Growing resilience to drought:

Natural resource management as a resilience intervention

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Kimberly Brown[1] & Jacki Schirmer[1,2]

[1]Health Research Institute & [2]Institute for Applied Ecology, University of Canberra

Background

Natural resource management (NRM) programs are typically designed to achieve positive environmental and/or land management outcomes. In addition to these intended benefits, NRM activities are widely acknowledged as often having co-benefits, particularly social or economic benefits that may not be the intended objective, but emerge as a result of a person engaging in NRM (GSAHS 2010, Schirmer et al. 2013). The co-benefits noted in past studies, although not always confirmed with empirical data, include improved social connections, farm financial performance, confidence in land management, and health and wellbeing, amongst others (Schirmer et al. 2013, Schirmer 2017).

In some cases, NRM activities are argued to help landholders increase resilience to the effects of drought. If they do, then NRM has a potentially important role to play in growing resilience of farmers to drought. For example, some NRM interventions aim to increase groundcover, increase water use efficiency, reduce loss of pasture during dry times, and increase planning for risks associated with drought. All of these may confer resilience to drought. However, there is little empirical analysis to demonstrate an impact of these types of activities. To understand whether and when NRM can contribute to building resilience to drought, it is necessary to identify which types of NRM action can lead to the types of co-benefits that are beneficial in assisting landholders to successfully cope with drought. This can then enable more specific design and targeting of NRM actions to achieve the positive drought resilience outcomes.

This report analyses the Regional Wellbeing Survey dataset to identify whether there is evidence that is consistent with the hypothesis that some types of NRM confer resilience to drought. First, a brief summary is given of different NRM activities and their likelihood of conferring resilience to drought. Second, the Regional Wellbeing Survey dataset is described, focusing on how it was analysed in conjunction with datasets identifying drought incidence to identify whether engaging in specific forms of NRM is associated with higher drought resilience. The findings are then presented, followed by discussing implications of the findings for designing NRM programs that can work to grow resilience to drought amongst Australian farmers.

Understanding resilience and how it can help in drought

Resilience is defined as *the ability of a person, household or community to successfully adapt to adversity and to capitalise on opportunities* (Schirmer and Hanigan 2017, drawing on multiple previous studies). A person with high resilience has access to 'resilience resources' they can draw on in difficult times. These resilience resources include both processes (for example, being able to engage in good decision making) and tangible assets (for example high financial reserves). By drawing on these resilience resources to cope with and adapt to challenges, and continuing to learn how to do this more successfully over time, a person can build their resilience over time (Schirmer and Hanigan 2017). A person with high resilience will be better able to cope with adverse events such as drought than a person with low resilience.

Having high resilience does not prevent negative impacts in events such as drought, but enables a person to minimise the size and duration of these impacts. This means that when comparing two people experiencing similar levels of drought, both would be expected to experience negative impacts, but the more resilient person would be better able to minimise these negative impacts through drawing on their resilience resources. As a result, they would experience less loss of quality of life in the form of things such as their farm performance and wellbeing. These are sometimes

called ‘resilience outcomes’, with indicators such as a person’s wellbeing and business performance useful indicators of whether they have high or low resilience.

Resilience is not ‘one size fits all’: to cope with a challenge such as drought, specific types of resilience resources may be needed. Some resilience resources – such as having high levels of financial reserves – may help in a wide range of situations, while others may be much more specific to a given situation. For example, specific on-farm actions such as building feed reserves for stock, improving water security or water use efficiency may confer resilience to drought, but will not help a person cope with other types of challenges such as a decline in commodity prices. Additionally, these actions may confer resilience for some farmers and not others: for example, building feed reserves is likely to be helpful for graziers but not for those operating horticultural enterprises.

Engaging in NRM may help people build resilience resources that assist in times of drought. It is likely that specific types of NRM will contribute to drought resilience in different ways for different types of farmers. Subsequent sections briefly examine which types of NRM may confer some resilience to drought, and for which types of farmers.

What are the outcomes of high resilience – what can be measured?

It is important to consider what the outcome should be if a person has higher resilience. In this report, we used two types of indicators to identify whether engaging in specific types of NRM help build higher resilience to drought:

- **Subjective wellbeing.** A person with higher resilience should experience fewer negative impacts during challenging times due to having improved capacity to cope with these challenges and to reduce their impacts. This should result in the person experiencing less decline in their subjective wellbeing during this times, and more rapid recovery of wellbeing after challenges. Subjective wellbeing is a widely used indicator of a person’s psychological resilience (Eid and Diener 2004, Schirmer and Hanigan 2017), and also acknowledged as often being impacted by drought (Albrecht et al. 2007, Sartore et al. 2008, Guiney 2012, Gunn et al. 2012), making it an important measure of resilience. Wellbeing can thus be considered a resilience outcome.
- **Farm performance**. In the specific context being examined in this report – the resilience of farmers to drought – farm performance is also an important resilience measure. A farmer with higher resilience will be able to cope with drought in ways that reduce its impacts on the farm enterprise. This would be reflected in the form of less negative impacts on key measures of farm performance when the farm is experiencing drought, and immediately post-drought. Farm performance can be measured in multiple ways, including by identifying whether there is high farm financial stress, adequate cash flow, the ability to easily service farm debt, and overall farm surplus in the form of the farm making either a loss, breaking even or making a surplus (Schirmer and Hanigan 2017).

What types of NRM may help support drought resilience?

NRM activities are diverse, and it is likely that some have no effect on resilience to drought while others may have a positive effect for some types of farmers. As a starting point, discussions with NRM professionals, as well as a review of drought resilience literature, was used to identify common types of NRM activities, and hypothesise for each what plausible ‘causal pathways’ might exist by which the activity potentially confers resilience to drought. Table 1 below summarises key hypotheses arrived at regarding whether different types of NRM activity have potential to confer

drought resilience, focusing on what ways they might do so, and for which types of farmers. Many of these were identified in conversations with NRM professionals rather than from existing literature, and so should be considered starting hypotheses only, typically with little to no supporting evidence from previous studies.

Table 1 NRM activities with potential to help build resilience to drought

NRM activity	**How likely is this to confer some drought resilience?** (initial informal hypothesis used to guide subsequent analysis)	**How might this increase resilience to drought?**	**Types of farms for which this is relevant**
Developing and implementing drought preparation plans	High	Engaging in forward planning for potential future challenges is a key way of increasing resilience: putting in place an action plan that better enables a farmer to prepare for drought, and in which they identify actions they will take in drought, can enable them to cope better during drought.	All
Developing and implementing strategies to address risks on the farm such as risk of climatic variability	High	Specific risk management planning involves identifying a range of risks on the farm and strategies to minimising their impact. This can reduce the risk of 'cumulative impacts' in which a farmer experiences not only drought but also impacts from other events, as the farmer has strategies for reducing impacts from a wider range of risks.	All
Increasing and protecting groundcover	High for graziers, unclear for others	Loss of groundcover during drought has multiple negative impacts, including reduced feed for livestock, higher rates of erosion, and reduced soil health. This in turn can increase recovery time after drought if poor soil structure and health inhibits regrowth of pasture or crops. Increasing and protecting groundcover can reduce impacts of drought through better maintaining feed during drought and enabling more rapid regrowth of pasture after drought.	All, but particularly livestock graziers, where maintaining healthy groundcover enables maintenance of some feed for a longer period into drought
Changing grazing systems to promote pasture regeneration	Medium but unclear which types of systems	Some NRM programs have promoted changing grazing systems to better promote pasture regeneration. This can involve a range of actions, such as shifting to short rotation high intensity grazing systems, using grazing charts, shifting to more intensive systems that use feed pads and other systems to reduce impacts on pasture. These different types of grazing system change may have differing implications for drought resilience, and there is little information available on how different grazing system approaches may affect drought resilience.	Livestock graziers
Accessing information on drought	Medium	Accessing information and advice on drought can help through providing knowledge that can be translated into actions to cope with drought. However, the effectiveness will vary depending on factors including the appropriateness of both the information content and of how it is delivered.	All

NRM activity	**How likely is this to confer some drought resilience?** (initial informal hypothesis used to guide subsequent analysis)	**How might this increase resilience to drought?**	**Types of farms for which this is relevant**
Tree planting, riparian fencing, regeneration of vegetation	Low	Encouraging regeneration of vegetation other than groundcover (shrubs and trees) has more limited links to drought resilience. While it is possible to argue that shade may be of assistance in some circumstances, and that having greater vegetation cover can protect soil structure and health, not all drought involves heatwave and these effects do not always clearly link to improved farm financial performance.	All
Pest animal control	Medium	During drought, grazing by feral animals can be a bigger problem than at other times, particularly for graziers who experience increased grazing by pest animals such as kangaroos. Control of these problems can improve resilience, although it depends on the relative cost-benefit of the control activities.	Graziers
Weed control	Low to medium	More effective control of weeds may reduce impacts of drought through reducing competition for scarce water and enabling available water to be better used for pasture or crop growth. However, the wide range of types of weeds with differing relationships with water scarcity and farm performance means it is likely to be difficult to identify an association between weed control and drought.	All, but with a wide variety of potential associations
Native pasture establishment	Medium	Establishing perennial native pastures is often promoted as a way of reducing water use on farms, and increasing pasture survival during periods of water scarcity, as well as promoted for soil health benefits. This may be associated with increased resilience to drought through improving groundcover retention into drought and more rapid pasture recovery after drought.	Graziers
Improving access to water	Medium	Improving access to water through changing water storages on farm, or through improving access to bore water or changing how water flows over the farm and hence absorption into soil, has potential to enable better farm productivity in times of reduced rainfall. However, the wide range of methods that can be used to improve access to water may have differing utility for different types of farmers in drought, meaning specific water access actions may each need to be assessed individually to identify any relationship.	All, but likely differing water access measures are more and less useful for different farm types in droughts
Improving water use efficiency	Medium to high	Investing in technology and processes that enable using less water to achieve the same amount of pasture or crop growth can enable farmers to maintain pasture and crop growth further into drought. However, many different	All but likely differences between graziers and crop growers in the types of

NRM activity	How likely is this to confer some drought resilience? (initial informal hypothesis used to guide subsequent analysis)	How might this increase resilience to drought?	Types of farms for which this is relevant
		actions can be used to improve water use efficiency; some may be more effective than others in supporting drought resilience.	water use efficiency that are most relevant
Encouraging a wider diversity of plants and organisms	Low	Encouraging growth of a wider diversity of plants and organisms on the farm can contribute significantly to biodiversity, and in some cases may increase drought resilience through better protecting groundcover or soil structure in drought, but will not always do this depending on the types of plants and organisms involved.	All
Increasing feed reserves	High	Increasing feed reserves in preparation for drought can enable graziers to cope longer into drought, and is supported by some NRM organisations as it can help reduce impacts on pastures and soil during drought. This is a more 'traditional' drought preparation measure rather than being NRM-specific.	Graziers
Increasing financial reserves	High	Farmers who prepare for drought by setting aside financial reserves ahead of drought are likely to cope better financially, and to be able to reduce impacts on land during drought as they can cope financially through a period of destocking or no crop growth better than those with no financial reserves. This is a non-NRM specific drought preparation measure, included to compare to NRM-specific measures.	All

Methods

This section briefly explains the dataset used to examine whether engaging in some types of NRM appears to confer some resilience to drought.

