



final report

Project code: B.NBP.0639

Prepared by: Stuart Buck, Brian Johnson, Joseph O'Reagain, Gavin Peck,
David Lawrence, Gina Mace and Byrony Daniels
Department of Agriculture and Fisheries

Date published: 10 February 2017

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Improving productivity of rundown sown grass pastures

Volume 2: Improving understanding and testing mitigation options with industry

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

This publication is published by Meat & Livestock Australia Limited ABN 39 081 678 364 (MLA). Care is taken to ensure the accuracy of the information contained in this publication. However MLA cannot accept responsibility for the accuracy or completeness of the information or opinions contained in the publication. You should make your own enquiries before making decisions concerning your interests. Reproduction in whole or in part of this publication is prohibited without prior written consent of MLA.

Abstract

This volume covers the activities, outcomes and learnings from the first component of the Improving productivity of sown grass pastures project, that being: Improving understanding and testing of mitigation options with industry.

Knowledge and understanding of the process, impact and mitigation strategies of pasture rundown varies across industry (graziers and advisors). While graziers are implementing practices aimed at overcoming rundown, there is little successful adoption of effective mitigation strategies. Therefore significant opportunities exist for the beef industry to increase productivity and returns from rundown sown grass pastures using the most applicable mitigation strategy(s).

A considerable amount of awareness raising and improvements in understanding occurred through various industry engagement activities and publications. It is estimated a total of over 2000 graziers and industry personnel directly engaged at project activities or with project staff at other events, and thousands more read project outcomes in media publications produced over the life of the project. Almost 130 on-farm demonstrations or research trials were initiated, and feedback from industry (e.g. pasture seed companies) indicates practice change is occurring. For example, fallowing is being used more frequently before sowing legumes, more graziers are seeking information and are sowing legumes, soil testing is being more frequently conducted in existing and for new pastures, and phosphorus fertiliser is now being applied to existing legume-grass pastures where soil phosphorus levels are low.

The project team used a broad engagement strategy, together with targeted learning-based approaches, to work with industry (graziers, advisors, seed industry) to improve the understanding of the process and impact of pasture rundown, identify and to develop and test mitigation options on-farm. This on-farm testing provided real farm data and practical application experiences that were extended to the wider grazing community.

Executive summary

There are three main components to this project:

1. Improving understanding and testing of mitigation options with industry
2. Testing persistence and comparative productivity of legumes in sown grass pastures in Queensland
3. Improving the productivity of legume grass pastures.

This volume covers the activities, outcomes and learnings from the first component of *the Improving productivity of sown grass pastures project*, that being: *Improving understanding and testing of mitigation options with industry*.

Knowledge and understanding of the process, impact and mitigation strategies of pasture rundown varies across industry (graziers and advisors). While industry are recommending and graziers are implementing practices to overcome rundown, there is little successful adoption of *effective* mitigation strategies by graziers. Therefore significant opportunities exist for the beef industry to increase productivity and returns from rundown sown grass pastures using the most applicable mitigation strategy(s). The project team used a broad engagement strategy, together with targeted learning-based approaches, to work with industry (graziers, advisors, seed industry) to improve the understanding of the process and impact of pasture rundown, and to identify and test mitigation options on-farm. This on-farm testing provided real farm data and practical experiences that were extended to the wider grazing community.

The objectives of this project component were:

1. Increase the awareness and understanding of pasture productivity decline through publication in popular media and other extension products (e.g. fact sheets, field days, field walks) and the use of existing sites as demonstrations.
2. Develop a learning package and, using this, engage with 26 grazer groups to demonstrably improve the understanding of pasture rundown processes, impacts, and mitigation options, and to identify and test mitigation options on-farm (160 documented management strategies, 90 on-farm research trials, 12 trials with detailed analyses).

A considerable amount of awareness raising and improvements in understanding occurred through various industry engagement activities and publications. It's estimated a total of over 2000 graziers and industry personnel directly engaged at project activities or with project staff at other events, and thousands more read project outcomes in media publications produced over the life of the project.

Increase awareness and understanding of pasture productivity decline

The project team engaged with graziers and industry at numerous workshops (see the next section on developing a learning package); 27 field days and 57 information events that were either coordinated or attended by project staff. Many presentations about pasture rundown were delivered at events coordinated by other organisations (e.g. Meat and Livestock Australia (MLA), Natural Resource Management (NRM) groups). A range of less formal yet highly valuable engagement also occurred with specific industry personnel, including seed companies and re-sellers, Queensland government extension staff, NRM personnel, retired agronomists and scientific peer audiences. Engagement with the general community occurred through the publication of three fact sheets, 25 newspaper and magazine articles, one radio interview, and two webinars. Engagement with scientific

audiences occurred at six national conferences through 23 papers. Overall, the range of engagements were critical to complement the learning package activities (e.g. workshops outlined in the next section) and information events which assisted in the effective dissemination of information across the broader grazier communities. As some of these conversations were one-on-one (especially with seed companies and re-sellers), meaningful dialogue with higher learning typically occurred. Anecdotal and direct feedback from seed companies indicate practice change is occurring, for example: fallowing is being used more frequently before sowing legumes; more graziers are seeking information on which legume and how to sow legumes; soil testing is being more frequently conducted in existing and for new pasture sowings; and phosphorus fertiliser is now being applied to existing legume-grass pastures where soil phosphorus levels are low.

Field days were aimed at demonstrating the successful implementation of strategies to address sown pasture rundown, for example fertiliser responses, legume establishment techniques, legume species comparisons. As graziers typically like to see and get an on-farm 'feel' for what works and what doesn't before tackling new technology themselves, field days can facilitate the adoption of management practices and were an effective action learning activity that complimented the other learning processes. A total of 27 field days were held across southern and central Queensland during the project period, with the majority during the last two years i.e. 2015 and 2016. Field days were either held at on-farm demonstration sites, on-farm research sites or at another location as organised by another industry organisation.

To compliment the range of other extension and engagement activities, project staff either coordinated information events or presented at forums organised by other organisations. Generally the aims of these events were to deliver general information about pasture rundown and the management strategies to address it. These events extended information to a large number of people across a large geographic area, and / or to audiences that would not necessarily come to an event focused solely on sown pasture rundown; generally a range of beef management topics were presented at these forums. As these knowledge awareness events differed to the workshops by having compressed information over a shorter time duration, immediate practice change was not specifically aimed for, and future engagement was not intentionally planned (the action plan development process did not occur). However some information days were preliminary type sessions to introduce the topic and facilitate future engagement i.e. workshops and on-farm demos were conducted subsequent to the information day. A total of 57 information events were undertaken and were generally held during the middle and end of the project period (2013 and 2015). Also, five were undertaken outside the target project area, in northern New South Wales, western Queensland and northern Queensland. The largest number of information events occurred in central Queensland, as many graziers in this area are highly concerned about the continuing decline of pasture productivity. Its apparent graziers have assessed that 'now is the time' to gain information and evaluate options to economically address pasture rundown, and so are eager to obtain information.

Develop a learning package and engage with grazier groups to demonstrably improve understanding of pasture rundown

The "learning package" was developed as a workshop linked to on-farm demonstrations and trials. Through an action learning process, participants learnt about the symptoms, causes and impacts of pasture rundown; what management options are available, and using this knowledge developed management action plans for their properties during workshops. Graziers were then supported to trial options on their own farm.

The action learning activities were not delivered as originally proposed. The project team were to engage with six grazier groups to develop and test the learning packages and test

mitigation options in the first year, and then engage with an additional 20 groups in years 2 – 5. Graziers were to be supported to test, compare and implement the “best” mitigation option(s) to suit their property and situation. The “learning package” was expected to evolve as new results became available but the content specifically targeted pasture rundown and included both workshop and on-farm field activities.

In reality, the project team was overwhelmed with interest from grazer groups in year 1 of the project. It was negotiated with MLA to conduct more workshops early in the project to meet this demand from producers. What resulted was a change in focus to more workshops early and therefore more focus on awareness, understanding and skills development with more people. Less on-farm testing and less follow up with people in groups occurred than outlined in the original proposal. The content delivered evolved and covered cause of pasture rundown, what management options can be used to mitigate the impacts and to develop a management strategy for participants’ properties.

In total 32 workshops were delivered over the life of the project, with most activities occurring in southern and central Queensland as these regions have the largest areas of sown grass pastures in northern Australia. Workshops were a highly successful method to deliver targeted information to a large audience across a wide geographic area. The project team exceeded the number of workshops required to deliver, and the number of participants engaged, due to the extensive interest across every district in the target regions. Initially the project team instigated these workshops and once other organisations heard about the value of the workshops the project team were inundated with requests to deliver more workshops (or shorter information style session) for a range of organisations at a number of locations. These requests clearly demonstrate the industry need for information as pasture rundown was, and still is, affecting a large number of graziers across millions of hectares.

Evaluation results collected from 326 workshop participants indicated attendees managed 814,000ha of sown and 881,000 of native pastures, and more than 286,000 head of cattle and 42,000 sheep. Anticipated practice change was also documented with many producers selecting different options for different paddocks on their property. Only a few (13%) of the responding participants indicated they were going to accept pasture rundown (and the resulting lower productivity) by reducing stocking rates, break up new country if available, or purchase more land. A larger number (41%) of responding participants indicated they were going to increase nitrogen cycling through either mechanical or chemical (herbicide) renovation. However, the majority (96%) of responding participants indicated they were going to increase nitrogen levels, with some applying fertiliser, but the majority were going to introduce legumes.

Workshops were an effective method of generating follow-up activity such as on-farm demonstrations and research trials. These sites enabled a continuation of learning, and in some cases these sites were utilised for field days enabling learning opportunities for the broader local community who were unable to attend another event e.g. workshop. However, the interest generated at the workshops for on-farm demonstrations wasn’t able to be matched with project resources (staff time and funds), and so consolidation and or picking of higher importance, strategic topics was undertaken. Likewise, interest and demand for workshops or information sessions from industry organisations was very high and more could have been delivered. The project team had to ensure sufficient resources were allocated to other contracted engagement activities, and so some requests for more workshops or information sessions were declined.

