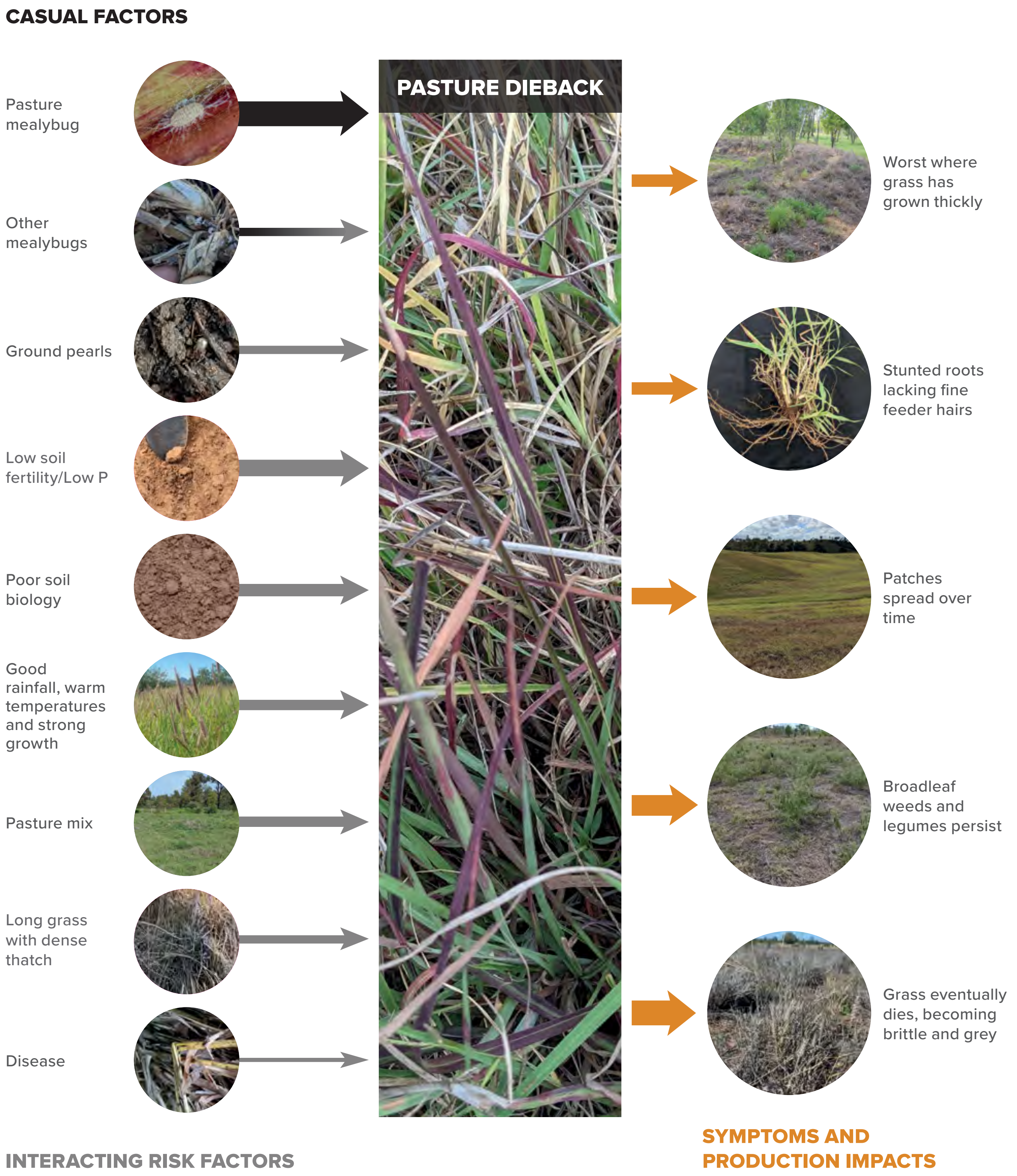
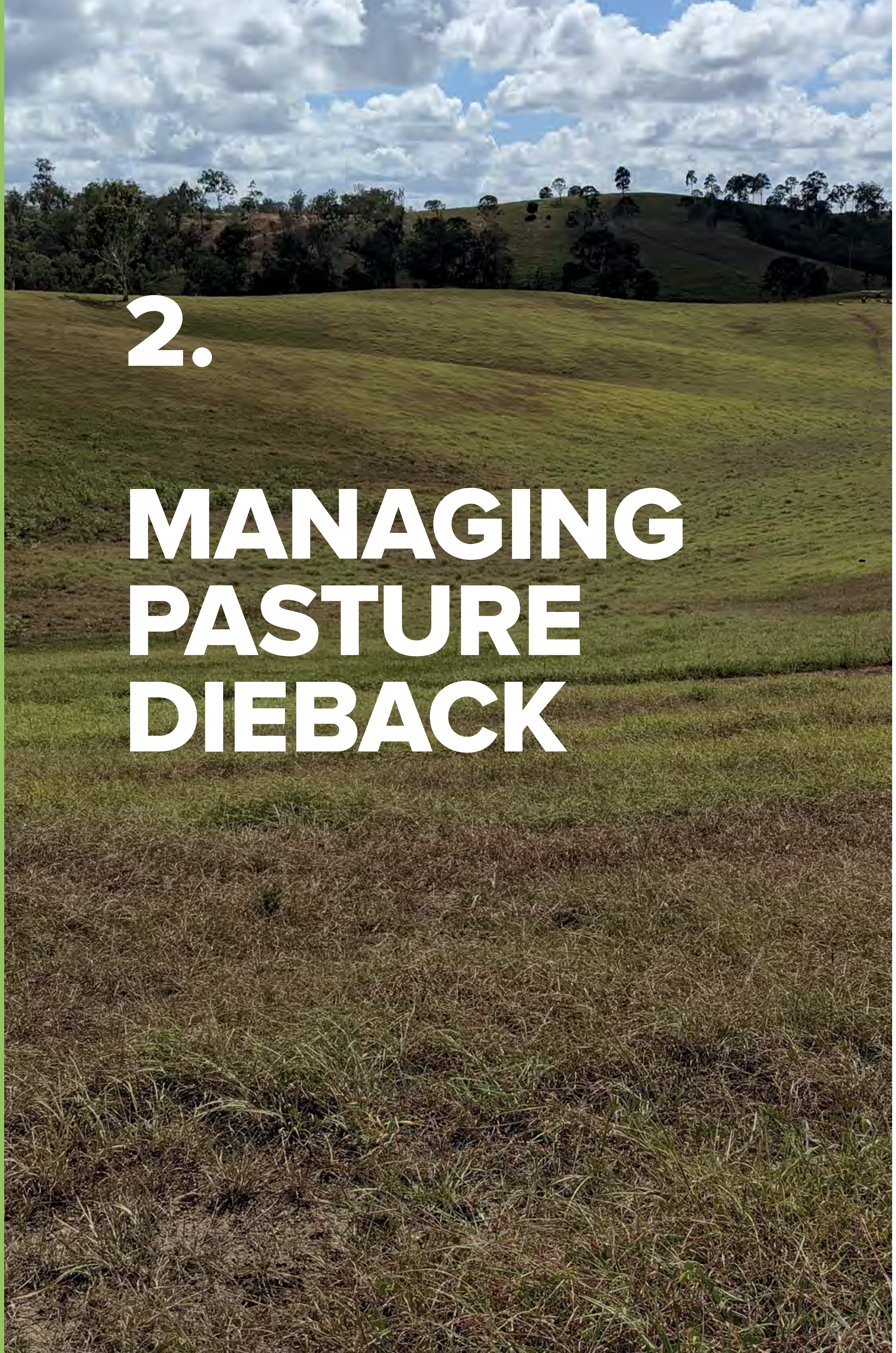