Study sample

To examine the potential for improvement in drought resilience associated with engagement in different types of NRM practice or process, we used cross-sectional data from a sample of farmers who participated in the 2015 Regional Wellbeing Survey (RWS). The RWS is an annual survey of people living in rural and regional Australia. The RWS collects data on a broad range of topics including farmer practices, rural life and resilience indicators (Schirmer et al., 2016). A detailed description of the methods used to collect data is provided in our 'Wellbeing, resilience, and liveability' report (Schirmer et al. 2016). This should be referred to for information about how the survey sampling is achieved, and known limitations of the data set. The survey was open during September to November 2015, and participants were able to complete the survey in paper form or online.

A total of 4,421 farmers participated in the RWS in 2015, although not all those who identified as farmers where included in the analysis. Only farmers who worked more than 20 hours per week on farm were included in analysis, as this group were less likely to work off farm, and more likely to be exposed drought related stressors. This resulted in a total analysable sample of 2072 farmers across Australia, comprising of 1168 graziers, 412 mixed cropping-graziers and 492 croppers-horticulturalist. The mean age of participants was 58.9 years (ranging from 19 years to 96 years). Men made up 66.7% of the sample.

Identifying farmers experiencing drought

Those farmers who were experiencing drought at time of survey were identified by using the Hutchinson Drought Severity Index count score (HDSI count). The HDSI count is a score based on the Hutchinson Score – an objective measure of relative dryness calculated using location specific rolling six-monthly rainfall totals (O'Brien et al, 2014). A Hutchinson Score of -4 to +4 is allocated to every 25km by 25km grid in Australia, for a particular month. This score compares the rainfall totals for the nominated month plus the previous 6 months to the rainfall totals for the same sequence of months over the past century. A Hutchinson score of -1 or less indicates a period of relative dryness.

The HDSI count index counts the number of consecutive months a particular location has been experiencing relative dryness (i.e. has a Hutchinson Score of -1 or less). A particular location is considered to be in drought when the HSDI count index reaches 5 (Smith et al, 1992), meaning they have experienced 5 consecutive months of relative dryness. Location grids reported in the HDSI count index were matched with localities reported in the RWS to identify which participants live in a locality that is in drought at the time of the survey (September 2015). Using this method, we identified 300 participants in our sample of farmers who lived in a locality which was experiencing drought at the time of survey (September 2015).

Given this report aims to answer questions about drought resilience outcomes for those who are participating in NRM practices and processes, the majority of the analysis included in this report was conducted on only those who were residing in a drought affected locality (n=300). In addition, not all survey questions were asked of all participants, and not all NRM practices and processes are

applicable to all types of farming – therefore for each NRM practice examined in this report, the sample size differs. Table 2 shows the number of farmers sampled for different NRM practices.

Table 2 Sample size of farmers by (i) engagement in different NRM activities and (ii) experience of drought in 2015

	No drought		Drought	
	Not done	Have done	Not done	Have done
Farm drought planning	808	960	172	124
Farm risk planning	801	923	137	149
Farm NRM planning	681	468	165	87
Monitoring whether achieving environmental objectives	761	427	166	95
Prioritise maintaining groundcover (graziers)	116	591	26	110
Prioritise maintaining groundcover (mixed crop-grazing)	30	199	9	50
Prioritise maintaining groundcover (cropping/horticulture)	66	217	19	55
Encouraging diversity of plants & organisms	397	814	90	176
Obtained drought information from Landcare	1147	529	208	75
Improved water use efficiency (irrigators)	185	275	43	82
Improved water use efficiency (dryland)	668	540	90	73
Increased native pasture (graziers)	407	571	83	61
Increased native pasture (mixed crop-grazing)	137	188	35	23
Increased native pasture (cropping/horticulture)	222	165	42	39
Investing in reducing input needs e.g. fertiliser, chemicals	824	918	135	153
Planting trees for shade and shelter	640	1129	84	207
Riparian fencing	1067	649	184	98
Working with others to reduce feral animals (graziers, mixed crop-grazing with a feral animal problem)	131	786	25	89
Working with others to reduce feral animals (cropping-horticulture with a feral animal problem)	54	171	10	34
Working with others to reduce weeds (those with a weed problem)	373	807	57	125
Increasing feed reserves (graziers, mixed crop-graziers)	394	925	63	150
Increasing feed reserves (cropping/horticulture)	222	159	42	38
Increasing financial reserves as drought preparation	910	866	166	127

Survey questions

The survey measures analysed in this report are summarised in Table 3. In addition to these, demographic characteristics of age and gender were included in models as covariates. These were chosen as they are considered to be factors which are known to be correlated with resilience indicators such as subjective wellbeing and farm performance. For those models which were not limited to a particular farm type, farm type was included in models as a covariate.

Table 3 Description of survey measures

Measure	Item	Survey items	Score
Subjective wellbeing	Personal Wellbeing Index (PWI)	Combined mean score of individual items of the PWI, converted to a scale from 0 – 100.	Scale from 0 (very poor) to 100 (very high wellbeing)
Farm performance	Farm financial stress	My farm business is under a lot of financial stress at the moment	1 (strongly disagree) to 7 (strongly agree)

Measure	Item	Survey items	Score
	Satisfaction with farm performance	I am satisfied with my farm business performance	1 (strongly disagree) to 7 (strongly agree)
	Farm surplus	Which of these best describes your farm business at the moment? (Response options: Making a large loss, Making a moderate loss, Making a small loss, Breaking even, Making a small profit, Making a moderate profit, Making a large profit)	1 (making a large loss) to 7 (making a large profit)
	Ability to service farm debt	How easy or difficult is it for you to service your farm business debt at the moment? (Response options: Very difficult to service my debt, Difficult to service my debt, Neither difficult or easy to service my debt, Easy to service my debt, Very easy to service my debt)	1 (very difficult to service debt) to 5 (very easy to service debt)
	Farm cash flow	How would you describe your average cash-flow on the farm over the last 12 months? (Response options: Very poor farm cash flow (it's difficult to access cash), Poor farm cash flow, Neither good or bad farm cash flow, Good farm cash flow, Very good farm cash flow)	1 (very poor farm cash flow) to 5 (very good farm cash flow)
NRM activities	Farm drought planning	I have started planning for the next drought (e.g. building new dams identified in my risk assessment)	Nominal variable – yes/no
	Farm risk planning	My farm plan includes assessment of likely risks that could affect the farm, and how to respond to them	1 (strongly disagree) to 7 (strongly agree)
	Farm NRM planning	I have a property management plan that includes natural resource management objectives	1 (strongly disagree) to 7 (strongly agree)
	Monitoring environmental objectives	I actively monitor whether I am achieving my environmental objectives on the land I manage, e.g. through photos or documenting change	1 (strongly disagree) to 7 (strongly agree)
	Prioritise maintaining groundcover	Ensuring I keep good groundcover is a priority in my land management	1 (strongly disagree) to 7 (strongly agree)
	Encouraging diversity	I aim to increase the diversity of plants and organisms on my land	1 (strongly disagree) to 7 (strongly agree)
	Obtained drought information from Landcare	I have received drought advice/information from Landcare or natural resource management groups	Nominal variable – yes/no
	Water use efficiency	I have improved my water use efficiency (e.g. reducing dam evaporation)	Nominal variable – yes/no
	Increased native pasture	Have you done any of the following in the last 5 years? Actively encouraged regeneration of native pastures?	Nominal variable – yes/no
	Investing in reducing input needs	Have you done any of the following in the last 5 years? Used new technology to reduce use of fuel, chemicals or fertilisers?	Nominal variable – yes/no

Measure	Item	Survey items	Score
	Planting shade/ shelter trees	Have you done any of the following in the last 5 years? Planted trees intended to provide shade or shelter?	Nominal variable – yes/no
	Riparian fencing	Have you done any of the following in the last 5 years? Fenced riparian areas?	Nominal variable – yes/no
	Collaborative feral animal control	Have you done any of the following in the last 5 years? Worked with others to reduce feral animals in my district?	Nominal variable – yes/no
	Collaborative weed control	Have you done any of the following in the last 5 years? Worked with others to reduce invasive weeds in my district?	Nominal variable – yes/no
	Increasing feed reserves	I have increased feed reserves/stockpiles (hay or silage stores)	Nominal variable – yes/no
	Increasing financial reserves	I have improved my financial reserves to buffer against future bad years on the farm	Nominal variable – yes/no

Analysis

To identify whether farmers who had engaged in different types of NRM had higher resilience to drought compared to those who had not, we analysed data in three steps. Each of these was done for each NRM action examined:

- Descriptive analysis. This analysis involved identifying the resilience outcomes of farmers who (i) had and hadn't engaged in the NRM action, and (ii) were and were not experiencing drought. This enabled identification of whether resilience outcomes varied depending on current exposure to drought.
- Bivariate analysis. Among our sample of farmers experiencing drought – this analysis examined whether there was a significant difference between the resilience outcomes of those engaged in the NRM action, compared to those who had not engaged in the NRM action.
- Regression analysis. Hierarchical multiple regression analyses were used to examine whether relationships between NRM and resilience outcomes for drought-affected farmers still held after controlling for three variables known to also affect resilience outcomes: gender, age and farm type (three farm types were examined: grazing, mixed cropping-grazing, and cropping/horticulture). In each regression, farmers experiencing drought were compared using a two-step regression. In the first step covariates known to be important to resilience outcomes (age, gender and farm type) were entered as the first step in the regression analysis. In the second step, a variable showing whether or not the farmer had engaged in the NRM action was included, to see if this made a significant different to predictive power of the overall model, and if engaging in NRM was a significant predictor of the resilience outcome (the dependent variable).

Farm type was also controlled for by splitting the sample according to farm type, and conducting a separate hierarchical multiple regression on these groups. This was done where particular NRM actions were considered to be less applicable to certain farm types, compared to others. For example, prioritisation of groundcover is important in different ways to graziers versus crop growers.

Interpreting findings

This study analyses data collected at a single point in time. This means it cannot identify causal relationships using longitudinal analysis (tracking change over time to identify whether those who adopt an NRM practice cope better with drought after adopting it than they did previously). Longitudinal analysis is particularly problematic for analysing cause and effect related to NRM and drought resilience, as it would require being able to track farmers through at least two droughts, one experienced before and one after adopting the NRM practice, while controlling for other factors that might change how resilient the farmer was to drought in both the first and second drought.