Almost 130 on-farm demonstrations and research trials were initiated, however a fewer number were seen through to completion. A range of issues impacted on the ability of graziers to undertake these activities including enthusiasm/desire at the time of implementation, time, machinery resources, finances, impending sale of property, and

weather conditions. Further, coordinating on-farm activities also took significant time and effort by the project team, and in some cases compromises had to be made to ensure time was allocated to other parts of the project. On-farm activities (regardless if these were demonstrations or research sites) were effective in engaging a large number of graziers and to demonstrate that the theory can be put into practice. The project team wanted to ensure knowledge imparted at the workshops actually lead to the aspiration and on-ground action of trying something different, with the team's support. This was seen as a critical step in the adoption pathway.

Acknowledgements

The authors wish to thank a number of people and organisations for their support in engaging industry on improving productivity of rundown sown grass pastures.

Several Landcare groups within central and southern Queensland assisted with organising workshops and field days. The following natural resource management organisations and their staff assisted with extension activities:

- The Fitzroy Basin Association
- Dawson Catchment Coordinating Association
- Capricornia Catchments
- Central Highlands Regional Resources Use Planning Cooperative
- Burnett Catchment Care Association

Incitec Pivot assisted the project through the supply of Green Urea fertiliser to support landholders assess how rundown (i.e. nitrogen deficient) their pastures were.

Final report outline

The final report has been organised in volumes due to the project having three components, each with multiple activities. The report has four volumes, volume one reports on the main results across the whole project with more detail being provided in the following volumes on each of the three components of the project. The titles of the four volumes are:

Volume 1: Project overview, key findings and recommendations.

Volume 2: Improving understanding and testing mitigation options with industry.

Volume 3: Persistence and comparative productivity of legumes in sown grass pastures.

Volume 4: Improving reliability of establishing legumes into existing grass pastures.

Table of Contents: Volume 2

1	Background.....	10
1.1	Success in achieving project objectives	10
1.1.1	Raising awareness	10
1.1.2	Delivering a “learning package”	11
2	Targeted grazier engagement.....	12
2.1	Workshops.....	12
2.1.1	Aim	12
2.1.2	Method.....	12
2.1.3	Results.....	13
2.1.4	Discussion	17
2.1.5	Learning from how workshops were delivered for future projects	19
2.2	On-farm demonstrations and research trials	20
2.2.1	Aim	20
2.2.2	Method.....	20
2.2.3	Results.....	21
2.2.4	Discussion	25
2.3	Field days	25
2.3.1	Aim	25
2.3.2	Method.....	25
2.3.3	Results.....	26
2.3.4	Discussion	28
2.4	Information sessions and forums at various events (such as Beefup forums)	28
2.4.1	Aim	28
2.4.2	Method.....	29
2.4.3	Results.....	29
2.4.4	Discussion	31
3	Industry engagement	31
3.1	Seed companies, resellers and commercial agronomists.....	31
3.1.1	AusWest Seeds (was bought out by PGG Wrightson seeds)	31
3.2	Beef extension and pasture agronomists within DAF and in other state government departments	32
3.3	Retired pasture agronomists	32
3.4	Natural Resource management groups.....	33
3.5	Scientific peer audience	33
3.6	Broader industry engagement through media and publications	35

List of figures

Fig. 1: Location of workshops.....	14
Fig. 2: Average dry matter and protein responses of fertilised sown pastures.	22
Fig. 3: Average incremental response rate of sown pastures to increasing rates of nitrogen fertiliser.	23
Fig. 4: Location of field days.....	27
Fig. 5: Location of information events.....	30

List of tables

Table 1: Indicative participation numbers anticipated in the project proposal and actuals delivered during the project for delivery of the “learning package”.....	12
Table 2: Locations, attendees, surveys collected and document strategies for workshops delivered by the project.	16
Table 3: Numbers of initiated on-farm activities addressing strategies and technique to address pasture rundown.....	21
Table 4: Legume establishment from the Wandoan on-farm research site.	24
Table 5: Legume establishment from the Moura on-farm demonstration site.	25
Table 6: The types and numbers of field days contributed to or organised by the project team.....	26
Table 7: Number of information events by region.	29
Table 8: Summary of conferences and papers delivered by the project team on sown pasture rundown.	34
Table 9: Details of webinars delivered by the project team on sown pasture rundown	35
Table 10: Summary of newsletter and magazine articles, and radio interviews conducted by the project team.	37

1 Background

There are three main components to this project:

1. Improving understanding and testing of mitigation options with industry
2. Testing persistence and comparative productivity of legumes in sown grass pastures in Queensland
3. Improving the productivity of legume grass pastures.

This volume of the report covers the activities, outcomes and learnings from the first component, which is *Improving understanding and testing of mitigation options with industry*.

Knowledge and understanding of the process, impact and management strategies of rundown varies across industry (graziers and advisors). While industry is recommending and graziers are implementing practices to overcome rundown, there is little successful adoption of effective mitigation strategies by graziers. Therefore significant opportunities exist for the beef industry to increase productivity and returns from sown grass pastures using the most applicable mitigation strategy(s). The challenge is to improve the industry's knowledge and understanding about rundown, so industry can make informed decisions and adopt the most applicable management option(s). To meet this challenge, the project team used a range of engagement activities centred on a learning-based approach to work with industry (graziers, advisors, seed industry) to improve the understanding of the process and impact of pasture rundown and to identify and test mitigation options on-farm. This on-farm testing provided real farm data and practical regional experiences that were extended to the wider grazing community.

1.1 Success in achieving project objectives

Two project objectives are related to this component of the project:

1. Increased awareness and understanding of pasture productivity decline through publication in popular media and other extension products (e.g. fact sheets, field days, field walks) and the use of existing sites as demonstrations.
2. Developed a learning package and, using this, engaged with 26 grazer groups to demonstrably improve understanding of pasture rundown processes, impacts, and mitigation options, and to identify and test mitigation options on-farm (160 documented management strategies, 90 on-farm research trials, 12 trials with detailed analyses).

1.1.1 Raising awareness

A considerable amount of industry engagement aimed at increasing awareness and understanding of pasture rundown occurred during the project. While the project team engaged with graziers and industry at workshops and events such as field days, a range of other engagement occurred with other industry personnel, including seed companies and re-sellers, Queensland government extension staff, natural resource management personnel, retired agronomists, scientific peer audiences, and the general community through fact sheets, newspapers, radio and newsletters. These engagements were critical to complement the learning package activities (i.e. workshops and on-farm trials), promoting dissemination of information across a broader audience base. As some of these conversations were one-on-one (especially with seed companies and re-sellers), meaningful dialogue with higher learning typically occurred.

1.1.2 Delivering a “learning package”

The “learning package” was developed to facilitate graziers through an action learning process to improve understanding and test management options. The process involved graziers:

- Learning about the causes, impacts and management options available for mitigating the impacts of pasture rundown.
- Assessing management options that are applicable to their situation (i.e. which management strategies are most suitable to their property based on availability of machinery, landscape features, soil types, pasture types etc.).
- Developing a management plan on what management options they intend to use on their own property.
- Trialling management options on farm.
- Sharing the results of the trials or demonstrations with other graziers.

The learning package was delivered as a workshop with follow up activities. The workshop included:

- Presentations covering the:
 - Symptoms and causes of declining pasture productivity (i.e. pasture rundown).
 - Costs to animal productivity, environmental performance and economic returns.
 - Nitrogen (N) cycling and the impact of low N availability (e.g. apply N fertiliser to demonstrate that nitrogen is limiting growth and the production potential),
 - Overview of the management options available to graziers. This included likely impacts on pasture and animal productivity.
- Documenting management strategies. Participants were facilitated through a process to plan what management options suited their property on a paddock by paddock basis.
- Planning on farm trials. Participants were supported to trial management options on their own property.

The technical content of the learning package changed over time as the industry needs changed and new and updated information from research trials were developed. Also, the process used were modified to suit the event and audiences. Existing training packages were reviewed (e.g. LeyGrain, GLM) and information incorporated where applicable. As results and outcomes from the research activities within this project became available they were included in the workshop process.

There was strong interest from graziers to participate in workshops during the project which led to a change in project delivery. Strong grazer interest resulted in more workshops being conducted in the first year and less on-farm testing and follow up with people in groups than originally proposed. In year 1, the project team engaged with 13 grazer groups, developed the learning package, and to a lesser extent tested mitigation options which contrasts with the 6 groups described in the project proposal. The strong interest and importance to graziers resulted in more participants and workshops being delivered than was anticipated in the project proposal (Table 1).

Table 1: Indicative participation numbers anticipated in the project proposal and actuals delivered during the project for delivery of the “learning package”.

Learning package deliverable	Indicative number in project proposal	Actual number achieved
Groups	26	32
Participants	208	418
Documented management strategy	160	237
Supported on-farm demonstration	90	157

2 Targeted grazer engagement

Specific, targeted activities with graziers were undertaken during the project, and these complimented the extension of information to the broader beef industry (outlined in section 3: Industry engagement). These targeted activities included workshops, on-farm demonstrations and research trials, field days and forums (information events). Activities were particularly targeted to graziers in southern and central Queensland, however due to the overwhelming interest a small number were undertaken outside of these regions (e.g. western and northern Queensland, and northern New South Wales).

2.1 Workshops

2.1.1 Aim

Workshops were delivered to improve participant understanding of pasture rundown processes, symptoms, impacts, and mitigation options. Workshops were also designed to assist grazer participants to identify the best mitigation option(s) for their own property, and provide the opportunity to test these on-farm, with the support of project staff. On-farm demonstrations and research trials were also utilised as focal sites for further grazer engagement e.g. field days, and to collect locally relevant pasture data to verify the benefits of the mitigation option and accelerate broader adoption.

2.1.2 Method

Generally, workshops were held for around $\frac{3}{4}$ day in a suitable venue such as a meeting room, community hall, or on-farm. Workshop content was primarily delivered using a PowerPoint presentation, hence the venue needed to be big enough to comfortably seat participants in all conditions (both summer and winter temperatures) and provide a suitable environment to use a data-projector.

The content of the workshops varied through the duration of the project. The earlier workshops primarily covered causes, symptoms, effects and management options to address sown pasture rundown. Workshops delivered towards the end of the project covered sown pasture rundown, however the content briefly discussed early legume establishment results from the research trials on legumes. Some information on legume species selection was presented as the results and insights from the old trial sites became available.