Figure 11. Summary of some of the factors associated with pasture dieback, and the symptoms that may be used to define its onset. The size of the arrow indicates the strength of the relationship.

RECOGNISING PASTURE DIEBACK



2. MANAGING PASTURE DIEBACK

BIOSECURITY

The first line of defence against pasture dieback is biosecurity. This can reduce the risk of dieback occurring in previously unaffected areas, as well as help limit spread where it does occur. A general property biosecurity plan used to minimise the risk from pests and diseases is likely to be useful to also minimise the risk of pasture dieback.

Key actions include:

- Monitor pastures for signs of dieback; consider limiting stock access to areas with isolated patches of dieback
- If cattle are purchased from dieback affected areas, keep them separate from other stock and monitor for signs of dieback in grazed pasture
- Avoid sourcing fodder from dieback affected areas
- Manage fodder distribution within the farm, limiting it to designated areas
- Limit access of external vehicles and machinery; use permanent onsite vehicles wherever possible
- Ensure vehicles and equipment that do come onto the property are free of dirt and trash, providing wash-down facilities if necessary
- Clean down boots, clothes and equipment when moving from pasture dieback affected areas into other areas on the property.
- Consider planting windbreaks, especially if upwind areas are affected by dieback

INSECTICIDES

Although insecticide appeared to control dieback in glasshouse trials, insecticides are **NOT recommended** for wider field application. Insecticides are unlikely to penetrate the soil sufficiently to destroy insects underground. However they are likely to kill beneficial insects such as ladybeetles, predatory bugs and lacewings above ground. They could therefore potentially make the problem worse. Insecticides are expensive, so the cost of broad-scale application is likely to be inhibitory. They can also leave chemical residues in meat if grazing withholding periods are not adhered to as well as damage the environment.