Given the limitations of longitudinal analysis in this instance, cross-sectional analysis of data collected at a single point in time is appropriate, but needs to draw on broader criteria for establishing likely causal associations. Theoretically, a positive association between adopting NRM and resilience outcomes could result from different causal pathways:

- Adopting NRM enables farmers to grow resilience (the hypothesis being examined in this study), or
- Farmers with higher resilience are more likely to adopt NRM.

The Bradford-Hill causal criteria suggest that some or all of the following criteria must be fulfilled to demonstrate presence of a likely causal relationship (Lucas and McMichael 2005):

- *Strength:* Strong associations are considered more likely to be causal than weak associations. In the case of this study, it is considered unlikely that engaging in an NRM action will on its own be a strong predictor of resilience outcomes, as many factors influence resilience and NRM will be only one of these. However, statistically stronger relationships are still considered evidence of meeting this criterion.
- *Consistency:* If the same association is demonstrated in a variety of different situations. With data from a single point in time, the consistency criterion could not be used in this study. However, it was possible to analyse whether the association was consistent across multiple measures of resilience, enabling some use of the consistency criterion.
- *Specificity:* If the association is present only amongst groups experiencing a specific exposure. In this case, this can be demonstrated if the association is present more strongly during drought or during the drought recovery period, then during periods in which farmers are not experiencing either drought or recovering from drought. If engaging in NRM is associated with significant differences during drought and there is less difference in resilience outcomes for those not experiencing drought, then this criteria is fulfilled as there is a stronger association during the conditions in which resilience would be expected to make a difference. This means it is important to compare differences in wellbeing and farm performance for farmers experiencing drought and not experiencing drought.
- *Temporality:* If the cause preceded the effect. In this study, the farmer was asked if they had adopted NRM practices in the past, and this was compared with resilience outcomes experienced by those experiencing drought at the time they completed the survey. This satisfies the temporality criteria as adoption of the NRM practice preceded the experience of

drought at the time of completing the survey. Temporality can also be defined as occurring when the farm is experiencing drought and not when they are not, similar to specificity.

- *Biological gradient:* If there is a 'dose-response' relationship in which larger doses result in larger response. This criterion may not apply to many NRM interventions, as many of these are not adopted in increment but rather are present or absent.
- *Plausibility and coherence:* These criteria are satisfied if there is a plausible and coherent reason, according to existing theory and evidence, why an association demonstrates a likely causal relationship. This was assessed in this project by identifying plausible theories (presented earlier in this report) regarding likely impact of engaging in different forms of NRM on drought resilience, to identify whether there are plausible pathways by which different NRM actions may confer drought resilience.
- *Experiment:* Demonstration of cause and effect in an experimental situation. This is not possible in the case of adoption of NRM and drought resilience.
- *Analogy:* Identification of analogous situations in which causality has been demonstrated, which also apply to this situation. This was not used in this study.

For this study, therefore, the criteria of strength, consistency, specificity, temporality, plausibility and coherence were used to assess whether observed associations were likely to be causal in nature. These are used in the results section to assess likely causal association.

Results

First, overall findings on whether different NRM actions are associated with improved drought resilience are examined for each measure of resilience. This is followed by summarising overall findings, and considering the strength of the evidence against the causal criteria outlined in the methods section.

In total, 16 NRM practices are examined. However, some of these are relevant to some farm types and not others. Prioritising maintaining groundcover was considered to be important to crop growers and graziers in different ways, with graziers more likely to experience improved resilience to drought through use of this practice due to the direct impacts on being able to maintain livestock longer during drought. Increasing native pasture and increasing feed reserves were both considered relevant for graziers and not for crop growers. For these three practices, farmers were examined in three groups: graziers, mixed crop-grazing enterprises, and those engaged in cropping or horticulture with no grazing. Working with others to reduce feral animals was considered to be likely to improve resilience (i) if the farmer lived in an area with a feral animal problem, and (ii) more for graziers than crop growers. It was therefore examined for only those who reported that feral animals were a problem in their district. Improving water use efficiency was more relevant to irrigators (who directly apply water to crop or pasture) than to dryland farmers. It was therefore examined for each of these groups separately. Overall, this meant that the 16 practices were examined in 23 categories.

Resilience outcome 1 – Wellbeing

As described earlier, the wellbeing of farmers was examined using the Personal Wellbeing Index, a measure of wellbeing widely used internationally.

Table 4 shows the average wellbeing score for farmers who were not in drought and in drought at the time the survey was conducted, using the Personal Wellbeing Index measure. It does this for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, there were 10 for which adopting the practice was associated with higher wellbeing during drought. Of these 10, nine relationships still held when regression analysis was conducted to control for the effects of age, gender and farm type.

These nine were then examined to identify if the observed effects were *drought-specific*. If investing in a particular NRM activity confers resilience to drought, then the difference in resilience should be greater during drought than in non-drought times. This means that to be able to claim there is evidence of a causal association, there should be evidence that adopting the practice specifically protects wellbeing in drought. If the wellbeing of landholders who adopt a practice is higher than those who don't adopt the practice at all times (whether or not they are experiencing drought), this indicates that the higher wellbeing during drought is not necessarily caused by the practice helping the person to cope with drought.

For each of the nine practices for which there was a significant difference in the wellbeing of those who had and hadn't adopted the practice during drought, Figure 1 shows the average wellbeing reported by those (i) not experiencing drought and (ii) experiencing drought. It then shows the average difference in wellbeing scores for those (i) not experiencing drought and (ii) experiencing drought. What is shown clearly is that, for all nine practices, the difference in wellbeing is larger during drought than when not experiencing drought. This is consistent with the hypothesis that the practices confer specific resilience to drought.

Wellbeing

NRM practices found to improve drought resilience

- Farm drought planning
- Farm risk planning
- Farm NRM planning
- Monitoring whether achieving environmental objectives
- Prioritising groundcover (for graziers/mixed)
- Increasing native pastures (graziers)
- Working with others to reduce feral animals (graziers/mixed with a feral animal problem)
- Increasing feed reserves (graziers/mixed)
- Increasing financial reserves as drought preparation

Table 4 Wellbeing – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Wellbeing – PWI		IN DROUGHT Wellbeing – PWI		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in wellbeing greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	75.7 ±1.2	76.3 ±1.0	74.6 ±2.7	77.3 ±2.6	Yes – better	Yes**	Yes
Farm risk planning	74.3 ±1.2	77.7 ±1.0	72.8 ±3.0	79.2 ±2.3	Yes – better	Yes**	Yes
Farm NRM planning	74.4 ±1.2	76.0 ±1.5	73.9 ±2.7	79.5 ±3.2	Yes – better	Yes**	Yes
Monitoring whether achieving environmental objectives	74.9 ±1.2	75.6 ±1.5	74.0 ±2.5	79.2 ±3.2	Yes – better	Yes**	Yes
Prioritise maintaining groundcover (graziers)	71.9 ±3.0	75.7 ±1.3	67.8 ±7.4	75.9 ±3.2	Yes – better	Yes*	Yes
Prioritise maintaining groundcover (mixed crop-grazing)	75.0 ±6.3	76.6 ±2.0	64.6 ±16.5	77.8 ±3.6	Yes – better	Yes*	Yes
Prioritise maintaining groundcover (cropping/hort)	70.7 ±4.5	76.4 ±2.1	72.7 ±9.1	79.5 ±3.6	Yes – better	No	
Encouraging diversity of plants & organisms	74.5 ±1.6	75.4 ±1.1	73.5 ±3.7	76.6 ±2.4	Yes – better	No	
Obtained drought information from Landcare	76.3 ±1.0	76.1 ±1.4	74.8 ±2.4	77.2 ±3.3	No	No	
Improved water use efficiency (irrigators)	75.4 ±2.6	75.9 ±2.1	76.0 ±5.0	76.5 ±3.6	No	No	
Improved water use efficiency (dryland)	76.0 ±1.2	76.4 ±1.4	76.5 ±3.6	76.3 ±3.4	No	No	
Increased native pasture (graziers)	76.3 ±1.6	75.8 ±1.3	71.7 ±3.9	77.2 ±4.4	Yes – better	Yes*	Yes
Increased native pasture (mixed crop-grazing)	77.2 ±2.6	77.0 ±2.1	78.5 ±4.9	74.2 ±6.5	No	No	
Increased native pasture (cropping/horticulture)	75.7 ±2.4	76.4 ±2.4	78.9 ±3.4	77.3 ±5.9	No	No	
Investing in reducing input needs e.g. fertiliser	75.2 ±1.2	76.8 ±1.0	74.5 ±2.9	77.3 ±2.5	Yes – better	No	
Planting trees for shade and shelter	75.3 ±1.3	76.7 ±0.9	74.9 ±4.1	76.2 ±2.1	No	No	
Riparian fencing	75.6 ±1.0	77.0 ±1.2	76.0 ±2.5	75.1 ±3.2	No	No	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	75.7 ±2.8	76.0 ±1.1	71.4 ±7.1	76.6 ±3.5	No	Yes**	Yes
Working with others to reduce feral animals (crop/hort with feral animal problem)	75.3 ±4.7	75.4 ±2.5	80.3 ±7.4	78.2 ±5.7	No	No	
Working with others to reduce weeds	75.1 ±1.8	76.0 ±1.1	76.3 ±4.5	75.6 ±2.9	No	No	
Increasing feed reserves (graziers/mixed)	74.7 ±1.7	77.1 ±1.0	69.8 ±4.8	76.9 ±2.5	Yes – better	Yes**	Yes
Increasing feed reserves (cropping/horticulture)	75.3 ±2.2	76.4 ±2.8	77.4 ±4.9	78.2 ±4.5	No	No	
Increasing financial reserves as drought preparation	73.3 ±1.2	79.0 ±0.9	71.9 ±2.6	81.4 ±2.4	Yes – better	Yes**	Yes

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

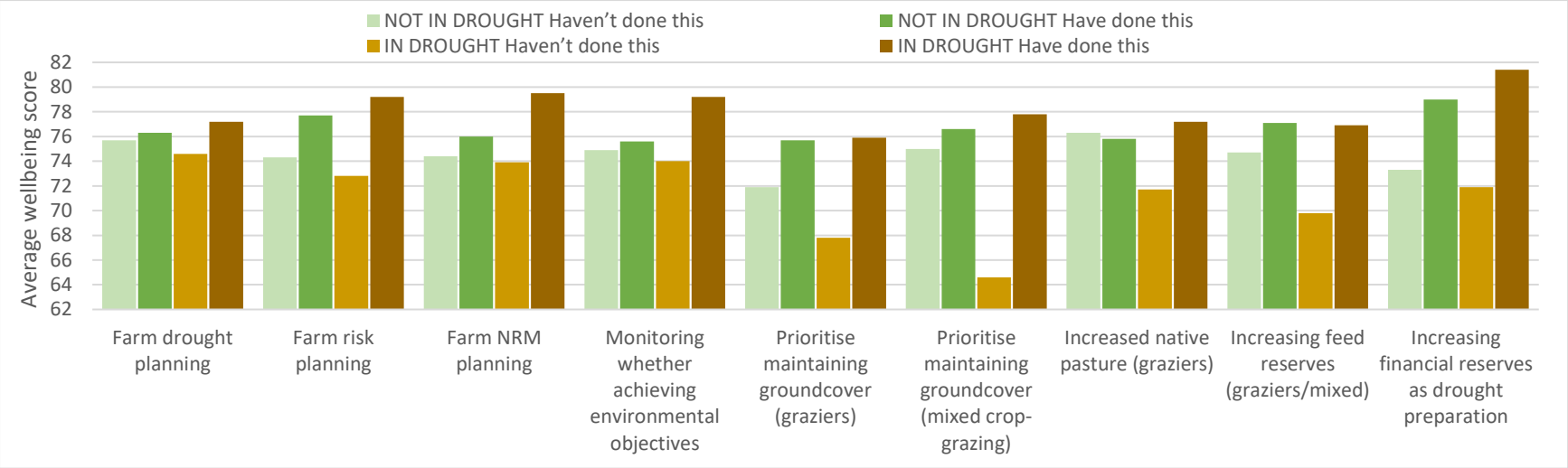

Figure 1 Wellbeing of those who had and had not adopted different NRM practices, when in drought and not in drought

Resilience outcome 2 – Self-reported farm financial stress

Farmers were asked if their farm was under a lot of financial stress at the time of completing the survey. This measure is a 'self-report' measure: farmers answer based on their subjective assessment of whether their farm is in financial stress, and therefore may have differing criteria for what constitutes financial stress. This means that the answers do not reflect an objective level of farm financial stress, and instead reflect the differing perceptions of farmers about what constitutes a high level of stress.