The project extension team developed the workshop to include participation and interaction, where attendees were provided the opportunity to discuss their experiences before developing their new knowledge into on-farm action. To facilitate this, ‘action plan sheets’

were developed, which provided the opportunity for attendees to write down an action plan and develop the most suitable mitigation option(s) to their own situation. The action plan included:

- what are you going to do differently
- what are the next steps to make it happen
- who
- when.

The action plan sheets were collated at the end of the day, scanned for the project team records and evaluation, and then handed back to participants as a record of their plans for future reference. Further discussions generally ensued, where workshop facilitators would ask participants to share what they had written, and why. This often led to conversations about them developing on-farm demonstrations for follow-up engagement and learning within the group.

2.1.3 Results

A total of 32 workshops were delivered between 2011 and 2015 across central and southern Queensland (Fig. 1, Table 2)

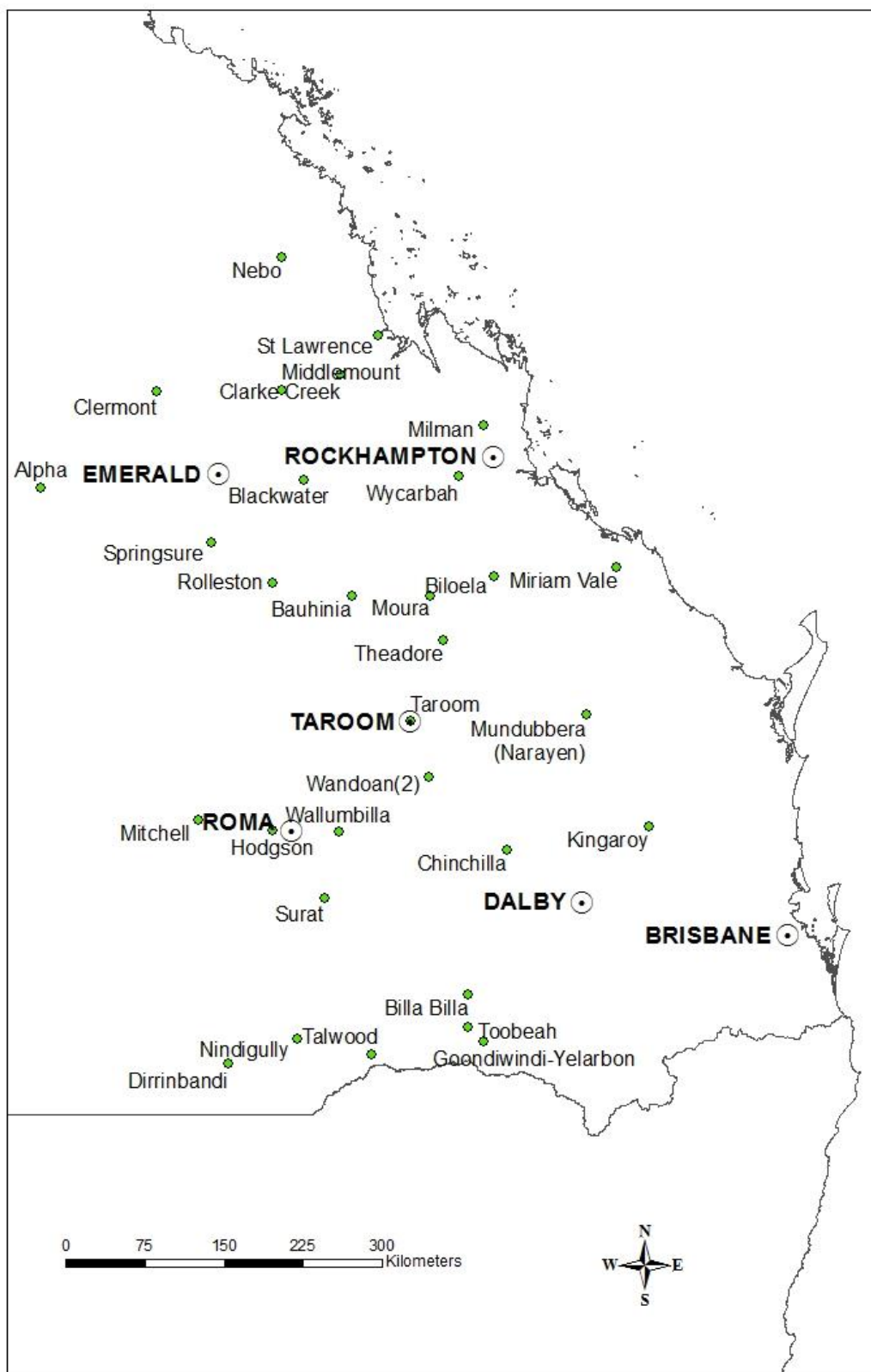


Fig. 1: Location of workshops.

A total of 418 people attended workshops on managing rundown sown grass pastures. This was an average of 13 producers per group which was higher than the proposed 8 – 12 producers attendance. There were 13 workshops delivered in year 1, eight in year 2, six in year 3 and five in year 4 with none in the last year. This is contrary to how workshops were to be delivered in the proposal, with six in the first year and 20 later in the project. The reason for this change was there was a lot of interest and enthusiasm from graziers, such that it was not going to be possible to restrict involvement to only six groups in the first two years of the project. In negotiation with MLA, the engagement approach was modified to cater for the demand with more workshops than described in the project proposal. There were 237 documented management strategies developed with producers during the workshops (Table 2).

Table 2: Locations, attendees, surveys collected and document strategies for workshops delivered by the project.

Grazier group	Attendees	Surveys collected	Rundown Strategies (Documented)
1. Biloela	5	4	4
2. Moura	11	11	9
3. Rolleston	12	12	8
4. Clarke Creek	21	13	7
5. Clermont	3	3	1
6. Springsure	10	10	9
7. Wycarbah	28	17	12
8. Wandoan	5	4	5
9. Taroom	18	16	16
10. Surat	18	0	7
11. Wallumbilla	9	13	12
12. Hodgson	8	6	5
13. Mitchell	17	8	6
14. Talwood	16	12	12
15. Chinchilla	8	8	7
16. Nindigully	13	12	11
17. Dirrinbandi	10	9	9
18. Nebo	11	11	1
19. Alpha	8	8	3
20. St Lawrence	15	5	4
21. Milman	15	13	12
22. Narayen	6	6	5
23. Mirriam Vale	12	6	6
24. Kingaroy	11	10	9
25. Blackwater	34	31	12
26. Bauhinia	15	15	9
27. Wandoan	8	7	5
28. Goondiwindi-Yelarbon*	18	16	5
29. Billa Billa*	7	6	5
30. Toobeah*	8	7	4
31. Middlemount*	24	19	10
32. Theodore*	14	8	7
TOTAL	418	326	237

Management strategies have been collated into modes of action to determine how many participants intend to implement which strategies. These are summarised below:

Evaluation results (326 surveys completed by approx. 78% of attendees)

Production areas

Area of sown pasture:	814,000 ha
Area of native pasture:	881,000 ha
Crop area:	180,000 ha

(from 251 surveys only, not asked on first 75 surveys)

Cattle numbers:	286,000 head
Sheep numbers:	42,000 head

Documented 'Strategies to manage rundown' from workshops (237 Strategies)

1. Issue: Accept Rundown and lower productivity (13%)
Management strategies to be implemented

- Break up new country if available (2%)
- Purchase more land (1%)
- Reduce stocking rates (5%)

2. Issue: Increase Nitrogen cycling (41%)
Management strategies to be implemented

- Mechanical renovation (35%)
- Chemical renovation (2%)

3. Issue: Increase Nitrogen levels (96%)
Management strategies to be implemented

- Apply fertiliser Nitrogen (27%)
- Introduce legumes (84%)

Increasing nitrogen (N) inputs through the use of legumes is clearly the most commonly intended management strategy, followed by mechanical renovation to increase nitrogen cycling.

As data and results from the research activities conducted in this project became available they were included in the workshop process with some preliminary establishment data delivered. Results from research were also delivered in a briefer format at information days reported in section 3.4.

A number of on-farm research demonstrations were instigated from the workshops. See section 3.2 for further information.

2.1.4 Discussion

Overall, workshops were a highly successful method to deliver targeted sown pasture rundown information to a large audience across a wide geographic area. The project team exceeded the project objectives in the number of workshops required to deliver, and the number of participants engaged, due to the extensive interest across every district with significant areas of sown pastures. Initially, the project team instigated the workshops and these were run in both southern and central Queensland during the early stages of the

project. Once industry and other organisations became aware of these events, the project team were inundated with requests to deliver more workshops (or shorter information style session), for a range of organisations at a number of different locations. Workshops were run in areas where there was deemed to be high interest and need at a particular locality. These requests clearly demonstrated the industry need for this information, as sown pasture rundown was (and still is) affecting a large number of graziers across many millions of hectares.

The initial workshop development process made the project team collate, synthesise, and deliver sown pasture rundown information into a producer friendly format. As indicated earlier, the cause of sown pasture rundown has been known about for some time, and so there was previously published material available that was compiled into the early workshop material.

The workshops were also an effective method of generating follow-up activity, such as on-farm demonstrations and research trials that ultimately lead to further learning opportunities e.g. field days. However, the interest generated at the workshops for on-farm demonstrations wasn't able to be matched with project resources (staff time and funds), and so consolidation and or picking of higher importance, strategic topics was undertaken. Likewise, interest and demand for workshops or information sessions from industry organisations was very high and more could have been delivered with more resources. The project team had to ensure sufficient resources were allocated to other contracted engagement activities, and so some requests for workshops or information sessions were declined.

Overall, positive feedback from participants was received. Participants learnt that sown pasture rundown due to nitrogen tie-up is different to land condition decline due to over stocking. They also learnt that the only way to address nitrogen tie-up is to increase nitrogen cycling or supply, and that legumes are the most economical, long term way of doing this. Knowledge and skills improvement is evidenced by the following feedback received by participants who filled out evaluation forms.