Refer to the Australian Pesticides and Veterinary Medicines Authority APVMA Minor and Emergency Use Permit website for a copy of the pasture mealybug permits for use in Qld and NSW (**portal.apvma.gov.au/permits**). Current permits and withholding periods (WHP) include:

- Imidacloprid (eg. Confidor 200SC) Permit 87423, 24 week grazing WHP
- Spirotetramat (eg. Movento 240SC) Permit 88482, 14 days grazing WHP
- Chlorpyrifos (eg. Lorsban 500EC or Cobalt) Permit 90238, Grazing WHP as per label requirements
- Carbaryl, Diazinon, Malathion, or Methomyl (eg. Kendon Carbaryl, Barmac Diazinon or Hy-Mal, Lannate-L) Permit 90239, Grazing WHP as per label requirements

BIOLOGICAL CONTROLS

The mealybug predator, *Cryptolaemus montrouzieri*, has been observed in large numbers in some pasture dieback affected areas. The insect has been reported in the literature as an effective biocontrol agent against various mealybug species (Gunawardana and Hemachandra, 2020). While the adult is readily recognisable as a type of ladybeetle, the larvae look like a large mealybug (Figure 12), and may be mistaken as such. This is believed to be a disguise against ants, which would otherwise defend the mealybugs as their source of honeydew. Females can lay up to 400 eggs, while both adults and larvae can consume up to 70 prey daily. However, while *Cryptolaemus* are efficient predators on the leaves, they cannot control mealybugs underground, which limits their effectiveness against pasture mealybug.

Figure 12. *Cryptolaemus* larvae (left) and adult (right) (Photos: N. Diplock, AHR)

Other generalist predators include lacewings, other ladybird species (e.g. the three-banded ladybird) and predatory midges. Green lacewing larvae disguise themselves with the bodies of their prey, so, like *Cryptolaemus*, can resemble large mealybugs (Figure 13). There are a number of parasitoid wasps that attack mealybugs and have proven effective biocontrol agents in the past. For example, the wingless parasitoid wasp *Neodusmetia sangwani* initially controlled Rhodesgrass mealybug in the USA (Chantos et al., 2009). A parasitoid wasp has been found which attacks pasture mealybug. However, like *Cryptolaemus*, these wasps cannot reach mealybugs deep underground.

Figure 13. Green lacewing larvae with mealybug prey (left) and three banded ladybird adult and pupae (centre and right) (Photos: N. Diplock, AHR)

CULTURAL AND AGRONOMIC MANAGEMENT

Field trials – grazing properties

Six large scale field trials were established in 2018 on dieback-affected grazing properties in central and southern Queensland. The trials tested a wide range of practices including burning, slashing, cultivation, re-sowing with legumes and/or pasture species, fertiliser application, and combinations of these. Plots were assessed 4 and 8 months after treatments were applied, and then again after 3 years. Dry conditions made it difficult to measure dieback and pasture productivity, so treatment effects were simply classed as positive or negative based on matched pairs (Figure 14).

Legumes are not affected by pasture dieback (Figure 15) or hosts to mealybug. The initial results showed that cultivating, adding moderate rates of nitrogen and phosphorus fertiliser and then re-sowing with legumes (e.g. butterfly pea, lablab, desmanthus) reliably improved plant biomass. Re-sowing with a mix of legume and pasture grass species was also frequently beneficial, in that increased feed available for cattle. Pasture seed that had been treated with insecticide (Poncho®) established well, suggesting that this may have provided some initial protection against dieback. For more on fertilisers see p26.

Cultivation alone, without re-sowing a desirable species, often had a negative effect. Weeds frequently established in the disturbed soil. However, cultivation with reseeding was often beneficial, a result also found in the Brian Pastures site trials.

Slashing or heavy grazing followed by fertiliser also produced transitory increases in pasture growth, with dieback symptoms soon re-appearing. However, these results may have been negatively affected by the poor environmental conditions at the time.

Burning initially increased growth but dieback soon returned. Although new, green shoots appeared after burning, this often failed to develop into substantial pasture. It seems likely that although burning killed aerial mealybugs, survivors deep underground soon restored the population. Burning is therefore not recommended for control of dieback.