Table 5 shows the average self-reported farm financial stress scores for farmers who were not in drought and in drought at the time the survey was conducted, for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, there were four for which adopting the practice was associated with lower financial stress during drought, and two for which it was worse. The four which predicted lower financial stress remained significant when controlled for age, gender and farm type in regression analysis, while only one of the two that predicted greater financial stress in drought (increasing native pasture area) remained significant after controlling for these factors.

To identify whether or not the effects of each of these five practices were *drought-specific* the difference in the average farm financial stress scores of those practicing and not practicing the NRM activities were compared for those (i) not experiencing drought and (ii) experiencing drought (Figure 2). Those who engaged in forward planning for drought and in increasing financial reserves for drought reported lower financial stress both when in drought and when not in drought. This means there is not clear evidence that these practices confer resilience to drought, although it is likely that having lower financial stress on the farm both helps a farmer invest in these practices prior to drought, and helps reduce impacts of these practices during drought.

The difference in farm financial stress levels reported by graziers and crop growers who prioritised maintaining groundcover was greater in drought than in non-drought times, indicating that this practice confers resilience to drought. Conversely, graziers who had increased native pasture were *more* likely to report high farm financial stress in drought, indicating poorer drought resilience outcomes for those who adopted this practice.

Farm financial stress

NRM practices found to improve drought resilience

- Prioritising groundcover (graziers and cropping/horticulture)

NRM practices found to worsen drought resilience

- Increased native pastures (graziers)

Table 5 Farm financial stress – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Farm financial stress		IN DROUGHT Farm financial stress		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in farm financial stress greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	4.0 ±0.1	3.8 ±0.1	4.5 ±0.3	4.2 ±0.4	No	**Yes***	**Not significantly**
Farm risk planning	3.9 ±0.1	3.9 ±0.1	4.5 ±0.3	4.2 ±0.3	No	**No**	
Farm NRM planning	3.9 ±0.1	4.0 ±0.1	4.5 ±0.3	4.1 ±0.4	No	**No**	
Monitoring whether achieving environmental objectives	3.9 ±0.1	4.1 ±0.2	4.4 ±0.3	4.2 ±0.4	No	**No**	
Prioritise maintaining groundcover (graziers)	3.7 ±0.4	3.8 ±0.2	5.0 ±0.8	4.1 ±0.4	Yes - better	**Yes***	**Yes - better**
Prioritise maintaining groundcover (mixed crop-grazing)	4.0 ±0.8	4.0 ±0.3	4.1 ±1.2	4.7 ±0.5	No	**No**	
Prioritise maintaining groundcover (cropping/hort)	4.4 ±0.5	4.2 ±0.3	4.9 ±1.0	4.1 ±0.6	Yes -better	**Yes***	**Yes - better**
Encouraging diversity of plants & organisms	3.8 ±0.2	4.0 ±0.1	4.5 ±0.4	4.3 ±0.3	No	**No**	
Obtained drought information from Landcare	3.8 ±0.1	3.9 ±0.2	4.5 ±0.3	4.0 ±0.4	Yes – better	**No**	
Improved water use efficiency (irrigators)	3.8 ±0.3	4.3 ±0.2	4.3 ±0.6	4.3 ±0.4	No	**No**	
Improved water use efficiency (dryland)	3.7 ±0.2	3.9 ±0.2	4.3 ±0.4	4.6 ±0.5	No	**No**	
Increased native pasture (graziers)	3.6 ±0.2	3.8 ±0.2	4.0 ±0.4	4.7 ±0.5	Yes – worse	**Yes***	**Yes - worse**
Increased native pasture (mixed crop-grazing)	3.8 ±0.3	3.9 ±0.3	4.4 ±0.6	4.8 ±0.8	No	**No**	
Increased native pasture (cropping/horticulture)	4.4 ±0.3	4.0 ±0.3	4.4 ±0.7	4.3 ±0.7	No	**No**	
Investing in reducing input needs e.g. fertiliser	3.8 ±0.1	4.0 ±0.1	4.4 ±0.4	4.2 ±0.3	No	**No**	
Planting trees for shade and shelter	4.0 ±0.2	3.8 ±0.1	4.3 ±0.5	4.3 ±0.3	No	**No**	
Riparian fencing	3.9 ±0.1	3.9 ±0.2	4.3 ±0.3	4.3 ±0.4	No	**No**	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	3.7 ±0.3	3.9 ±0.1	4.7 ±0.7	4.5 ±0.4	No	**No**	
Working with others to reduce feral animals (crop/hort with feral animal problem)	4.6 ±0.5	4.3 ±0.3	3.9 ±1.3	4.1 ±0.8	No	**No**	
Working with others to reduce weeds	4.0 ±0.2	4.0 ±0.1	4.0 ±0.6	4.5 ±0.4	Yes – worse	**No**	
Increasing feed reserves (graziers/mixed)	4.3 ±0.3	4.1 ±0.3	4.3 ±0.7	4.4 ±0.7	No	**No**	
Increasing feed reserves (cropping/horticulture)	4.3 ±0.3	4.1 ±0.3	4.3 ±0.7	4.4 ±0.7	No	No	
Increasing financial reserves as drought preparation	4.5 ±0.1	3.2 ±0.1	5.0 ±0.3	3.5 ±0.4	Yes – better	**Yes****	**Not significantly**

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

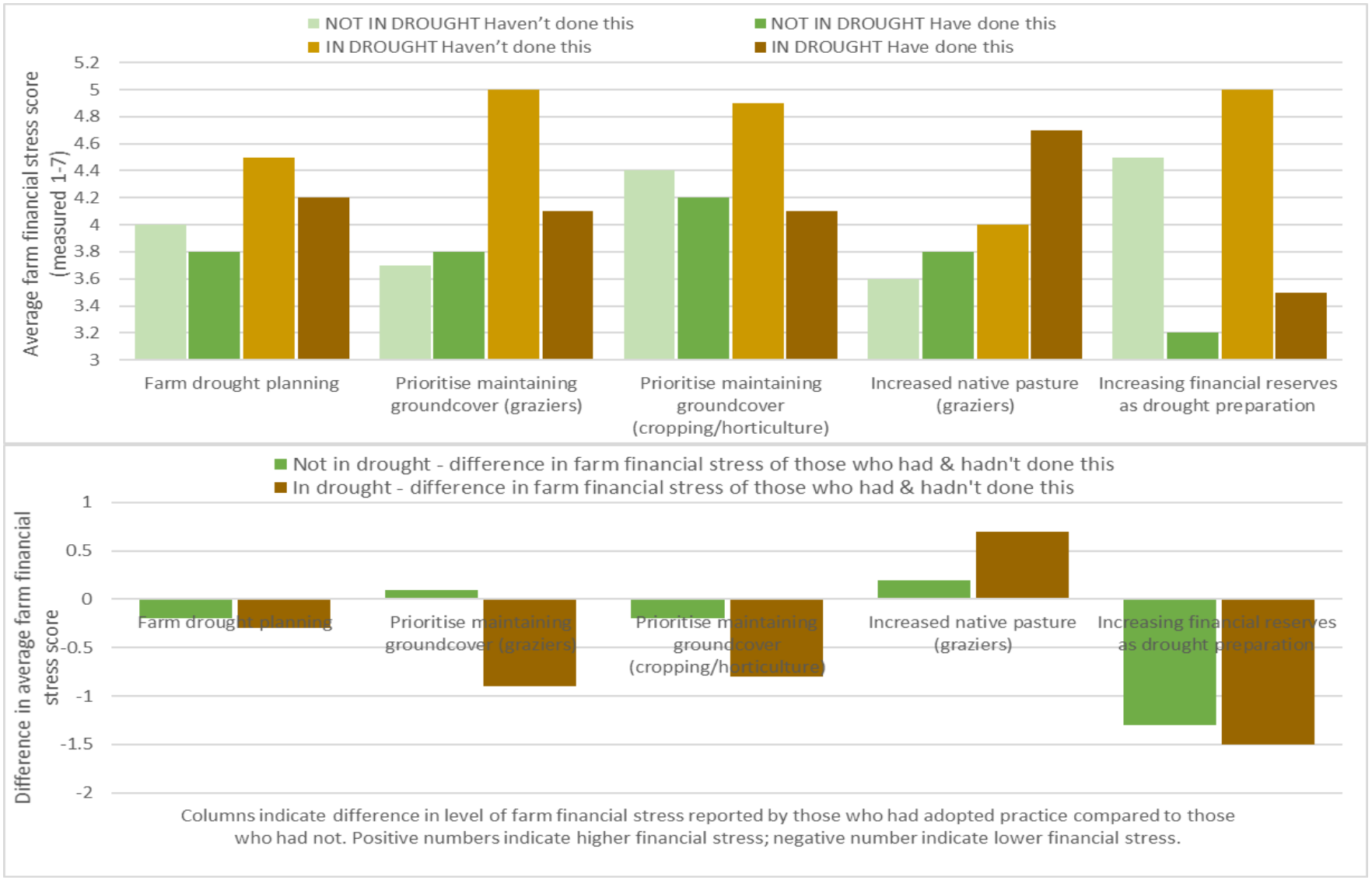

Figure 2 Farm financial stress of those who had and had not adopted different NRM practices, when in drought and not in drought

Resilience outcome 3 – Satisfaction with farm financial performance

Farmers were asked how satisfied they were with their farm financial performance at the time of completing the survey. Farmers answered based on their subjective assessment of their satisfaction with farm financial performance, and different farmers may have differing criteria for what constitutes good farm financial performance. This means that the answers do not reflect an objective level of farm financial performance, but rather farmers' perceptions of how their farm is performing financially.