Specified knowledge and skills targeted by the project (impact of activities ranked in order by means)

Knowledge:

- the contribution of legumes to reduce rundown
- the symptoms of sown pasture rundown
- how the different options to overcome rundown work
- the likely impacts of rundown on my business
- how rundown and grazing practices interact
- what mechanical renovation does and does not do for rundown

Skills:

- increase the sustainability of my pastures
- develop an overall strategy to deal with rundown
- assess the extent of rundown in my pastures

Lowest rated learning/understanding:

- the costs (\$/ha) of rundown options for my property

Individual graziers biggest learning, changes as a result and future RD&E needs

Participants' biggest learning from the project's "Rundown activities"

(% of respondents)

Rundown: How Nitrogen works and is tied up	24%
Rundown: How to overcome	18%
Rundown: Symptoms and how to recognise	15%
Legumes: Benefits and how they work	15%
Legumes: Adapted species/varieties	13%
Legume establishment	7%
Nitrogen fertiliser	5%
Rundown: Impacts	7%

Over 82% of respondents nominated specific things they would change on their properties as a result of the things they learned at the "Rundown activities".

(% of respondents)

Legumes: To increase nitrogen	44%
Fertiliser: To increase nitrogen	14%
Do more trials	10%
Assess pasture more	10%
Legumes: establish in strips	6%
Persist and have confidence	3%

Further RD&E needs

(% of respondents)

Legumes: Species advice and support	24%
Legumes: Support/guide to establish into grass	14%
Trials (general)	14%
General advice to improve pastures	12%
Soil tests to understand and support work	6%
Fertiliser recommendations and advice	4%
Economics	2%

2.1.5 Learning from how workshops were delivered for future projects

When this project was developed it was thought that running a smaller number of workshops in the first two years, getting a few activities on ground then building up the number of workshops later was the better approach. In reality delivering a larger number early then tapering off meant that there was more on ground activity implemented early so results and outcomes could be incorporated into discussions with groups. The following should be considered in future extension activities:

1. Workshops should be conducted whenever there is interest and enthusiasm from producers.
2. There is a trade-off between how many activities such as workshops, field days or info days can be done simultaneously. It is not possible to do everything in any one year.
3. More workshops earlier means there are more on farm activities to show off later in the project.

2.2 On-farm demonstrations and research trials

2.2.1 Aim

As discussed in section 3.1, workshop participants were encouraged and assisted to develop a documented strategy for managing sown pasture rundown on their farm. From these, participants were supported to develop on-farm activities, including demonstrations or research trials, to test aspects of mitigation options. The project team assisted participants in clarifying specific research question(s), trial design, measurement and analysis of results. Overall, these on-farm activities provided a focal point for post-workshop activity, and the opportunity to test locally relevant mitigation options to accelerate adoption of techniques that improve nitrogen cycling or supply. Further, it was intended to collect data from management options that were not being investigated elsewhere in the project, or were seen as alternative mitigation options.

In the initial stages of the project (yrs. 1-3), six intensively supported grazer groups were to be coordinated, and from these approximately five participants per group were anticipated to conduct on-farm demonstrations. One intensively measured (i.e. more intensive soil, pasture or animal analysis and replication where appropriate) on-farm research trial per group was also to be supported. Indicative numbers of activities for the six intensively supported groups were 30 on-farm demonstrations, and six intensively analysed on-farm research trials.

In the final stages of the project (yrs. 3-5), all participants in 20 grazer groups were to be supported to develop a documented strategy for managing pasture rundown in their situation. Each grazer group coordinated was to use the existing on-farm sites (established with the six groups described above) for learning activities as well as establishing some additional trial sites. Approximately three participants per group were to be supported to do on-farm demonstrations. These trials were to involve simple comparison of participants preferred mitigation strategy on their own farm, predominantly taking their own measurements with project team support for trial design and analysis. Up to six additional sites (across all groups) were to be supported to conduct on-farm research trials, with the project team supporting design, measurement and analyses of results. Indicative numbers of activities for the 20 groups were 60 on-farm demonstrations, and six intensively analysed on-farm research trials.

2.2.2 Method

On-farm field activities were undertaken across both southern and central Queensland. These activities were split into on-farm demonstrations or on-farm research trials. The on-farm demonstrations typically had minimal or no replication, minimal data collection, ran only for 1-2 yrs, and were aimed more at 'demonstrating' the practical application of a mitigation strategy. Whereas the intensively analysed on-farm research trials were replicated, a larger amount of data was recorded, ran for 2 – 4yrs, and were aimed more to 'research' mitigation strategies that were not as well known.

Topics, co-operators and sites were generally identified during a workshop or at another information delivery event. Sometimes project staff approached a certain grazer, or the grazer nominated themselves. Topics chosen were relevant to the producer, i.e. what he/she wanted to do, and to some extent were vetted by project staff to ensure relevancy and a spread of topics across the group (and project). Demonstration sites were coordinated and measured by both the producer and project staff, whereas the research trials were generally initiated, coordinated and measured by project staff.

2.2.3 Results

A large number of on-farm demonstrations and research trials were initiated (Table 3), however a fewer number were seen through to completion. A range of issues impacted on the ability of graziers to undertake these activities including enthusiasm/desire, time, resources, finances, impending sale of property, and weather conditions. Many graziers were reluctant to lock up a paddock, or part of a paddock, when dry weather conditions were prevailing; every blade of grass was highly valuable for some due to prolonged below average rainfall. Further, coordinating on-farm activities also took significant time and effort by the project team, and in some cases compromises had to be made to ensure time was allocated to other parts of the project. Demonstrations were however, aimed at the grazier initiating, conducting and assessing the outcomes without the project team support. Without the occasional nudge, some graziers would have allocated their time to other parts of their businesses, and some did regardless of the time dedicated by the project team.

Based on the three mitigation options to address rundown, three strategies to address pasture rundown were examined. These included:

1. Techniques that increased N cycling through pasture renovation, e.g. mechanical cultivation, herbicide.
2. Techniques that increased N levels through:
 - the application of N fertiliser,
 - establishing legumes, and including legume species general assessments, legume and phosphorus fertility interactions
3. Other options such as the impact of fire.

Table 3: Numbers of initiated on-farm activities addressing strategies and technique to address pasture rundown.

Strategy	Technique used/trial focus	Number of on-farm Demonstrations	Number of on-farm Research trials
Increase N Cycling	Cultivation	2	1
	Herbicides	1	1
Testing N response	Urea (at various rates)	58	17
N Fertiliser management	Urea (at various rates)	9	8
Legumes	Legume establishment	23	3
	Legume species comparisons	12	3
	Legume response to P	12	5
Other	Fire	2	0
Total		119	38

On-farm activities investigating the impacts of nitrogen fertiliser application

As indicated by the above table, the majority of both on-farm demonstration and research trials were investigating the response to nitrogen fertiliser. The project team supplied nitrogen fertiliser to graziers so they could test or demonstrate that pasture rundown (due to soil nitrogen tie-up) is affecting their pasture and is due to a lack of plant available nitrogen supply, and not other factors such as drought (or lack of rainfall), grazing management (or over stocking), or another soil nutrient (e.g. phosphorus). Also, the project team were keen to demonstrate the extent of just how rundown pastures are currently, or conversely the magnitude of response, that is the amount of extra grass grown for every kilogram of extra nitrogen supplied to the pasture.

Due to a lack of contemporary nitrogen fertiliser research in sown pastures across southern and Central Queensland, the project team supported a large number of replicated sites with multiple nitrogen rates to obtain a robust understanding of the pasture impacts to increased nitrogen supply. Results from about 40 replicated sites with multiple nitrogen fertiliser rates from southern and central Queensland were collated together. Results showed applying nitrogen increased grass yield at all sites, and the magnitude was dependant on the amount of nitrogen applied. At the higher nitrogen rates (100 kg N/ha and 200 kg N/ha), dry matter grass yield was around double that of unfertilised grass. This demonstrates declining sown pastures in central and southern Queensland have a large capacity to utilise extra nitrogen supply and produce higher pasture yield. Grass protein levels also increased, but only up to the 100 kg N/ha rate, beyond which protein levels stabilised (Fig. 2). It should be noted that at the stage of growth (around flowering) when treatments were sampled, protein levels of the unfertilised treatment were around maintenance level for live weight in livestock. Protein levels in all other treatments were high enough to support weight gain.

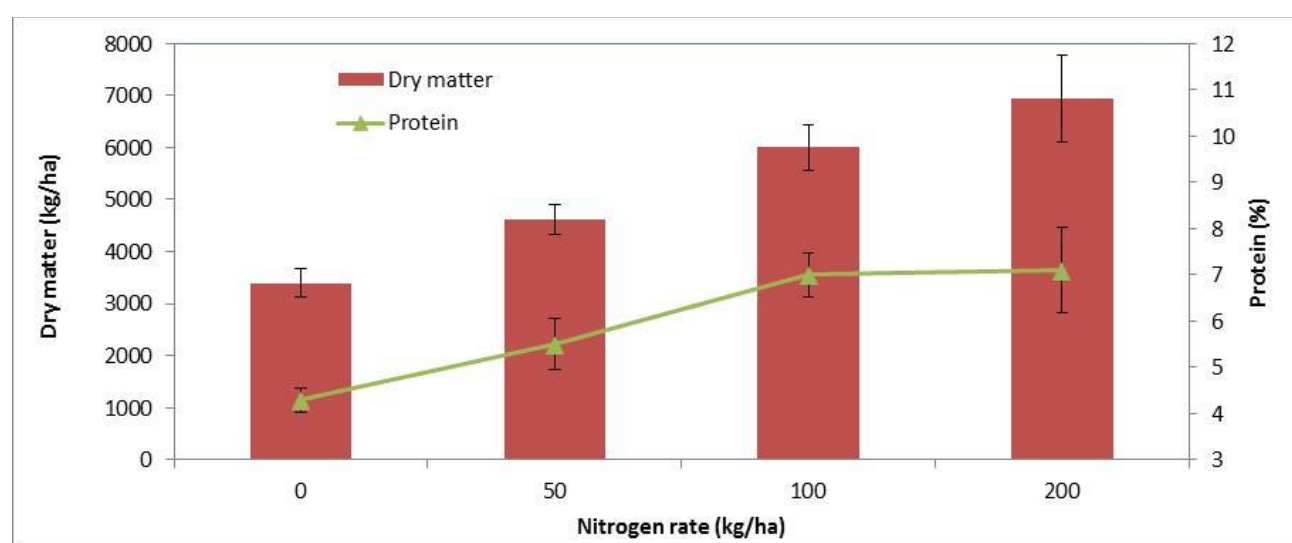


Fig. 2: Average dry matter and protein responses of fertilised sown pastures. Error bars show standard error.