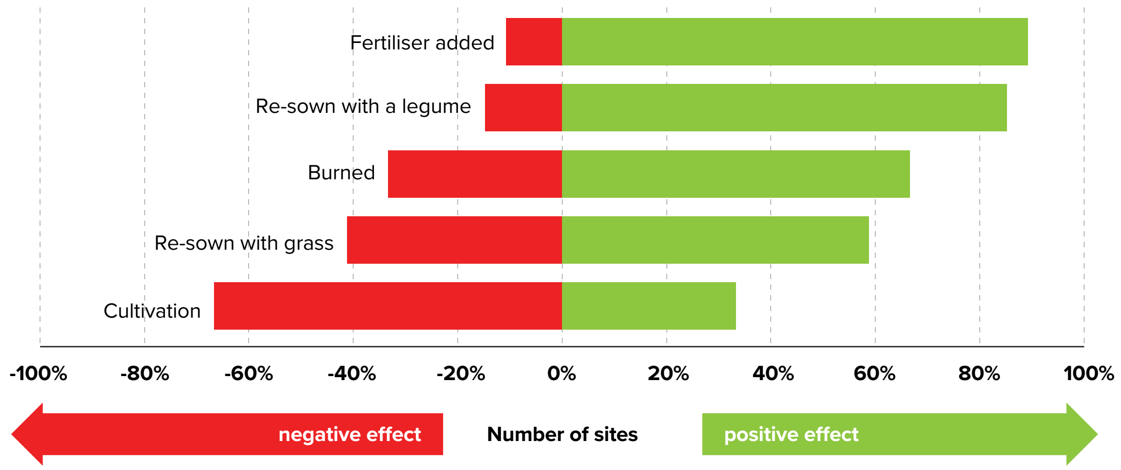


Figure 14. Effect of various agronomic treatments on total pasture biomass after eight months. Average data from three quadrats at four trial sites, each site assessed twice.

Figure 15. Dieback does not affect legumes, as this Wynn cassia seen here growing with dieback affected blue bisset (left); the cassia is still flourishing two weeks later when the grass has died (Photos: N. Diplock, AHR)

The 2018 sites were revisited in November 2020 to examine whether any treatment effects remained after three years (Figure 16). Despite the dry conditions, clear differences were visible between the treatments. Blocks which had been cultivated, then resown with a mixture of pasture and legumes had **50 to 60%** ground coverage with useful species (e.g. American or Gayndah Buffel grass, Callide and Reclaimer Rhodes grass or legumes). In contrast, the untreated control plots were often bare or had been invaded by weeds, with only **10%** coverage of useful species. Plots which had been burned had even less.