Table 6 shows the average satisfaction with farm financial performance scores for farmers who were not in drought and in drought at the time the survey was conducted, and for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, there were six for which adopting the practice was associated with higher satisfaction with farm financial performance during drought, and one – feral animal control - for which it was worse for some types of farmers and better for others. All positive associations still held when regression analysis was conducted to control for the effects of age, gender and farm type. The negative relationship between feral animal control and satisfaction with farm financial performance did not hold when controlled for age and gender.

These significant relationships were then examined to identify if the observed effects were *drought-specific*. As shown in Figure 3, for all but one practice (increasing financial reserves in preparation for drought), the difference in satisfaction with farm financial performance was greater during drought than when not in drought. This is consistent with the hypothesis that the practices of forward planning for drought and farm risks, prioritising maintenance of groundcover, improving water use efficiency, investing in collaborative feral animal control, and increasing feed reserves, confer specific resilience to drought. Increasing financial reserves to prepare for drought may confer resilience to drought, but is likely to be more readily able to be implemented by those experiencing positive farm financial performance, potentially explaining why those who reported doing this had higher satisfaction with farm financial performance both when experiencing drought and when not experiencing drought.

Satisfaction with farm financial performance

NRM practices found to improve drought resilience

- Farm drought planning
- Farm risk planning
- Prioritising groundcover (for graziers)
- Improved water use efficiency (irrigators)
- Working with others to reduce feral animals (graziers/mixed with a feral animal problem)
- Increasing feed reserves (graziers/mixed)

Table 6 Satisfaction with farm financial performance – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Satisfaction with farm financial performance		IN DROUGHT Satisfaction with farm financial performance		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in wellbeing greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	4.2 ±0.1	4.4 ±0.1	3.9 ±0.3	4.2 ±0.3	Yes - better	**Yes***	**Yes – slightly**
Farm risk planning	4.2 ±0.1	4.5 ±0.1	3.6 ±0.3	4.3 ±0.3	Yes - better	**Yes****	**Yes**
Farm NRM planning	4.2 ±0.1	4.1 ±0.2	3.9 ±0.3	4.1 ±0.4	No	**No**	
Monitoring whether achieving environmental objectives	4.2 ±0.1	4.2 ±0.2	4.0 ±0.3	3.9 ±0.4	No	**No**	
Prioritise maintaining groundcover (graziers)	4.0 ±0.3	4.2 ±0.1	3.3 ±0.6	4.1 ±0.3	Yes – better	**Yes***	**Yes**
Prioritise maintaining groundcover (mixed crop-grazing)	4.0 ±0.6	4.1 ±0.2	3.9 ±1.2	4.4 ±0.5	Yes – better	**No**	
Prioritise maintaining groundcover (cropping/hort)	4.3 ±0.4	4.2 ±0.2	3.9 ±0.8	3.8 ±0.5	No	**No**	
Encouraging diversity of plants & organisms	4.3 ±0.2	4.1 ±0.1	3.9 ±0.4	4.0 ±0.3	No	**No**	
Obtained drought information from Landcare	4.4 ±0.1	4.2 ±0.1	4.1 ±0.2	3.9 ±0.4	No	**No**	
Improved water use efficiency (irrigators)	4.3 ±0.3	4.3 ±0.2	3.5 ±0.5	4.2 ±0.4	Yes - better	**Yes****	**Yes**
Improved water use efficiency (dryland)	4.3 ±0.1	4.4 ±0.1	4.0 ±0.4	4.2 ±0.4	No	**No**	
Increased native pasture (graziers)	4.3 ±0.2	4.4 ±0.1	3.9 ±0.4	4.1 ±0.4	No	**No**	
Increased native pasture (mixed crop-grazing)	4.3 ±0.3	4.3 ±0.2	4.4 ±0.5	3.9 ±0.7	No	**No**	
Increased native pasture (cropping/horticulture)	4.2 ±0.2	4.2 ±0.2	3.7 ±0.6	3.9 ±0.6	No	**No**	
Investing in reducing input needs e.g. fertiliser	4.3 ±0.1	4.4 ±0.1	4.0 ±0.3	4.0 ±0.3	No	**No**	
Planting trees for shade and shelter	4.2 ±0.1	4.4 ±0.1	4.2 ±0.4	3.9 ±0.2	No	**No**	
Riparian fencing	4.3 ±0.1	4.3 ±0.1	4.0 ±0.3	3.9 ±0.3	No	**No**	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	4.3 ±0.3	4.3 ±0.1	3.7 ±0.5	4.2 ±0.4	Yes - better	**Yes***	**Yes**
Working with others to reduce feral animals (crop/hort with feral animal problem)	4.3 ±0.4	4.2 ±0.2	4.7 ±1.2	3.5 ±0.6	Yes - worse	**No**	
Working with others to reduce weeds	4.2 ±0.2	4.3 ±0.1	4.1 ±0.5	4.0 ±0.3	No	**No**	
Increasing feed reserves (graziers/mixed)	4.2 ±0.2	4.4 ±0.1	3.8 ±0.5	4.2 ±0.3	Yes -better	**Yes***	**Yes**
Increasing feed reserves (cropping/horticulture)	4.1 ±0.2	4.3 ±0.3	4.0 ±0.5	3.6 ±0.6	No	**No**	
Increasing financial reserves as drought preparation	3.9 ±0.1	4.7 ±0.1	3.7 ±0.3	4.5 ±0.3	Yes - better	**Yes****	**No**

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

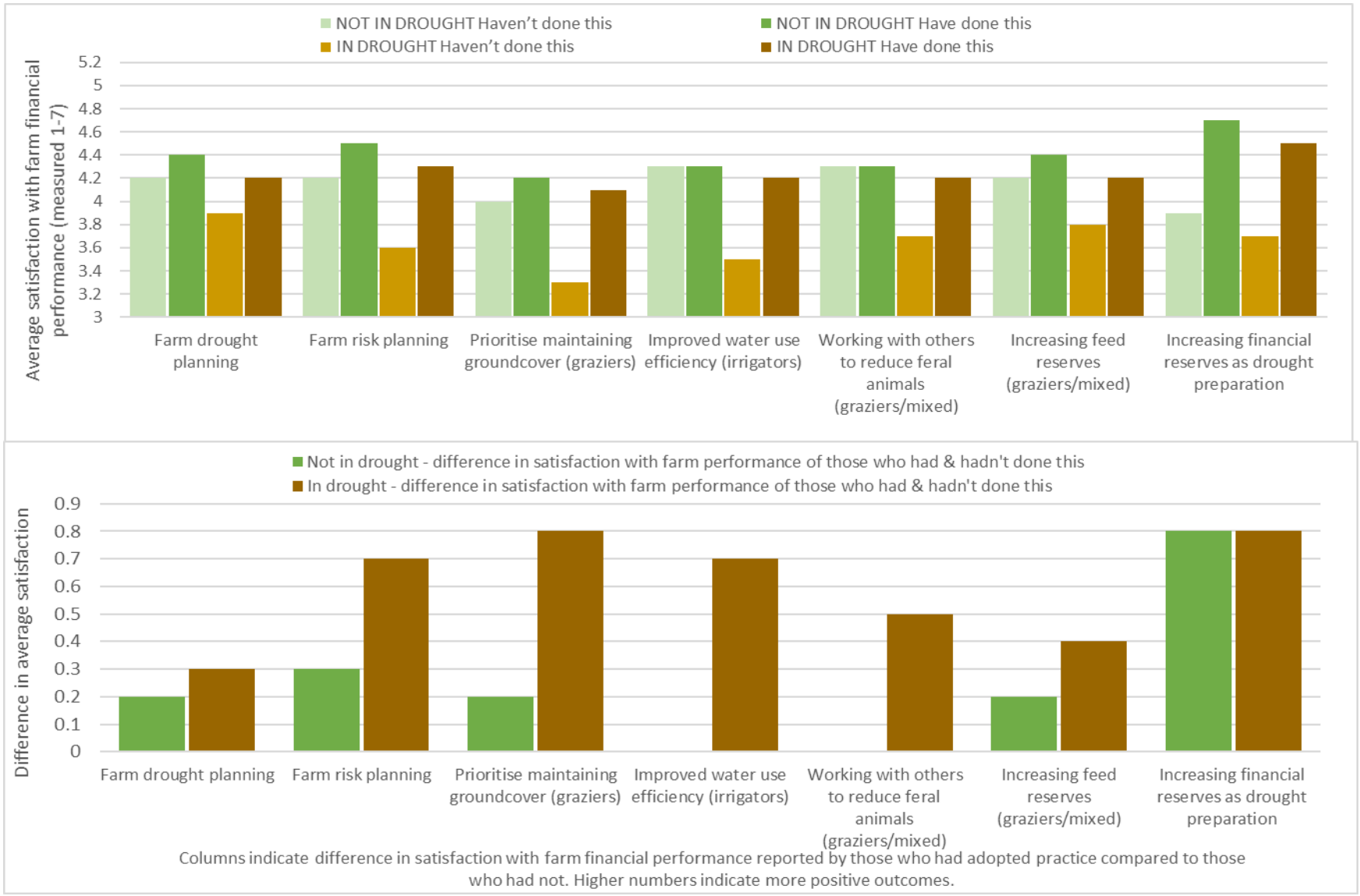

Figure 3 Satisfaction with farm financial performance of those who had and had not adopted different NRM practices, when in drought and not in drought

Resilience outcome 4 – Farm financial surplus

Farmers were asked to report their overall farm surplus in the last 12 months: they were asked to identify if their farm made a large loss, moderate loss, small loss, broke even, made a small profit, moderate profit or large profit. Farmers were instructed to assess this based on the surplus remaining *after* they accounted for paying themselves an income. The size of the financial surplus was not specified and, as such, the answers reflect the proportion of return on investment rather than size of farm surplus. As many farmers are known to not exclude their living costs from calculations of farm profit, this measure is better understood as a measure of financial surplus than of profit. This measure is self-reported, and some farmers will not have as accurate an assessment of their farm financial surplus as others.

Table 7 shows the average farm financial surplus reported by farmers who were not in drought and in drought at the time the survey was conducted, and for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, there were four for which adopting the practice was associated with higher levels of farm financial surplus. Of these four relationships, three still held when regression analysis was conducted to control for the effects of age, gender and farm type. In addition, one NRM practice which was not found to be associated with higher levels of farm financial surplus in initial bivariate analysis, was found to have a significant relationship once the analysis was controlled for age and gender. This bought the total number of NRM practices found to be associated with higher levels of farm financial surplus after controlling for age, gender and farm type to four.