The capacity of the pasture to respond to nitrogen fertiliser changed as fertiliser rates increased. Dry matter response (kg DM / kg N applied) was lower at the 100 – 200kg N/ha fertiliser increment compared to the response at the 0 – 50kg N/ha and 50 – 100 kg N/ha increments (Fig.2). At the 0 - 50 kg N/ha fertiliser rate increment, 25 kg of extra dry matter per hectare was produced for every kg of nitrogen applied. The response was similar at the next increment (50 -100kgN/ha) with 28 kg of extra dry matter produced for every kg of nitrogen applied (Fig. 3). The response rate decreased to 9 kg of extra dry matter at the 100 – 200kg N/ha fertiliser rate increment, indicating lower dry matter response efficiency at N rates above 100kg/ha, possibly because another factor (e.g. other nutrients and or water) became the limiting factor for increased production. The response rates recorded here are similar to previous research in central Queensland on a buffel grass pasture, where a response of about 30 kg extra dry matter of grass per kg nitrogen applied up to 120 kg N/ha was measured (Graham *et al.* 1981). It's anticipated the response rate would increase as more nutrients are tied up in organic matter and pastures decline further over time, based on other pasture growth factors remaining the same.

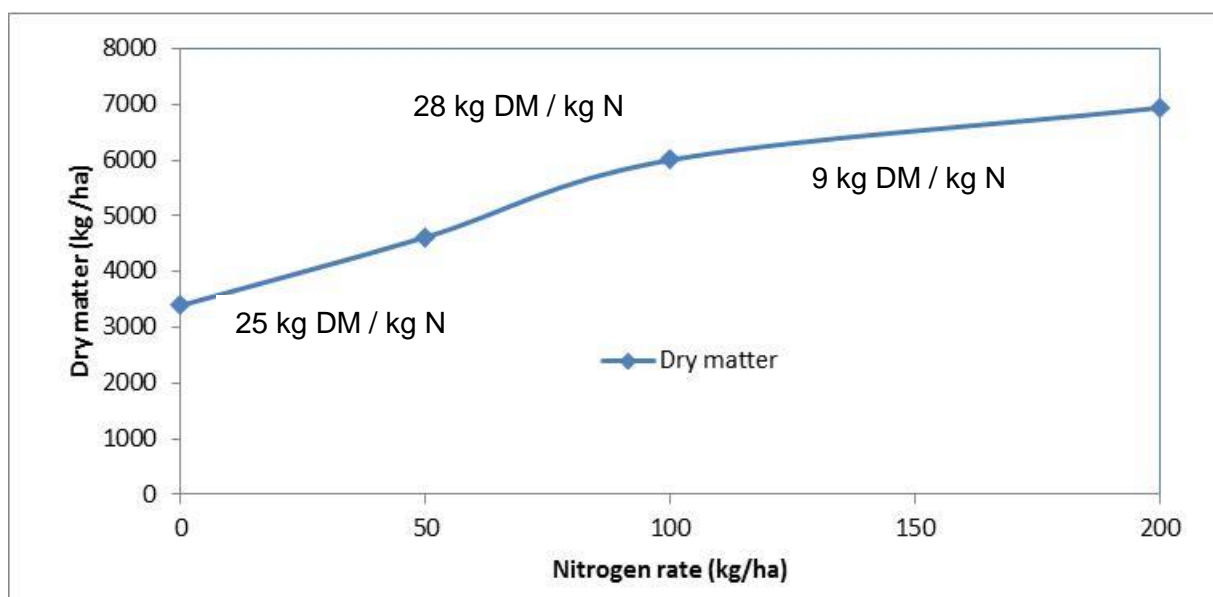


Fig. 3: Average incremental response rate of sown pastures to increasing rates of nitrogen fertiliser.

While cattle stocking rate and live weight gain were not investigated in these studies, it is assumed that fertilised pastures with higher grass production and protein could be utilised at higher stocking rates, and that animal growth would also be increased. The potential beef production and economics of fertilising sown pastures in southern and central Queensland is reported in an MLA funded review (Lawrence *et al.* 2015). This study concludes that when 100 kg N/ha of fertiliser is applied, average gross margins in the year of application were calculated to increase by 121 - 217% when dry matter yield responses of 40 kg DM/kg N (i.e. an additional 4000kg/ha) and an additional live weight gain of 0.2 kg/AE/Day (i.e. an extra 70 kg AE/year) can be achieved.

On-farm research activities investigating legumes.

Investigations into legumes was the next commonly undertaken on-farm demonstration or research trial. The technique used to sow and establish legumes is a critical part of ensuring success, and so many graziers were keen to investigate what works on their own property. However, a larger number of sites investigated the impact of phosphorus on existing legume-grass pastures, with both summer (e.g. leucaena) and winter (e.g. medics) growing legumes. Many of these sites, especially the winter medic sites, were initiated but not measured due to a lack of legume growth caused by low winter rainfall conditions.

One on-farm research trial at Wandoan investigated the establishment of five legumes, with and without phosphorus fertiliser, into pasture that was sprayed out in strips and fallowed for 10 months prior to sowing. This site was replicated three times. The legumes chosen included desmanthus (cv. Progardes and Marc), Caatinga stylo (cv. Unica and Prima mixed together), Siratro (Aztec Atro) and Burgundy bean (cv. Cadarga and Juanita mixed together). Also, burgundy bean (only) was sown into unfallowed pasture to demonstrate the importance of stored soil moisture prior to sowing legumes. Even though the sprayed strips were fallowed for almost 12 months prior to sowing, low rainfall during this period meant only a small amount of soil moisture was actually stored.

Sowing occurred on 15 February 2013. Legume establishment counts were conducted approximately eight weeks after sowing. There was good establishment of all legumes (Table 4). There was no establishment benefit from the application of phosphorus fertiliser (data not shown). Burgundy bean established with the highest plant numbers recorded. All

other legumes recorded similar numbers of plants establishing. Seedling vigour with Caatinga stylo was observed to be slow, with contamination from other stylo species (e.g. *S.scabra*) also evident. Plant population counts taken where legume was sown into unfallowed pasture showed no plants established, demonstrating the significant benefits fallows can provide especially during dry rainfall conditions. A second plant establishment measurement was taken on 30 April 2014, about 14 months after sowing. Results showed that Burgundy bean and Caatinga stylo plant numbers had regressed slightly while other species maintained plant numbers. The Caatinga stylo seed was contaminated with *S. scabra* which may explain the reduction in plant numbers.

An inspection of the site in March 2016 indicated that burgundy bean and siratro had died out, both desmanthus cultivars were still performing well, and Caatinga stylo was continuing to thicken up. The results from this on-farm research (OFR) site have impressed the owner of the property, and he's subsequently purchased Desmanthus (cv.Marc) and Caatinga stylo seed and has sown them both in other paddocks and plans to do more.

Table 4: Legume establishment from the Wandoan on-farm research site

Fallow period	Legume	Legume plants established: 8 weeks after sowing (plants/m ²)	Legume plants established: ~14 months after sowing (plants/m ²)	Legume plants established: 37 months after sowing (observation)
Almost 12mths prior to sowing	Burgundy bean	15 a*	7	No plants found
	Desmantus cv. Marc	11 ab	21	Population maintaining
	Siratro cv. Aztec atro	10 b	9	No plants found
	Desmanthus cv. Progades	8 b	9	Population maintaining
	Caatinga stylo	7 b	5	Population increasing
No fallow	Burgundy bean	0 c	No plants found	No plants found

*P<0.05

An on-farm demonstration site near Moura in central Queensland investigated the impact of a range of cultivation and or spraying regimes on legume establishment into existing grass over time (no replication). The pasture was buffel grass (predominately cv. Gayndah). The plots were sown (broadcast) with a 50:50 mixture (by weight) of Desmanthus (cv. Marc) and Caatinga stylo (cv. Primar and Unica) at 4kg/ha between August and October 2012, depending on the number of fallow operations. The multi spray treatment was sown February 2013, after a complete summer fallow. While treatments had different sowing times and weren't replicated or randomised, the outcomes (Table 5) are similar to the research trials on legume establishment. Longer fallows with more operations to remove grass and increase soil water levels at planting result in more legume plants established. Also, similar to the research trials, the attrition rate of young legume seedlings is high. A high number of plants need to be initially established for the longer term population to end up at the target 4 plants/m² or higher.

Table 5: Legume establishment from the Moura on-farm demonstration site

Treatment	3-5mths after sowing (Dec 2013)	7-9mth after sowing (May 2013)	19-21mths after sowing (May 2014)
Undisturbed	0	0	0
1 cultivate	0	0	0
1 spray	0	1.5	1
2 spray	4	1.5	0
1 cultivate, 1 spray	3	0.75	0
2 cultivate	1	0	0.5
2 cultivate, 1 spray	7	1.5	2.5
Multi spray	Not sown	5	2.7

A number of on-farm demonstrations and research trials investigated comparative legume dry matter performance, and pasture responses to phosphorus fertiliser. Legumes will respond to applied phosphorous where soil test indicate low levels.

2.2.4 Discussion

Undertaking a range of on-farm activities (regardless if these were demonstrations or research sites) was effective in engaging a large number of graziers, and demonstrating that theory can be put into practice. The project team wanted to ensure knowledge imparted at the workshops actually lead to the aspiration and on-ground action of trying something different, with the team's support. This was seen as a critical step in the adoption pathway. Also, on-farm activities were very effectively utilised for extension such as field days or low-key paddock walks, to extend information to a wider audience that might not attend a workshop. However, coordinating and ensuring on-farm activities actually happened was time consuming, and without the project staff guidance and drive most would not have happened. Also, a range of issues meant that a number of on-farm activities were initiated, but were not completed. These issues include time commitment, resources including machinery, the need for feed in the paddock, impending sale of the property, dry conditions experienced during the project.