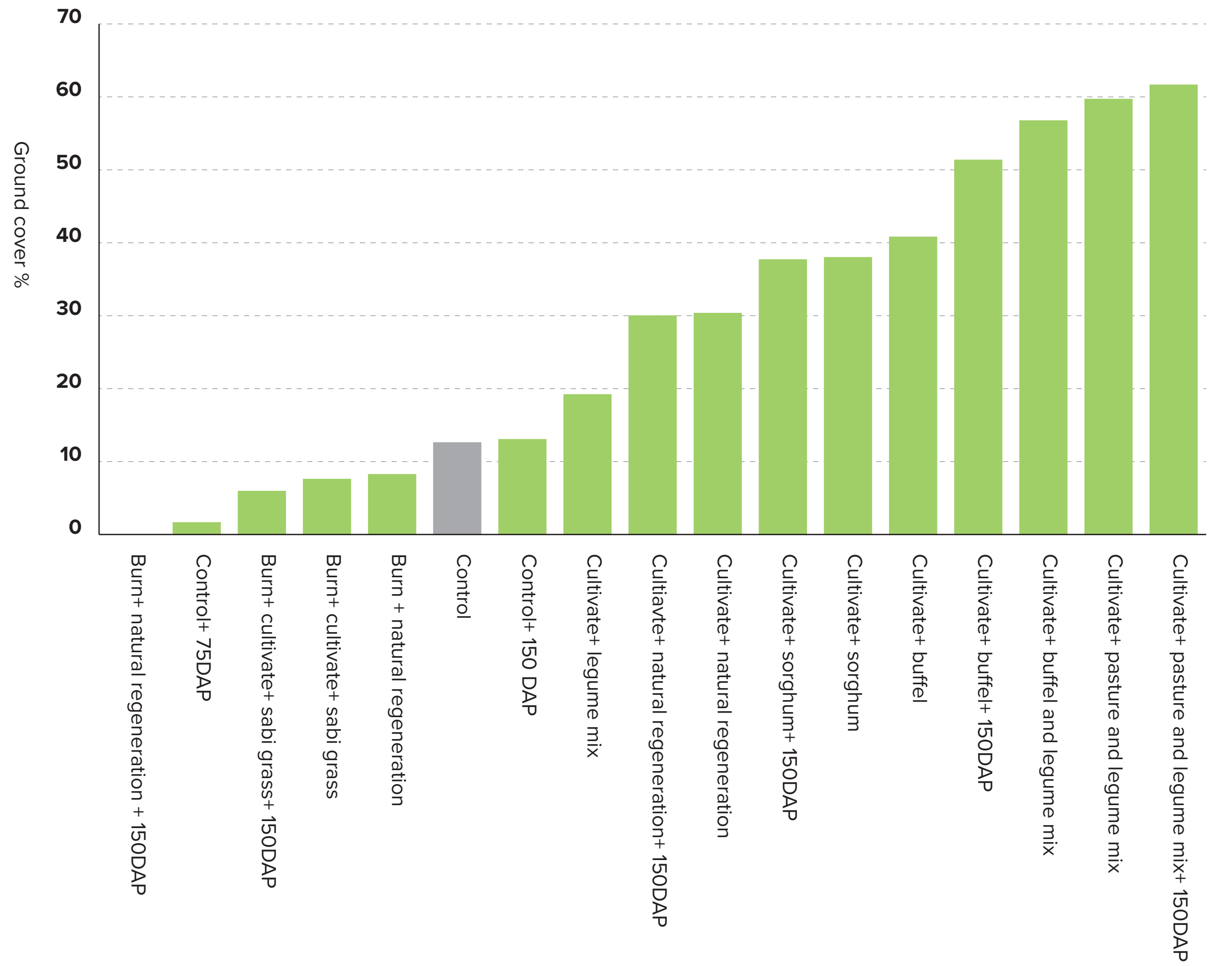


Figure 16. Average ground cover (%) of useful pasture species (sabi, buffel, Rhodes grass or edible legumes) at a trial site in Jambin. Assessments conducted November 2020, nearly 3 years after treatments were applied.

Some early results were affected by dry conditions as well as changes in grower management of certain sites. For example, some sites were grazed, whereas others were not. They need to be confirmed by longer term trials. This includes more detailed examination of legumes which, despite excellent initial results, can fail to persist without ongoing intervention. Further, similar studies are now (2021) being undertaken at four separate sites in central Queensland. These will examine the effect of stick raking and re-sowing with various pasture species and legumes, use of fertilisers and specific tolerance of different species to dieback following cultivation and re-sowing.

MANAGING PASTURE DIEBACK

Field trials – Brian Pastures site

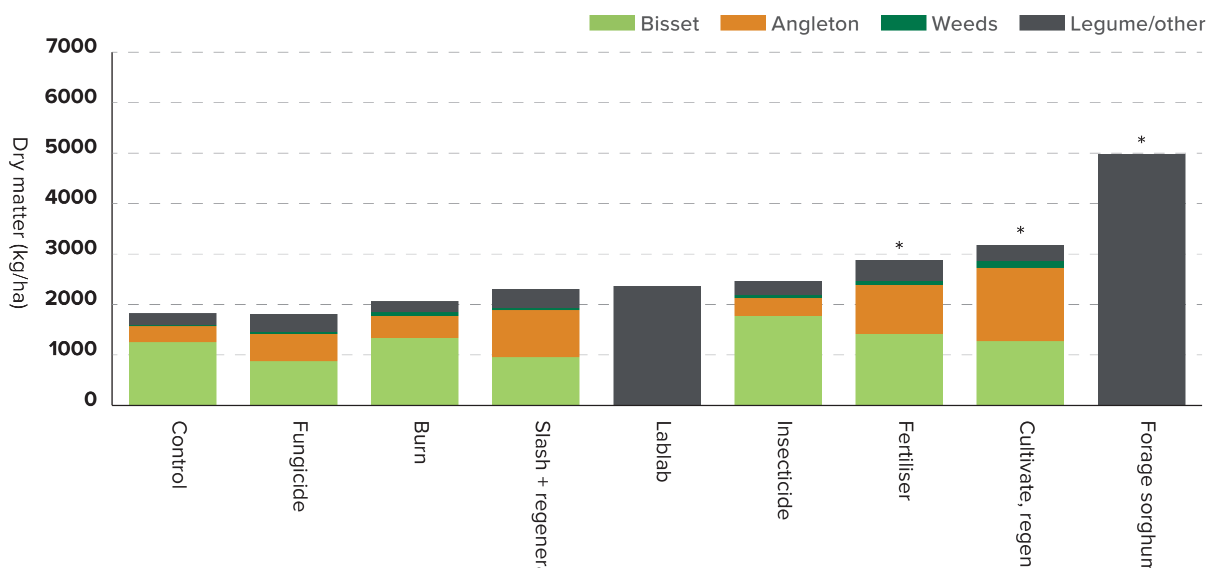
A number of different management strategies have also been tested at the Queensland DAF Brian Pastures Research facility near Gayndah. Two trial sites with replicated treatments were established in 2018; one was a Bisset creeping bluegrass pasture with moderate dieback symptoms , the other having the same pasture species but with very advanced dieback (only weeds and legumes remaining). These trials were also challenged by the dry conditions in 2018–9, followed by heavy rainfall in February 2020.