These relationships were then examined to identify if the observed effects were *drought-specific*. As shown in Figure 4, the only practice for which the difference in farm financial surplus was larger during drought than when not experiencing drought was investing in reducing input needs. Those who had invested in reducing input needs were more likely than those who had not to report a financial surplus during drought. There was a small positive difference for farm risk planning and increasing financial reserves, but not large enough to be considered significant.

Farm financial surplus

NRM practices found to improve drought resilience

- Investing in reducing input needs e.g. fertiliser

Table 7 Farm financial surplus – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Farm financial surplus		IN DROUGHT Farm financial surplus		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in wellbeing greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	4.3 ±0.1	4.5 ±0.1	3.9 ±0.3	3.9 ±0.3	No	**No**	
Farm risk planning	4.3 ±0.1	4.5 ±0.1	3.8 ±0.3	4.1 ±0.3	Yes – better	**Yes****	**Not significantly**
Farm NRM planning	4.3 ±0.1	4.2 ±0.1	3.9 ±0.3	3.9 ±0.4	No	**No**	
Monitoring whether achieving environmental objectives	4.4 ±0.1	4.1 ±0.1	3.9 ±0.3	3.9 ±0.4	No	**No**	
Prioritise maintaining groundcover (graziers)	4.3 ±0.3	4.3 ±0.1	3.9 ±0.7	3.9 ±0.3	No	**No**	
Prioritise maintaining groundcover (mixed crop-grazing)	3.9 ±0.7	4.3 ±0.2	3.2 ±1.1	4.2 ±0.4	Yes – better	**No**	
Prioritise maintaining groundcover (cropping/hort)	4.3 ±0.4	4.5 ±0.2	3.4 ±0.8	3.8 ±0.5	No	**No**	
Encouraging diversity of plants & organisms	4.5 ±0.1	4.2 ±0.1	3.9 ±0.4	3.9 ±0.2	No	**No**	
Obtained drought information from Landcare	4.5 ±0.1	4.3 ±0.1	3.9 ±0.2	4.0 ±0.3	No	**No**	
Improved water use efficiency (irrigators)	4.4 ±0.2	4.4 ±0.2	4.1 ±0.5	4.4 ±0.3	No	**No**	
Improved water use efficiency (dryland)	4.5 ±0.1	4.4 ±0.1	3.8 ±0.4	3.7 ±0.4	No	**No**	
Increased native pasture (graziers)	4.5 ±0.1	4.2 ±0.1	4.1 ±0.4	3.7 ±0.4	No	**No**	
Increased native pasture (mixed crop-grazing)	4.6 ±0.3	4.4 ±0.2	4.3 ±0.5	3.9 ±0.5	No	**No**	
Increased native pasture (cropping/horticulture)	4.4 ±0.2	4.6 ±0.2	3.8 ±0.5	3.9 ±0.6	No	**No**	
Investing in reducing input needs e.g. fertiliser	4.3 ±0.1	4.5 ±0.1	3.6 ±0.3	4.2 ±0.3	Yes – better	**Yes****	**Yes**
Planting trees for shade and shelter	4.4 ±0.1	4.4 ±0.1	4.1 ±0.4	3.9 ±0.2	No	**No**	
Riparian fencing	4.4 ±0.1	4.3 ±0.1	3.9 ±0.2	3.9 ±0.3	No	**No**	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	4.5 ±0.2	4.3 ±0.1	3.6 ±0.6	4.0 ±0.4	No	**No**	
Working with others to reduce feral animals (crop/hort with feral animal problem)	4.0 ±0.4	4.5 ±0.2	4.1 ±1.0	4.1 ±0.6	No	**No**	
Working with others to reduce weeds	4.3 ±0.2	4.3 ±0.1	3.9 ±0.5	3.8 ±0.3	No	**No**	
Increasing feed reserves (graziers/mixed)	4.2 ±0.2	4.5 ±0.1	3.7 ±0.4	4.0 ±0.3	No	**Yes***	**No**
Increasing feed reserves (cropping/horticulture)	4.4 ±0.2	4.5 ±0.2	4.0 ±0.5	3.6 ±0.6	No	**No**	
Increasing financial reserves as drought preparation	3.9 ±0.1	4.9 ±0.1	3.4 ±0.2	4.6 ±0.3	Yes - better	**Yes****	**Not significantly**

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

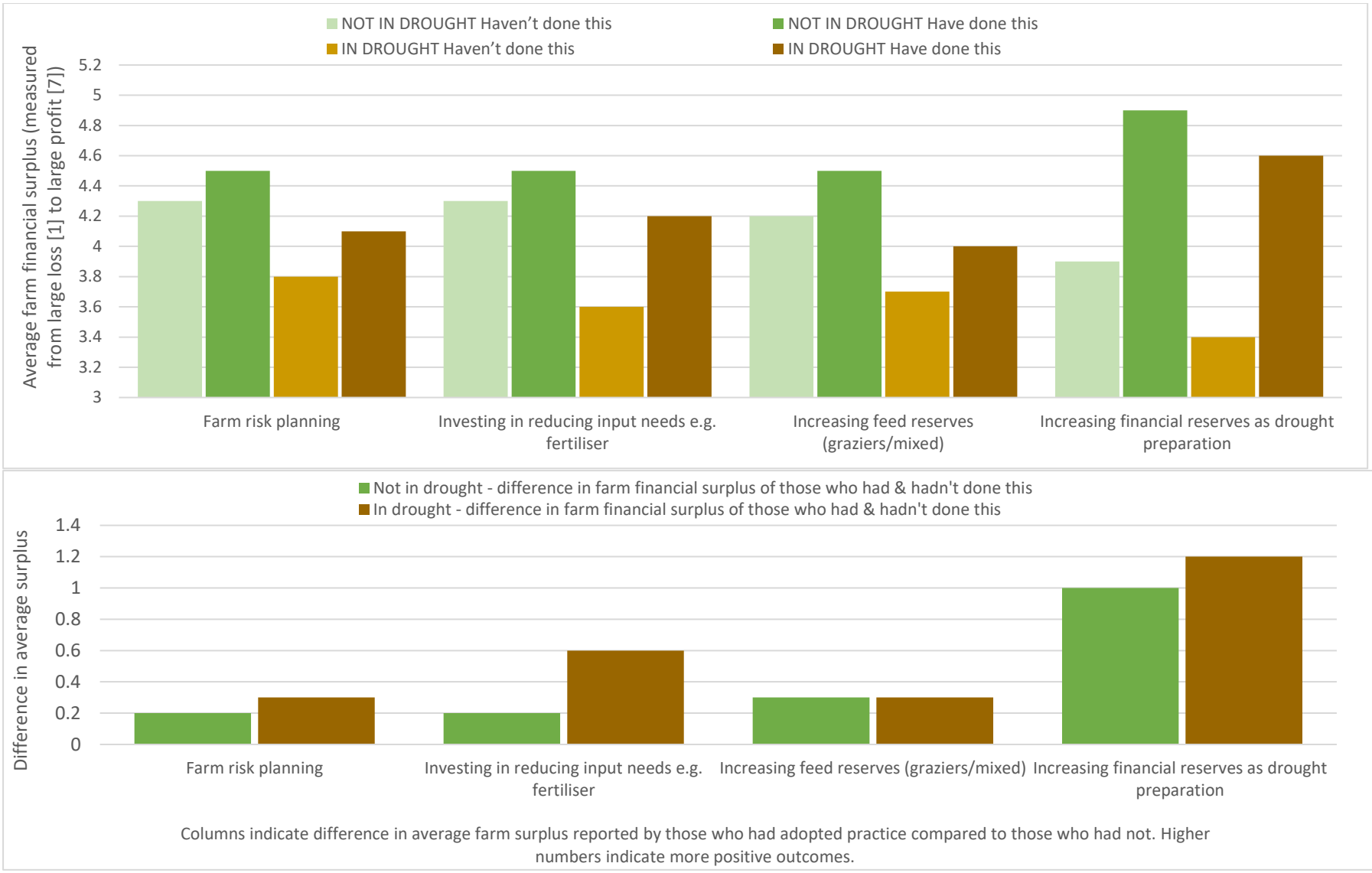

Figure 4 Farm financial surplus reported by those who had and had not adopted different NRM practices, when in drought and not in drought

Resilience outcome 5 – Ability to service farm debt

Farmers were asked to report how easy or difficult it was for them to service their farm debt at the time of completing the survey. Farmers answered based on their subjective assessment and may have differing criteria regarding their capability to service their farm debt. This means that the answers do not reflect an objective level of debt service ability, but rather farmers' perceptions of what constitutes easy or difficult debt servicing.

Table 8 shows the average score for debt servicing (lower numbers indicate more difficulty servicing debt) for farmers who were not in drought and in drought at the time the survey was conducted, for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, there were five for which adopting the practice was associated with farmers finding it easier to service farm debt, and two associated with farmers finding it harder to service farm debt. Of the five positive relationships, three still held when regression analysis was conducted to control for the effects of age, gender and farm type. Of the two negative relationships, one still held after controlling for age, gender and farm type.

These relationships were then examined to identify if the observed effects were *drought-specific*. As shown in Figure 5, for three of the four NRM practices the difference in ability to service farm debt was larger during drought than when not experiencing drought. In two cases – farm risk planning and prioritising maintaining groundcover – this was positive, with farmers finding it easier to service farm debt. In the other – crop growers working to manage feral animals – it was negative, with poorer performance during drought.