2.3 Field days

2.3.1 Aim

Field days were aimed at demonstrating the successful implementation of strategies to address sown pasture rundown, for example fertiliser responses, legume establishment techniques, legume species comparisons. Graziers typically like to see and get an on-farm 'feel' for what works and what doesn't, before tackling new technology themselves. Thus, field days are an effective action learning activity to compliment other adoption process of workshops or seminars. Further, field days enable discussion between industry personnel such as agency staff, agribusiness and graziers about the practical application of strategies such as what machinery might be required, what soil or pasture types should be tackled first, what the animal grazing management requirements are likely to be.

2.3.2 Method

A range of field days were conducted at on-farm demonstrations and research trials during the project, and while most were generally organised and delivered by project staff, staff also contributed to the messages delivered at field days coordinated by other organisations e.g.

seed companies, agribusiness re-sellers, NRM groups, consultants. Field days were either planned in advance, or were conducted when there was an emergent opportunity to showcase a result from particular treatments or in a commercial situation. Project staff generally presented technical content on each day, however a few field days also had presentations/ discussions by other industry professionals. Also, some field days had more formal sit-down presentations, but generally either handouts were used for presenting information or semi-structured discussions occurred in the paddock while looking and discussing the outcomes of the pasture improvement technique(s).

2.3.3 Results

A total of 27 field days were held during the project period, with the majority during the last two years i.e. 2015 and 2016 (Table 6). Field days were either held at on-farm demonstration sites, on-farm research sites or at another location as organised by an industry organisation (i.e. industry days). Industry days were field days instigated and coordinated by another organisation, often following implementation of strategies planned in consultation with project staff and included presentations from the project team on the day. Engaging with a range of other organisations created synergies and efficiencies for the project team, where resources were pooled together to produce better outcomes for participants and the service providers. It also enabled project messages to be extended to other grazier and industry personnel that might not have attended one of the project's field days i.e. collaboration efficiently extended the project's reach.

Table 6: The types and numbers of field days contributed to or organised by the project team.

Type of field day	Number of days
On-farm research trial	7
On-farm demonstration	8
Industry day	12
Total	27

Field days were held across both southern and central Queensland and were predominately located in districts where sown buffel grass pastures are prevalent (Fig. 4). As learnings and insights were being generated over time from the on-farm research trials, multiple field days were held at specific trials e.g. the establishment trials near Wandoan where four field days were held on this property.

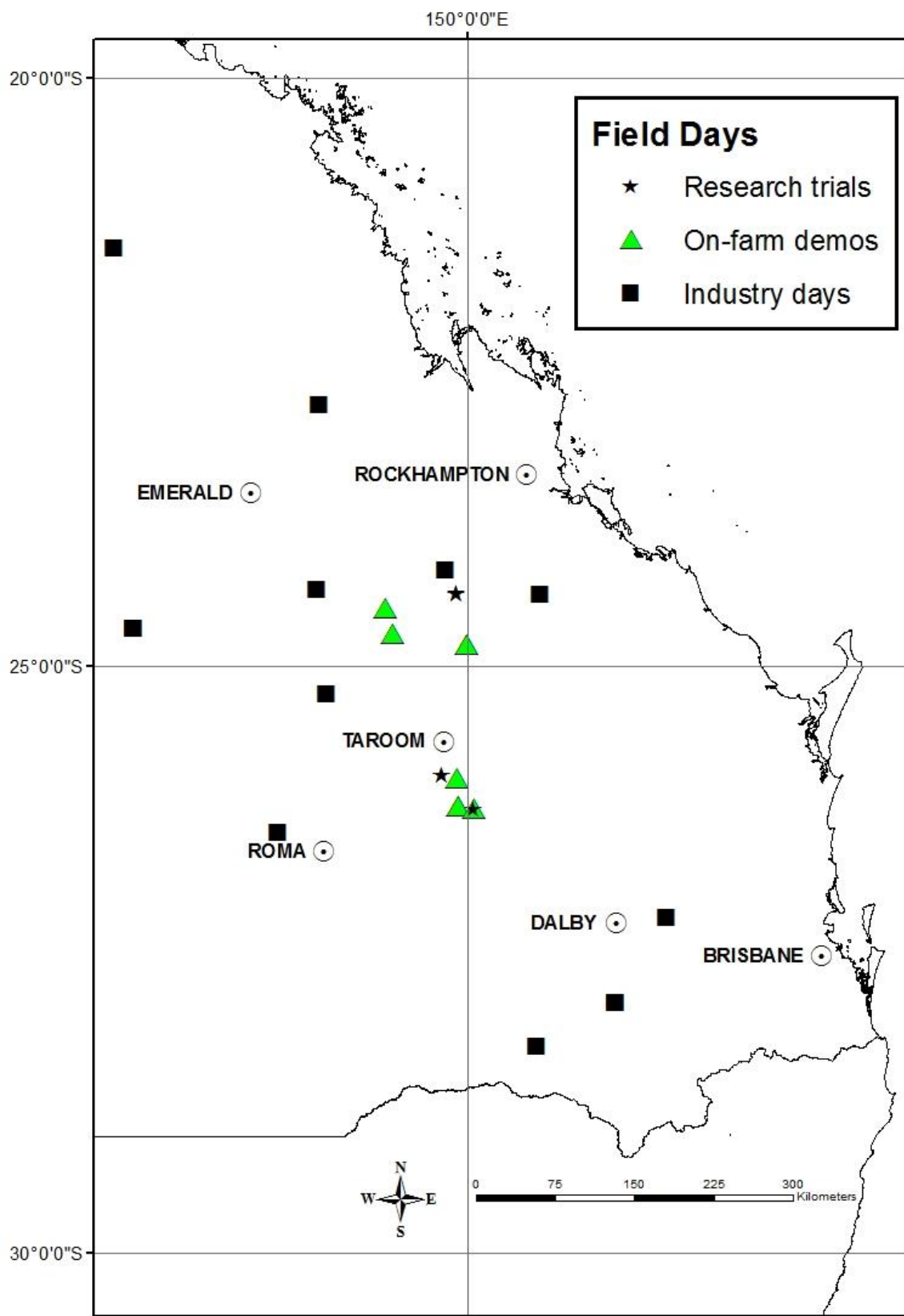


Fig. 4: Location of field days

The topics and discussion points were dictated by what was demonstrated in the paddock. The majority of the field days showcased the successful legume establishment and increased production by introducing legumes into existing pastures. Other field days covered outcomes of fertiliser use and pasture responses, however there were fewer of these days.

Participant numbers were not recorded, however it's estimated participant number averaged between 10-20 at each day (at two field days around 60-70 participants attended). Therefore, potentially up to 540 participants attended field days associated with the project, or attended days where project information was delivered.

2.3.4 Discussion

Field days generally met the aims of:

- Demonstrating successful implementation of strategies. In some cases field days also demonstrated what didn't work too, which is just as important.
- Facilitating discussion across a range of people, especially about the practical implementation of strategies.
- Facilitating the adoption process, although practice change can be slow and difficult to measure.

Field days were well supported by producers if held for a short period of time, say a couple of hours or a half day, rather than full days. The project team were conscious of not overloading producers with too many field days, as participant time is limited and the days needed to showcase something new or different. More field days could have been held, however seasonal conditions in some years were not conducive to showcasing outcomes in a constructive way. It can take time for strategies to show differences from the control treatments, therefore it was deemed better to not showcase until results were clearer.

The project team probably didn't take as many opportunities as possible to ensure DAF beef extension staff were at these field days, even though these staff were more than welcome. The project team also needed to better evaluate the outcomes of the days, especially recording participant number, and collecting participant feedback for example what were the main learning(s), what practice change might happen, what was good, and what could have been improved).

2.4 Information sessions and forums at various events (such as Beefup forums)

2.4.1 Aim

To compliment the range of other extension and engagement activities, project staff coordinated or contributed to, a range of forum and information sessions at events organised by other organisations. Generally the aims of these events were to deliver general information about sown pasture rundown and the management strategies to address it. They also aimed at extending information to a large number of people across a large geographic area, and or to audiences that would not necessarily come to an event focused solely on sown pasture rundown; generally other topics and speakers presented at these forums and so there was broad content covering management strategies to improve beef production. These knowledge awareness events were different to the workshops by having a shorter time duration, immediate practice change was not specifically aimed for, and future engagement was not intentionally planned (the action plan development process did not occur). However some information days were preliminary type sessions to introduce the

topic and facilitate future engagement i.e. workshops and on-farm demos were conducted subsequent to the information day.

2.4.2 Method

As mentioned, these events were either initiated and coordinated by project staff, or project staff contributed to events organised by other organisations. Information delivery was commonly PowerPoint presentation in a large auditorium (hall, meeting room etc.) or on-farm in a shed or veranda. Sometimes handouts were used if the venue was not suitable or suited the aims of the day. Topics were typically a combination, or all of:

- Understanding rundown (causes, symptoms, management strategies to address)
- Legume species selection
- Legume establishment principles
- Results from legume establishment trial results

2.4.3 Results

A total of 57 information events were undertaken and were generally during the middle and end of the project period, typically between 2013 and 2015 (Table 7). The largest number of information events occurred in central Queensland. A large number of graziers in this area are concerned about the continuing decline of pasture productivity and the subsequent increasing incidence of Indian couch (*Bothriochloa pertusa*).

Table 7: Number of information events by region.

Region	Number of information days
Northern New South Wales	1
Western Queensland	2
Northern Queensland	2
Southern Queensland	20
Central Queensland	32
Total	57

Information events organised by external organisations were events such as:

- MLA Beef-up forums, and Beef Week (2012 and 2015)
- Natural resource management group (e.g. Fitzroy Basin Association, Burnett Catchment Care Association, Queensland Murray Darling Committee) beef and pasture production forums
- Agribusiness (e.g. BGA, CRT, AusWest Weeds, Landmark, FarmStuff, Incitec Pivot) producer forums

Like the field days, accurate participant numbers were not collected or assessed by the project team at these information events as we were not the organising group. Participant numbers varied from event to event, but it is estimated that an average of 12 participants attended these events, therefore around 700 graziers and industry personnel would have heard key messages generated by this project.