A key finding was that the Bisset creeping bluegrass had naturally regenerated, especially in the severely dieback affected trial, despite ongoing presence. Recent observations (April 2021) show that this process is continuing.

After two years, the treatments involving fertiliser, cultivating plus regenerating and sowing forage sorghum all improved total dry matter compared to the control at the moderately affected site.

Although a single cultivation and allowing to regenerate also slightly increased dry matter at the severely affected site, the difference was not significant. This was partly because the severely affected area recovered better than the site with previously moderate dieback, dry matter increased by an average 50% across all treatments.

Angleton grass, a species observed to be more tolerant to pasture dieback, tended to increase relative to Bisset creeping bluegrass, with legumes also showing strong growth across most treatments. Interestingly, the combination of cultivation and regeneration increased the ratio of grasses to legumes, particularly at the severely affected site, possibly indicating they were favoured by this treatment.



*indicates mean values that are significantly different to the control

Figure 17. Moderately dieback affected site

Dieback tolerant species

Legumes: Annual and perennial forage legume species are not affected by dieback. Cowpea and lablab are productive, annual species which are easy to grow and can provide short term feed. Cowpea is better for wetter areas and can deliver quick, early growth. Lablab is more drought tolerant and provides longer, sustained growth. Perennial legumes worth considering include *Desmanthus, Leucaena*, butterfly pea and the stylos, especially in pasture mixes. Some of these can persist for decades with good management:

- ***Desmanthus* spp.** may be useful certain areas, especially when blends of different selections are selected to suit the site characteristics e.g. heavy vs sandy soil.
- **Caatinga stylo** (*Stylosanthes seabrana*) is more cold tolerant than Caribbean stylos, can persist after heavy grazing and is the only one suited to clay soils, but requires a specific rhizobium to flourish.
- **Fine stem stylo** (*Stylosanthes guianensis* var. Intermedia) is suitable in a limited geographic range of sandy soils and coastal areas, but seed may be difficult to obtain.
- **Shrubby stylos** (*Stylosanthes scabra*) grow well in infertile soils if there is good drainage and at least 600mm annual rainfall.
- **Siratro or purple bush bean** (*Macroptilium atropurpureum*) is a sprawling vine that provides feed as well as reducing soil erosion. It can thrive in many different soil types and dry conditions, but does not tolerate poor drainage.
- **Burgundy bean** (*Macroptilium bracteatum*) is deep rooted and drought tolerant. Although relatively short-lived it regenerates well from new seedlings.
- **Butterfly pea** (*Clitoria ternatea*) grows well on heavier soil in tropical regions and can persist indefinitely in situations that allow self-seeding. It has good drought tolerance but has variable responses to waterlogging and is sensitive to frost.

Legumes must be inoculated with the correct strain of *Rhizobia* bacteria to grow well. To provide optimum animal nutrition, perennial legumes are best used as part of a pasture mix with grasses. However, it may be more effective to plant pure stands of legumes in heavily dieback affected areas.