Ability to service farm debt

NRM practices found to improve drought resilience

- Farm risk planning
- Prioritise maintaining groundcover (cropping/horticulture)

NRM practices found to worsen drought resilience

- Working with others to reduce feral animals (cropping/horticulture with feral animal problem)

Table 8 Ability to service farm debt – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Ability to service farm debt		IN DROUGHT Ability to service farm debt		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in wellbeing greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	3.2 ±0.1	3.1 ±0.1	2.9 ±0.2	2.9 ±0.2	No	**No**	
Farm risk planning	3.2 ± 0.1	3.2 ± 0.1	2.8 ± 0.2	3.0 ± 0.2	Yes – better	**Yes****	**Yes - slightly**
Farm NRM planning	3.1 ± 0.1	3.1 ± 0.1	2.8 ± 0.2	3.1 ± 0.3	No	**No**	
Monitoring whether achieving environmental objectives	3.2 ± 0.1	3.1 ± 0.1	2.8 ± 0.2	3.1 ± 0.3	Yes – better	**No**	
Prioritise maintaining groundcover (graziers)	3.2 ± 0.2	3.3 ± 0.1	2.6 ± 0.5	3.0 ± 0.3	Yes – better	**No**	
Prioritise maintaining groundcover (mixed crop-grazing)	2.8 ± 0.5	2.8 ± 0.2	2.7 ± 0.6	3.0 ± 0.3	No	**No**	
Prioritise maintaining groundcover (cropping/hort)	3.1 ± 0.3	3.0 ± 0.2	2.4 ± 0.5	2.9 ± 0.3	Yes - better	**Yes***	**Yes**
Encouraging diversity of plants & organisms	3.2 ± 0.1	3.1 ± 0.1	2.9 ± 0.3	2.9 ± 0.2	No	**No**	
Obtained drought information from Landcare	3.2 ± 0.1	3.1 ± 0.1	2.9 ± 0.2	2.9 ± 0.2	No	**No**	
Improved water use efficiency (irrigators)	3.2 ± 0.2	3.0 ± 0.1	2.9 ± 0.4	3.0 ± 0.3	No	**No**	
Improved water use efficiency (dryland)	3.2 ± 0.1	3.1 ± 0.1	2.8 ± 0.3	2.8 ± 0.3	No	**No**	
Increased native pasture (graziers)	3.4 ± 0.1	3.2 ± 0.1	3.0 ± 0.3	2.9 ± 0.4	No	**No**	
Increased native pasture (mixed crop-grazing)	3.1 ± 0.2	2.9 ± 0.2	2.9 ± 0.4	3.0 ± 0.5	No	**No**	
Increased native pasture (cropping/horticulture)	3.0 ± 0.2	3.0 ± 0.2	3.0 ± 0.4	2.7 ± 0.3	No	**No**	
Investing in reducing input needs e.g. fertiliser	3.2 ± 0.1	3.1 ± 0.1	2.8 ± 0.2	3.0 ± 0.2	No	**No**	
Planting trees for shade and shelter	3.0 ± 0.1	3.2 ± 0.1	3.1 ± 0.3	2.9 ± 0.2	No	**No**	
Riparian fencing	3.2 ± 0.1	3.2 ± 0.1	3.0 ± 0.2	2.8 ± 0.2	No	**No**	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	3.3 ± 0.2	3.2 ± 0.1	3.0 ± 0.6	2.9 ± 0.2	No	**No**	
Working with others to reduce feral animals (crop/hort with feral animal problem)	3.0 ± 0.3	2.9 ± 0.2	3.9 ± 0.8	2.8 ± 0.3	Yes – worse	**Yes***	**Yes**
Working with others to reduce weeds	3.2 ± 0.1	3.1 ± 0.1	3.1 ± 0.3	2.8 ± 0.2	Yes – worse	**No**	
Increasing feed reserves (graziers/mixed)	3.1± 0.1	3.2± 0.1	2.9± 0.4	2.9± 0.2	No	**No**	
Increasing feed reserves (cropping/horticulture)	3.1 ± 0.2	2.9 ± 0.2	3.0 ± 0.4	2.7 ± 0.4	No	No	
Increasing financial reserves as drought preparation	2.8 ± 0.1	3.6 ± 0.1	2.6 ± 0.2	3.3 ± 0.2	Yes – better	**Yes****	**No**

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

Figure 5 Ability to service farm debt reported by those who had and had not adopted different NRM practices, when in drought and not in drought

Resilience outcome 6 – Farm cash flow

Farmers were asked how good or poor their farm cash flow was at the time of completing the survey. Farmers answered based on their subjective assessment of how good or bad their farm cash flow was. These answers did not reflect an objective assessment of cash flow, but rather farmers perceptions of how available cash was in their farm business at the time of completing the survey.

Table 9 shows the average farm cash flow reported by farmers who were not in drought and in drought at the time the survey was conducted, and for those who had and had not engaged in each type of NRM action examined.

Of the 16 NRM practices examined in 23 specific situations, five were found to be associated with a better farm cash flow, and one practice was identified as being associated with poorer cash flow. Of these six relationships, three were found to be associated with good cash flow in the regressions where age, gender and farm type were controlled for.

These relationships were then examined to identify if the observed effects were *drought-specific*. As shown in Figure 6, the difference in self-reported farm cash flow was larger during drought than when not experiencing drought for two practices: improving water use efficiency, and graziers working with others to reduce feral animals. This is consistent with the hypothesis that the practices confer specific resilience to drought. For the other – increasing financial reserves – there was not a greater difference in cash flow during drought than in non-drought times.

Farm cash flow

NRM practices found to improve drought resilience

- Improved water use efficiency (irrigators)
- Working with others to reduce feral animals (graziers/mixed with a feral animal problem)

Table 9 Farm cash flow – differences in resilience outcomes of farmers who had and hadn't adopted different NRM practices

NRM action	NOT IN DROUGHT Farm cash flow		IN DROUGHT Farm cash flow		Is there a significant difference between those doing NRM & not doing NRM?	Does the relationship hold when control for age, gender & farm type?	Is the difference in wellbeing greater during drought than in non-drought times?
	Haven't done this	Have done this	Haven't done this	Have done this			
Farm drought planning	3.0 ±0.1	3.0 ± 0.1	2.9 ±0.2	3.1 ± 0.2	No	**No**	
Farm risk planning	3.0 ± 0.1	3.0 ± 0.1	2.8 ± 0.2	3.1 ± 0.2	Yes – better	**No**	
Farm NRM planning	3.0 ± 0.1	2.8 ± 0.1	2.9 ± 0.2	3.0 ± 0.3	No	**No**	
Monitoring whether achieving environmental objectives	3.1 ± 0.1	2.8 ± 0.1	3.0 ± 0.2	3.0 ± 0.3	No	**No**	
Prioritise maintaining groundcover (graziers)	3.1 ± 0.2	3.0 ± 0.1	2.7 ± 0.4	3.1 ± 0.2	Yes – better	**No**	
Prioritise maintaining groundcover (mixed crop-grazing)	3.1 ± 0.4	3.1 ± 0.2	3.2 ± 0.6	3.1 ± 0.3	No	No	
Prioritise maintaining groundcover (cropping/hort)	2.9 ± 0.3	2.9 ± 0.2	2.9 ± 0.5	2.8 ± 0.3	No	**No**	
Encouraging diversity of plants & organisms	3.2 ± 0.1	2.9 ± 0.1	3.0 ± 0.2	3.0 ± 0.2	No	**No**	
Obtained drought information from Landcare	3.0 ± 0.1	3.0 ± 0.1	3.0 ± 0.2	2.9 ± 0.2	No	**No**	
Improved water use efficiency (irrigators)	3.1 ± 0.2	3.0 ± 0.2	2.7 ± 0.4	3.2 ± 0.2	Yes – better	**Yes****	**Yes**
Improved water use efficiency (dryland)	3.1 ± 0.1	2.9 ± 0.1	2.9 ± 0.3	3.0 ± 0.2	No	**No**	
Increased native pasture (graziers)	3.2 ± 0.1	2.8 ± 0.1	3.0 ± 0.3	3.0 ± 0.3	No	**No**	
Increased native pasture (mixed crop-grazing)	3.1 ± 0.3	3.1 ± 0.3	3.2 ± 0.3	3.0 ± 0.5	No	**No**	
Increased native pasture (cropping/horticulture)	3.0 ± 0.2	2.9 ± 0.2	3.1 ± 0.3	2.6 ± 0.3	Yes – worse	**No**	
Investing in reducing input needs e.g. fertiliser	3.0 ± 0.1	3.0 ± 0.1	2.9 ± 0.2	3.1 ± 0.2	No	**No**	
Planting trees for shade and shelter	3.1 ± 0.1	3.0 ± 0.1	3.1 ± 0.3	2.9 ± 0.2	No	**No**	
Riparian fencing	3.0 ± 0.1	3.0 ± 0.1	2.9 ± 0.2	3.0 ± 0.2	No	**No**	
Working with others to reduce feral animals (graziers/mixed with feral animal problem)	3.1 ± 0.2	2.9 ± 0.1	2.6 ± 0.5	3.1 ± 0.3	Yes – better	**Yes****	**Yes**
Working with others to reduce feral animals (crop/hort with feral animal problem)	2.8 ± 0.4	3.0 ± 0.2	2.8 ± 1.0	2.8 ± 0.4	No	**No**	
Working with others to reduce weeds	3.0 ± 0.2	2.9 ± 0.1	3.0 ± 0.3	2.9 ± 0.2	No	**No**	
Increasing feed reserves (graziers/mixed)	2.9 ±0.2	3.1± 0.1	3.0 ±0.4	3.0 ±0.2	No	**No**	
Increasing feed reserves (cropping/horticulture)	2.9 ± 0.2	2.9 ± 0.2	2.9 ± 0.4	2.8 ± 0.3	No	No	
Increasing financial reserves as drought preparation	2.7 ± 0.1	3.4 ± 0.1	2.7 ± 0.2	3.3 ± 0.2	Yes - better	**Yes****	**No**

** significance of change in $R^2 < 0.1$, ** significance of change in $R^2 < 0.05$*

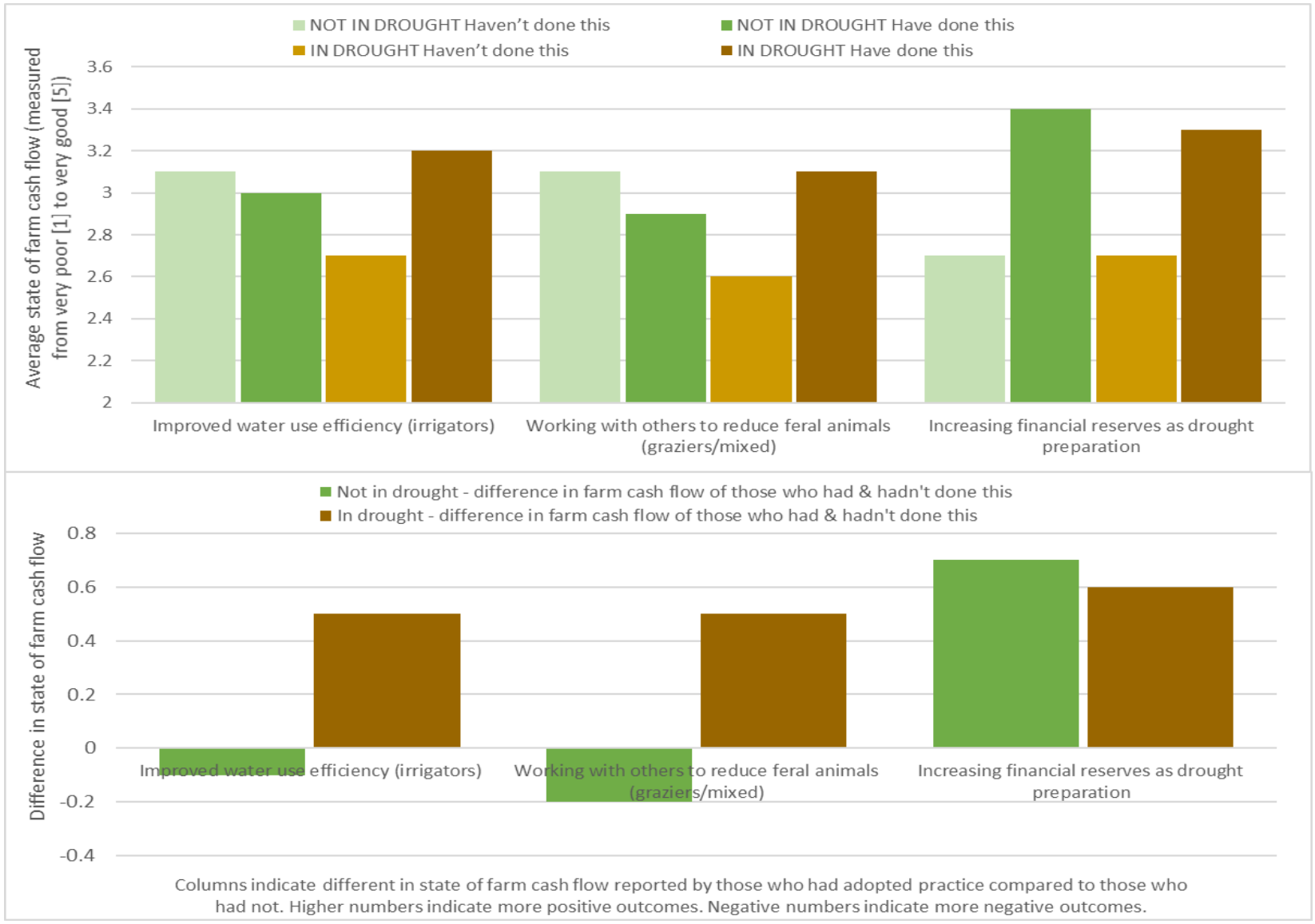

Figure 6 Farm cash flow state reported by those who had and had not adopted different NRM practices, when in drought and not in drought