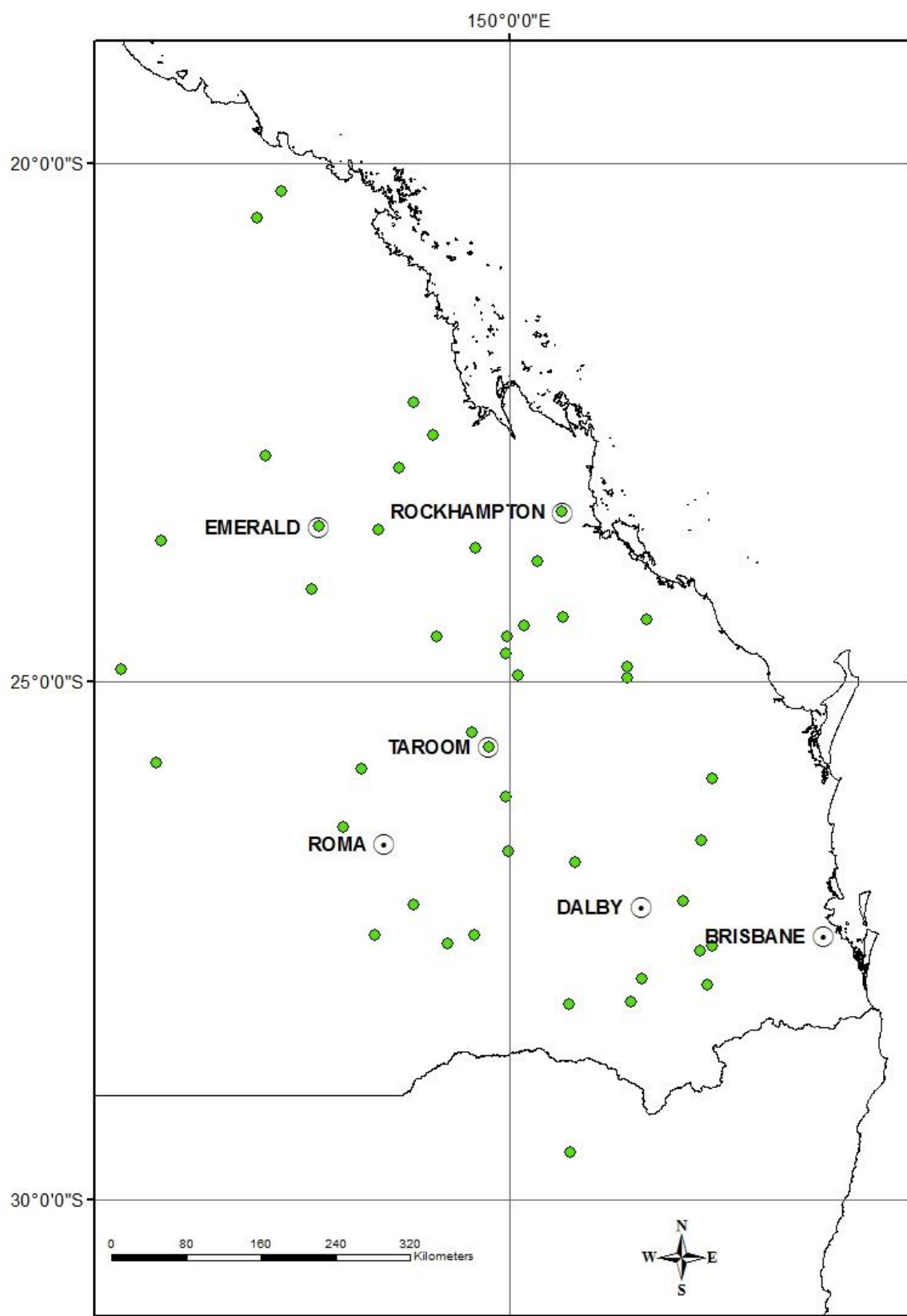


Fig. 5: Location of information events

2.4.4 Discussion

The high interest and hence demand for information on sown pasture rundown did surprise the project team, particularly that the topic/issue of rundown is not new. Its apparent graziers have assessed that 'now is the time' to gain information and evaluate options to economically address pasture rundown, and so they are eager to obtain information about it. Due to this demand, the project team coordinated or collaborated in a high number of information days, which enabled key messages to be extended to a large number of graziers and industry personnel. This high demand also prompted the team to continually update extension messages and presentations/handouts with up-to-date information from the research trials, ensuring the latest information was delivered. The project team were willing supporters of events coordinated by other organisations, and could have presented at more events. However, the team wanted to ensure balance and so enough time was allocated for other activities.

3 Industry engagement

A broad industry engagement strategy has been critical to complement the learning package activities (e.g. workshops) by assisting effective dissemination of information across a broad audience base. As some conversations with industry have been one-on-one (especially with seed companies, re-sellers and NRM groups), meaningful dialogue with higher learning typically occurred. Anecdotal and feedback from seed companies indicate practice change is occurring, for example, there is more use of fallowing before sowing legumes, more graziers are seeking information before sowing legumes, more soil testing is being conducted in existing and for new pastures, and phosphorus fertiliser is now being applied to existing legume-grass pastures.

3.1 Seed companies, resellers and commercial agronomists

Extensive engagement with a range of seed companies, resellers and commercial agronomists has occurred during the duration of the project. Engagement has been at numerous levels, including email, telephone, face-to-face meetings, or at industry events such as forums or field days. The project team has engaged with many seed companies, including (in no particular order):

- Agrimix (who market *Progarde desmanthus* across northern Australia)
- Heritage Seeds (market a range of grass and legume pasture seed across Australia)
- PGG Wrightson seeds (market a range of grass and legume pasture seed across Australia)
- Southedge Seeds (was bought out by PGG Wrightson seeds)

3.1.1 AusWest Seeds (was bought out by PGG Wrightson seeds)

- Illing Seeds (market a range of grass and legume pasture seed predominately in southern Queensland)
- Progressive Seeds (market a range of grass and legume pasture seed across Australia)
- Selected Seeds (market a range of grass and legume pasture seed across Australia)
- Tas Global Seeds (market a range of grass and legume pasture seed predominately in the temperate regions of southern Australia)

While extensive engagement has occurred with a range of companies, the project team have had the most interaction with *Agrimix*. *Agrimix* have engaged with the project team by

sharing intellectual concepts and data, have supplied specific desmanthus lines for project research trials, have presented information at project field days, and the project team have presented at their field days. This collaborative engagement has enabled the project team to extend information on legumes to a wider grazier audience, assisting to accelerate adoption of legume establishment and management techniques, and generally accelerate the improvement of pasture management across Queensland.

While engagement with the other seed companies has not been as extensive, interaction has been highly valuable. Project staff have regularly discussed market and industry issues, swapped intellectual concepts and plans, and updated seed company reps on research trial outcomes. Industry regularly use, and seed companies have advocated, low cost legume establishment techniques that consistently result in unreliable outcomes. The project team have taken steps to change this paradigm and upskill industry advisors so they advocate better agronomy to their clients and achieve more reliable legume establishment into grass-only pastures. The project team has also provided feedback on product acceptance and concerns in the market place, for example:

- Seed supply issues
- Seed quality issues
- Rhizobium survival in legume seed coatings
- Inability to re-inoculate coated legume seed
- Dormancy requirements of legumes sown into different situations
- Future industry needs

Similar engagement has occurred with sales/merchandise and agronomist personnel within resellers such as Landmark, CRT, BGA, Elders, Ag-n-Vet, FarmStuff. However, the project team has engaged in depth with some resellers by presenting targeted pasture management information. Specifically, information sessions have been delivered to agronomists with BGA, CRT and AusWest seeds, where targeted pasture and legume management information was delivered in a half to one day forum. This extension process was highly efficient for our project team, as a limited number of sessions were delivered to multiple agronomists who in turn passed on this knowledge to their numerous clients. The project team have also delivered information to sales/merchandise and agronomist personnel during the extensive array of workshops, information days and field days that were open to the wider beef and grazing industry (see section 3 [Targeted grazier engagement] for more information).

3.2 Beef extension and pasture agronomists within DAF and in other state government departments

Outcomes from the project have been extended to government agronomists both within Queensland and interstate. Pasture management staff DAF are close collaborators with the project team, jointly undertaking pasture management projects, and actively collaborating in new project proposals. Interstate engagement with state departments and CSIRO have occurred, especially with the New South Wales pasture agronomist team. This team currently has a focus of introducing and testing sub-tropical and tropical pasture species in cooler sub-tropical environments. The project team have provided intellectual and technical information on pasture establishment and management details, as well as herbicide and insecticide recommendations.

3.3 Retired pasture agronomists

Retired pasture agronomists have been highly supportive of this project, and have provided significant intellectual capacity to the project team. Specially, contribution was made (site locations, site treatments, data) that enabled assessments at past pasture evaluation sites,

access to data and project reports. This data has been invaluable in determining which legumes are persistent over the longer term, especially under persistent grazing, and enabled the extension team to assure graziers at extension events that there are legumes that will persist with sown pastures such as buffel grass. Also, the outcomes from legume surveys at old pasture evaluation sites has led to a new project 'Cold tolerant stylos for southern-inland Queensland', and directed other project work where new legume trial sites were set-up with the aim of collecting data to fill geographical production and persistence gaps in the old pasture sites (Volume 3 of this report).

3.4 Natural Resource management groups

The network of NRM groups across Queensland have been valuable to the success of this project. Their role has been to assist information dissemination to the wider grazing industry. Linkages, support, close collaboration and facilitation from NRM groups has assisted in the successful industry engagement with landholders at our activities e.g. workshops, information days and field days. Also, a range of NRM and Landcare groups have asked for our technical expertise on pasture management, enabling better outcomes for their projects. Overall, these linkages enabled higher level KASAP (knowledge, aspiration, skills, attitudes, and practice) changes for a larger number of stakeholders, across a larger geographic area than would have been possible if each organisation(s) was working independently. Further, this close collaboration and networking lead to a collaborative project, for example the Fitzroy Basin Association (FBA) funded some of the project team to deliver pasture management information to graziers within the Fitzroy basin, and to facilitate on-farm adoption of techniques to address sown pasture rundown (primarily incorporating legumes into existing grass pastures).