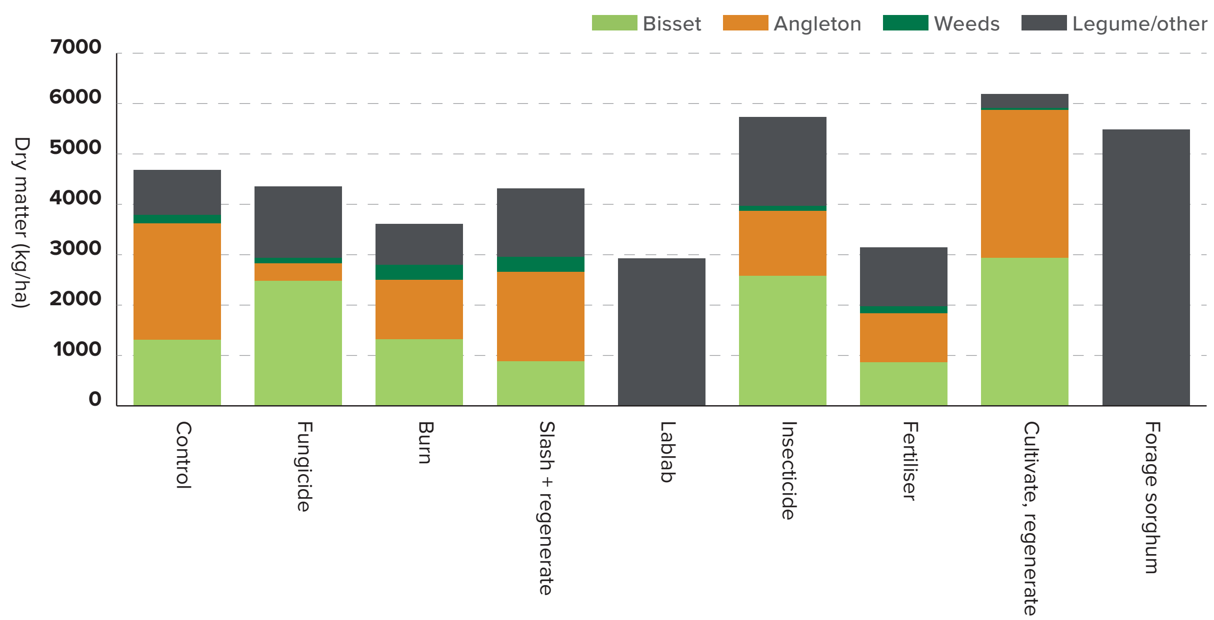


Figure 18. Severely dieback affected site

MANAGING PASTURE DIEBACK

Grasses: Tropical pasture grasses vary in their susceptibility to dieback. There are reports that Biloela buffel is more tolerant of dieback than American or Gayndah buffel, while Callide and Katambora-type Rhodes grasses have established well in field trials on dieback affected pastures. There are indications they are still persisting in central Queensland after three years. Callide-type Rhodes grass varieties have good forage quality but are only suited to higher rainfall, fertile coastal soils, whereas the Katambora types (e.g. Reclaimer) can persist in drier inland areas.

Re-sowing with pasture mixes, particularly with legumes, has been shown to be effective in many trials. The cost of resowing is high, cultivation is difficult in many Queensland grazing areas, and some grass species can take up to a year to fully establish, depending on environmental conditions. Despite these drawbacks, it remains the best option so far.

Forage crops such as sorghum, millet, oats, and barley do not appear to be affected by dieback. While not a permanent solution, such crops can feed stock in the short term. Seed, sowing and establishment costs need to be considered, as well as the suitability of the region and issues relating to animal health.

Tests for relative susceptibility to pasture mealybug have shown that Rhodes grass is less susceptible than American buffel. Panic grasses appear to be more tolerant of pasture mealybug and less susceptible to dieback. New research is now investigating a wide range of pasture species and mixes for their tolerance to pasture dieback, as well as vigor and persistence in dieback affected areas.

Fertilisers

Dieback has been reported as worse under trees and between rows of Leucaena, even though these areas might be expected to have better biodiversity and soil health. One possible explanation is that soil in these areas contains higher levels of nitrogen. Increased nitrogen has been demonstrated to stimulate activity of many pests, including sap sucking insects such as mealybug (Fadlelmawla et al., 2020). It is therefore **not recommended to apply pure nitrogenous fertilisers** such as urea to dieback affected pastures.

Despite this, there are significant benefits in pasture productivity from improving soil nutrient levels. Fertilisers containing both phosphorus and nitrogen such as MAP (mono-ammonium phosphate) and DAP (di-ammonium phosphate), or even superphosphate (phosphorous plus sulfur), can be useful for improving nutrition. It has previously been observed that early symptoms of dieback resemble phosphorous deficiency; while lack of nutrients is not thought to be a cause of dieback, it may contribute to its severity.

Improved nutrition can help with crop establishment as well as increase early growth. The initial field trials found that, on average, fertilising cultivated and re-sown pastures with 150 kg/ha DAP increased dry matter pasture yield by 72% over the first 8 months. Pasture mass increased by more than 20% in 14 of the 15 sites assessed. Even after three years a slight improvement in ground cover remained, although differences were no longer significant.

Obtaining a soil test from a reputable testing laboratory, combined with a fertiliser recommendation from an experienced pasture agronomist, is the best way to optimise fertiliser application.

Other strategies – intensive grazing

Grazing and slashing prevent accumulation of the thick, thatched grass which provides ideal mealybug habitat. Graziers have reported that intensive grazing can limit dieback by reducing biomass and stimulating plant growth. Stock can be managed to graze out edible weeds, prevent seeding of undesirable species, and improve seed dispersal of preferred grasses. Slashing, to simulate heavy grazing, is one of the practices being tested in the current field trials.