Synthesising results

The results were synthesised by comparing the statistical findings and assessing the strength of evidence for a causal relationship using the criteria of (i) strength, (ii) consistency, (iii) specificity and temporality, and (iv) plausibility and coherence. Table 10 summarises this analysis.

Overall, there were seven practices for which evidence is appropriately strong and consistent enough to suggest that they confer resilience to drought:

- Farm risk planning: Assisting farmers to actively engage in forward planning for risks, and in investing in strategies designed to minimise impacts of those risks, was associated with better farmer wellbeing and improved farm financial performance during drought. This suggests that NRM investments focused on reducing risk of negative impacts from climatic variability can improve resilience.
- Maintaining groundcover – graziers: Graziers who focus on maintenance of groundcover as a priority in their land management reported better wellbeing and farm financial performance during drought. Assisting graziers to better maintain groundcover – something which can be supported in a range of ways by NRM programs – can improve drought resilience.
- Working collaboratively to reduce feral animals – graziers: Graziers living in areas with feral animal problems report better wellbeing and farm performance during drought if they engage in collaborative feral animal control. Continuing to invest in building these types of collaborative control initiatives can improve resilience to drought.
- Increasing feed reserves – graziers: Increasing feed reserves improves resilience to drought. NRM activities that assist graziers in building capacity for increased feed storage and building feed reserves can assist in building resilience to drought.
- Farm drought planning: Forward planning for drought is associated with improved resilience to drought.
- Increasing financial reserves to prepare for drought: This practice is not specific to NRM, and is typically undertaken by farmers who already have high wellbeing and good farm performance; as such, as is likely it both assists in building drought resilience but also reflects positive outcomes outside of drought.
- Improved water use efficiency – irrigators: Improving water use efficiency was associated with improved farm financial performance in drought, although not as strongly as for some other measures.

For some other practices, there was some evidence but not sufficient to confidently state that the practice is associated with improved drought resilience: these included developing NRM plans, monitoring achievement of environmental objectives, prioritising maintaining groundcover amongst those engaged in mixed crop-grazing and cropping enterprises, and investing in reducing input needs on the farm. Some practices that theoretically were argued to have potential to help build resilience to drought were not associated with higher drought resilience. These were obtaining information on drought from Landcare, dryland farmers improving water use efficiency, expansion of native pastures by graziers and mixed crop-graziers, working collaboratively to address weed problems, and crop growers working collaboratively to address feral animal problems.

Several practices that were not predicted to increase resilience to drought, as expected, did not predict drought resilience. These included encouraging greater plant and organism diversity, increasing native pasture amongst those involved in crop growing, planting trees, riparian fencing, and crop growers increasing feed reserves.

Table 10 Overall assessment of the role of different practices in building drought resilience

	Overall statistical association identified						Strength	Consistency	Specificity & temporality	Plausibility and coherence	Overall assessment
NRM action	**Well-being**	**Farm financial stress**	**Satisfaction with farm performance**	**Average farm surplus**	**Farm debt**	**Farm cash flow**					
Farm drought planning	✓✓	✓	✓	×	×	×	High	Mod	Mod	High	✓✓
Farm risk planning	✓✓	×	✓✓	✓✓	✓✓	×	High	High	High	High	✓✓✓
Farm NRM planning	✓✓	×	×	×	×	×	Mod	Low	Mod	Mod	Possible
Monitoring whether achieving environmental objectives	✓✓	×	×	×	×	×	Mod	Low	Mod	Mod	Possible
Prioritise maintaining groundcover (graziers)	✓	✓	✓	×	✓	×	Mod	High	High	High	✓✓
Prioritise maintaining groundcover (mixed)	✓	×	×	×	×	×	Low	Low	Mod	High	Possible
Prioritise maintaining groundcover (cropping/hort)	×	✓	×	×	×	×	Low	Low	Mod	Mod	Possible
Encouraging diversity of plants & organisms	×	×	×	×	×	×	N/A	Low	Low	Low	×
Obtained drought information from Landcare	×	×	×	×	×	×	N/A	Low	Low	Low	×
Improved water use efficiency (irrigators)	×	×	✓✓	×	×	✓	High	Low	High	High	✓
Improved water use efficiency (dryland)	×	×	×	×	×	×	N/A	Low	Low	Mod	×
Increased native pasture (graziers)	✓	✓↓	×	×	×	×	Low	Low	Low	High	×
Increased native pasture (mixed)	×	×	×	×	×	×	N/A	Low	Low	Mod	×
Increased native pasture (cropping/hort)	×	×	×	×	×	×	N/A	Low	Low	Low	×
Investing in reducing input needs	×	×	×	✓✓	×	×	Mod	Low	Mod	Mod	Possible
Planting trees for shade and shelter	×	×	×	×	×	×	N/A	Low	Low	Low	×
Riparian fencing	×	×	×	×	×	×	N/A	Low	Low	Low	×
Working with others to reduce feral animals (graziers, feral animal problem)	✓✓	×	✓	×	✓	✓✓	High	High	High	High	✓✓
Working with others to reduce feral animals (crop/hort, feral problem)	×	×	×	×	✓↓	×	Low	Low	Low	Mod	×
Working with others to reduce weeds	×	×	×	×	×	×	N/A	Low	Low	Mod	×
Increasing feed reserves (graziers/mixed)	✓✓	×	✓	✓	×	×	High	Mod	Mod-high	High	✓✓
Increasing feed reserves (cropping/hort)	×	×	×	×	×	×	N/A	Low	Low	Low	×
Increasing financial reserves as drought preparation	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	V. high	V. high	Low-mod	High	✓✓

Discussion

The results suggest that targeted investment in NRM can help farmers build resilience to drought. In particular, designing programs that assist farmers to do the following can build drought resilience:

- Forward planning for a range of risks including drought: The results showed that risk planning, rather than drought planning, was the stronger predictor of drought resilience. This suggests that it is important to engage not just in specific planning for drought but in realistic assessment of the range of risks that could occur on the farm, enabling farmers to better develop strategies to address all risks. This can improve resilience to drought through minimising impacts from a range of risks on the farm. Importantly, resilience is built not just by engaging in planning, but by farmers being supported to then invest in the strategies they have identified to reduce risk. This means that the type of investment that assists is likely to be investment that supports farmer to enact risk management plans, rather than investment that focuses on developing a plan without also providing support for implementation of the plan.
- Maintaining groundcover: As predicted, graziers who had a strong focus on maintenance of groundcover had improved resilience to drought. A useful next step would be to explore in more depth the specific strategies and practices used by these graziers to maintain groundcover, and identify if some of these are more useful for improving resilience to drought than others in the form of maintaining groundcover (and via this soil health, water quality and livestock wellbeing and productivity) in dry times.
- Feral animal control: The findings suggest that collaborative control programs are effective in reducing the financial impacts caused to graziers by feral animals during drought. Collaborative pest control programs have been a common feature of NRM investment and these findings suggest they are particularly important for reducing impacts of drought on livestock enterprises.
- Increasing water use efficiency: The data on water use efficiency for irrigators were not as conclusive, and this likely reflects at least in the part that the measure of drought used is not as applicable to irrigators as it is to dryland farmers. Many irrigators will experience a decrease in water allocation (or increase in water prices for those who purchase water on the temporary market) only some months after drought occurs, and hence some irrigators recorded as being in drought in the dataset may not yet have been experiencing drought. The data still support the argument that improving water use efficiency has financial benefits for irrigators in drought, as it enables higher volumes of production from lower amounts of water.
- Increasing feed reserves and financial reserves. These practices are not necessarily 'NRM' practices, although a range of NRM programs can support farmers to increase feed reserves. They are associated with improved resilience to drought.

In this study, some NRM practices were examined that were *not* considered likely to confer resilience to drought. This was done deliberately, as it helps identify whether the associations seen are a result of people being more likely to undertake NRM if they have higher resilience to drought, or a result of people being more resilient to drought due to undertaking NRM. It was considered possible that the associations seen were due to people who had higher resilience also being more likely to engage in NRM. Having higher drought resilience may result in a person having more capacity to engage in NRM due to experiencing fewer impacts from drought, and this had potential to confound the analysis. However, if this was the case, people who adopted *any* type of NRM would be expected to have higher drought resilience. If this was not the case, and it was instead adopting

specific types of NRM that led to higher drought resilience, the expectation was that higher drought resilience would be observed only amongst those farmers who adopted the specific forms of NRM predicted to increase drought resilience. The results clearly showed the latter – while several of the NRM practices expected to increase drought resilience were associated with higher drought resilience, none of those which were not expected to build drought resilience showed the same association. This further strengthens the argument for a causal linkage in which the NRM practices in question are conferring higher resilience to drought.

Some practices that theoretically were argued to have potential to help build resilience to drought were not associated with higher drought resilience. Further work is needed to understand whether with more specific measures, these practices would be identified as building drought resilience. The measures used in this study were broad, and future work should use more specific measures to better assess how NRM contributes to drought resilience.

Conclusions

Some types of NRM investment are strongly associated with higher resilience to drought. Investing in helping farmers engage in forward planning and actions to plan for and manage risk on the farm (including forward planning for drought), in feral animal control and groundcover management strategies amongst graziers, in improving water use efficiency, and in supporting graziers to build feed reserves, all help farmers cope more successfully with drought. It is likely that a range of other NRM practice also confer resilience to drought, but this could not be examined within this project.

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