3.5 Scientific peer audience

The reason why sown pasture rundown occurs has been known about for some time. DAF staff undertook preliminary research, development and extension during the 1980's, and from this work a range of reports and scientific journal papers were published. The outcomes from this current project have been extended to the scientific peer audience through a number of conferences. These conferences have been held across Australia and the project team have delivered multiple papers across a range of sown pasture rundown topics (Table 8).

Table 8: Summary of conferences and papers delivered by the project team on sown pasture rundown.

Event	Location	Title of paper delivered
Northern Beef Research Update Conference 2011	Darwin	Innovative methods of establishing legumes to increase diet quality and address sown pasture rundown
Northern Beef Research Update Conference 2013	Cairns	Legumes reduce Indian couch invasion in buffel grass pastures Persistence of tropical pasture legumes in southern and central Queensland Improving reliability of legume establishment in sown grass pastures Desmanthus and Caatinga stylo boost productivity of buffel grass pastures Economic returns of management options used to tackle pasture rundown Increasing seeding rate is not the answer to improving legume establishment in buffel grass pastures in inland areas Managing 'rundown' in grass pastures On-Farm Research – Exploring options to manage sown pasture rundown Pasture rundown – Are your sown pastures nitrogen deficient? Comparative performance of pasture legumes in southern and central QLD Graziers and seed industry are concerned about sown pasture rundown
Northern Beef Research Update Conference 2016	Rockhampton	Phosphorus fertiliser boosts grass-legume pasture yields up to 4 years after application Increasing seeding rate does not improve legume establishment in undisturbed buffel grass pastures Better agronomy improves the reliability of establishing legumes into existing grass pastures Graziers: Legumes are the best option to address sown pasture rundown
Australian grasslands Association symposium 2012	Melbourne	Legumes are the best option for improving returns from sown pastures in northern Australia
Australian Agronomy conference 2012	Armidale	Leucaena: Highlighting the value of good agronomy for establishing pasture systems. Persistence of pasture legumes in southern and central Queensland Graziers, pasture seed industry and researchers are concerned about pasture productivity decline
Australian Agronomy Conference 2015	Hobart	Determining the extent of declining pasture productivity with nitrogen fertiliser Improving the reliability of establishing legumes into grass pastures in the sub-tropics. Medics in southern Queensland: Effects of sowing method, weed control and phosphorus application on plant population and biomass.
Total number of conference papers:		23

Two desktop project reviews were produced using the on-farm demonstration and research trial results collected by this project, and were completed during the operating period of this project; 1. *Use of phosphorus fertiliser for increased productivity of legume-based sown pastures in the Brigalow Belt region – a review (B.NBP.0769)* 2. *Fertilising for yield and quality in sown grass pastures and forage crops (B.NBP.0768)*. The outcomes of these reviews have also been extended to the national scientific peer audience through the same conferences as outlined above. The significance of these reviews, through feedback generated from the conference papers, is that our scientific peers in southern states are surprised by the lack of knowledge and understanding of the response (forage and animal) to fertilisers in northern Australia. A reason for this is fertilisers have been used in forage systems for decades in the south (i.e. "we've been using fertilisers for years, so everyone knows about the benefits"...), but fertilisers have not played a role in northern Australian forage production systems, especially in rain fed situations away from the higher production in coastal or irrigated conditions (i.e. the research has not been done).

To date, no scientific journal papers have been published, however there is significant scope for a number of papers to be compiled. The project team intend to undertake this task, however papers won't be completed before the end of the project.

3.6 Broader industry engagement through media and publications

The project team has utilised a range of mechanisms and mediums to extend project findings to the broader beef community, including fact sheets, internet, newspapers, newsletters, magazines, and radio.

Three fact sheets were developed to summarise key aspects of sown pasture rundown:

1. Causes, symptoms and introduction to management options
2. Management option – increasing nitrogen inputs (legumes and fertiliser)
3. Management option – increasing nitrogen cycling (renovating the pasture with cultivation)

These fact sheets were printed and distributed at field days, workshops, information days, and through the DAF Beef extension network. The fact sheets were also published on the FutureBeef website www.futurebeef.com.au.

Webinars were also utilised to extend project outcomes to a state, national and international audience. In total, two webinars were delivered, and details are presented in Table 9.

Table 9: Details of webinars delivered by the project team on sown pasture rundown

Webinar number	When	Topic	Presenter(s)	Participants
1	November 2014	Sown pasture rundown	Brian Johnson and Stuart Buck	72 viewed live on the day 153 registrations
2	December 2015	Establishing small seeded legumes into existing grass pastures	Gavin Peck	81 viewed live on the day 236 registrations 357 watched the recording 3mths after
Total known number of industry people who viewed webinar content			510	

Newsletters, magazines, and radio have also been heavily utilised to extend information and project outcomes to a broad audience. In particular, numerous articles were written for the DAF newsletters *CQ BEEF* and *Beef Talk* due to the geographical distribution of the audience across this project target regions. Also, in recent years these newsletters have been published in the Queensland Country Life, which has further expanded the readership to around 16,000 people each edition.

Articles published in DAF's <i>CQ Beef</i> newsletter (Central QLD)			
Publication	Title	Content	When
CQ Beef	Nitrogen the key to fighting big losses from rundown sown pastures	Options to improve nitrogen supply – legume establishment and nitrogen fertiliser	December 2012
CQ Beef	Forage legumes for short or long-term pastures on clay soils	Characteristics of legumes for short or long term pastures	May 2013
CQ Beef	Pasture recovery after flooding	Principles and practices to restore pastures after flooding	May 2013
CQ Beef	How rundown are CQ pastures?	Results of fertilising rundown pastures with nitrogen	Sept 2013
CQ Beef	Good legume establishment comes from better agronomy	Results of legume establishment trial near Wandoan.	Sept 2013
CQ Beef	What can be done about Indian couch in sown pasture	Pasture composition impacts of having a legume in a grass pasture	July 2014
CQ Beef (Queensland Country Life)	Keys to successful legume establishment	List of management steps to improve the reliability of legume establishment	December 2015
CQ Beef (Queensland Country Life)	Which legume into permanent pastures on clay soils: leucaena, desmanthus or Caatinga stylo?	Attributes of 3 legume options for permanent pastures on clay soils.	December 2015

outlines the articles that have been published in various newsletters, magazines and on the radio during the project duration.

Table 10: Summary of newsletter and magazine articles, and radio interviews conducted by the project team

Articles published in DAF's CQ Beef newsletter (Central QLD)			
Publication	Title	Content	When
CQ Beef	Nitrogen the key to fighting big losses from rundown sown pastures	Options to improve nitrogen supply – legume establishment and nitrogen fertiliser	December 2012
CQ Beef	Forage legumes for short or long-term pastures on clay soils	Characteristics of legumes for short or long term pastures	May 2013
CQ Beef	Pasture recovery after flooding	Principles and practices to restore pastures after flooding	May 2013
CQ Beef	How rundown are CQ pastures?	Results of fertilising rundown pastures with nitrogen	Sept 2013
CQ Beef	Good legume establishment comes from better agronomy	Results of legume establishment trial near Wandoan.	Sept 2013
CQ Beef	What can be done about Indian couch in sown pasture	Pasture composition impacts of having a legume in a grass pasture	July 2014
CQ Beef (Queensland Country Life)	Keys to successful legume establishment	List of management steps to improve the reliability of legume establishment	December 2015
CQ Beef (Queensland Country Life)	Which legume into permanent pastures on clay soils: leucaena, desmanthus or Caatinga stylo?	Attributes of 3 legume options for permanent pastures on clay soils.	December 2015

Articles published in DAF's Beef Talk newsletter (Southern QLD)			
Beef Talk (Beef Talk is published in the Queensland Country Life)	Tropical legumes for grazing – and N factor.	<ul style="list-style-type: none"> • Suitable legumes for more fertile, heavier clay soils. • Ley pastures/short term pastures on old cropland. • Long-term pastures 	Nov 2014
Beef Talk (Queensland Country Life)	Top tips for forage in summer 2014 -15	Forage types, seed quality, forage usage considerations, considerations when thinking about forages.	Nov 2014
Beef Talk (Queensland Country Life)	Are your pastures suffering from nutrient tie-up?	Information on sown pasture rundown now available on line via Future Beef website.	Mar 2015
Beef talk (Queensland Country Life)	Perennial pasture legumes – start planning for them now	Advice on preparing seedbeds for moisture storage and weed control.	June 2015

Beef Talk (Queensland Country Life)	Keys to successful legume establishment	List of management steps to improve the reliability of legume establishment	December 2015
---	--	---	---------------

Interviews with ABC radio			
ABC radio	Sown Pasture Rundown	Background to the issue (how and why), and brief coverage of how to improve rundown pasture.	Jan 2015
Articles published in MLA newsletters			
Feedback	Research into action - Northern feedback	Legumes for longevity	March/April 2016
Feedback	On-farm – Desmanthus for dollars	Including desmanthus into pastures increases annual beef production	Sept/Oct 2015
Feedback	Pasture Management – Northern perspective	Stop the decline – the problem of sown pasture rundown in N.Aust.	Jan/Feb 2014
Feedback	Pasture management – Looking forward : and looking back	Sustaining grass pastures; legumes can persist for 20+yrs	Jan/Feb 2014
Feedback	Pasture management – Working it out	Outcomes of workshops across QLD	Jan/Feb 2014
Feedback	In-brief – Legume discovery brings new hope	The discovery that legumes have persisted for up to 30yrs has excited agronomists	March 2013
Feedback	On-farm: Pastures	Road testing Rhizobia, and the benefits of legumes to address sown pasture rundown	August 2013
Feedback	On-farm – Improve pasture productivity	Grass-legume pastures to combat rundown	Sept 2012
Feedback	On-farm – Producers fight that rundown feeling	Testing strategies for keeping sown grass pastures productive	Aug-Sept 2011
Frontier	Feedbase	Economic analysis of options to arrest sown pasture rundown	Autumn 2011
Frontier	Feedbase	Reducing rundown for pasture productivity	Autumn 2010

Articles published in national farm business magazines			
Australian Farm Journal	Agronomists solutions to buffel grass rundown	Background to pasture rundown, and management solutions.	June 2012
Total number of articles and interviews.		26	