Modification of grazing practices must consider the local environmental conditions and be commercially viable. It is also important to avoid further damage through overgrazing and loss of groundcover. Some graziers are using the strategy of high pasture utilisation in areas or years when pasture dieback is prevalent, followed by conservative grazing practices when pasture dieback is not an issue. As the nutritional value and palatability of dieback affected pasture is poor, when dieback is first observed it may be best to heavily graze the paddock before dieback spreads further: the 'use it or lose it' strategy (I. Naggs, pers. com.). However, it must also be considered that cattle can potentially carry mealybugs with them when they move to other areas.

Other strategies – soil aeration

Some graziers are trialling soil aeration of coastal pastures and achieving apparent success (I. Naggs, pers. com.). Aeration helps to overcome soil compaction, releases mineralised plant nutrients and disturbs the habitat of soil pests such as pasture mealybug and ground pearls. Further trials and observations are required before soil aeration can be widely recommended.

Other strategies – increasing plant biodiversity

Many Queensland pastures are virtual monocultures. Increasing pasture diversity can improve environmental resilience by providing habitat for beneficial microbes in soil and beneficial insects above. For example, parasitoid wasps feed on nectar from flowers, while *Cryptolaemus* and other ladybirds need other prey to survive on when pasture mealybugs are not present.

Soils containing a diverse range of plants are also more likely to host colonies of mycorrhizae – fungi that grow on and in plant roots. These fungi can help plants take up nutrients (including phosphorous), increase defense responses and protect from stress. When grass-pastures are combined with mixes of legumes, forages, or other edible shrubs, beef production can still occur if dieback affects all grasses present in the paddock.

MANAGING DIEBACK – BEST BETS

Biosecurity

- Monitor paddocks and do not allow stock to freely access areas with developing dieback patches.
- Avoid sourcing fodder from dieback affected areas.
- Limit movement of cattle purchased from dieback affected areas and monitor paddock for signs of dieback.
- Limit access of external vehicles and equipment to the property and ensure those entering are free from mealybug, mud, grass and other organic matter.
- Consider planting windbreaks, particularly downwind of dieback affected areas.

Insecticide

- APVMA Minor Use Permits enable the use of certain of insecticides to control pasture mealybug. Insecticides are NOT recommended for widespread application: they should only be used as an early intervention to manage small patches of infestation and prevent further spread.

Biological control

- Encourage beneficial insects, such as the “mealybug destroyer” *Cryptolaemus*, by increasing pasture biodiversity.
- While this approach can provide many benefits, biological control agents are greatly affected by prevailing conditions (season, food source), making it challenging to achieve large impacts in the short term.

Agronomy

- Legumes are not susceptible to dieback.
- Annual forage crops do not appear to be affected by dieback and may provide short-term feed.
- Cultivation, then re-seeding with a legume or pasture plus legume mix, and fertilising with 150kg/ha DAP, has provided high productivity improvements on dieback affected pastures.
- Fertilisers have had limited effectiveness in field trials. However, blended products that include multiple nutrients may correct deficiencies and help seedlings establish; use soil test results to guide fertiliser type and application rate.
- Burning, or cultivating without re-seeding, have shown variable results, increasing weed growth while allowing dieback to return. Further research is needed to determine the longer-term effectiveness of these practices.
- Manage grazing or use slashing to reduce thatch and promote pasture productivity (Cell and heavy grazing benefits need to be validated).

CONCLUSION

There is no easy ‘cure’ for pasture dieback. The massive scale of the affected area makes active intervention challenging.

There is not even absolute proof of the cause, although it is highly likely that pasture mealybug is a key mediator of the condition.

It is unlikely that targeting mealybugs directly will be cost-effective in the long term. Rather, maintaining property biosecurity and increasing biodiversity eg by incorporating tolerant pasture species such as legumes and tolerant grasses or other forages, should be key practices to consider.

Work is continuing to find solutions which are practical and affordable for graziers. to implement. Research updates, new management strategies and other information on pasture dieback will be promoted through MLA as well as through State government agencies as information becomes available.

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WEB LINKS

NSW DPI Pasture Dieback info is:
dpi.nsw.gov.au/agriculture/pastures-and-rangelands/establishment-mgmt/pests-and-diseases/pasture-dieback

DAF Pasture Dieback Industry network via:
futurebeef.com.au/knowledge-centre/pasture-dieback/

Queensland University of Technology:
cms.qut.edu.au/__data/assets/pdf_file/0006/786066/pasture-mealybugs-technical-note.pdf

Applied Horticultural Research:
ahr.com.au/blog/7i5xsuz0t4i8exke4kly6sy3mgis6e

MLA's Pasture Dieback Hub:
mla.com.au/research-and-development/Grazing-pasture-management/pasture-dieback/

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