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Managing the grazing landscape: Insights for agricultural adaptation from a mid-drought photo-elicitation study in the Australian sheep-wheat belt

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ABSTRACT

Globally, and under uncertain climate conditions, the agricultural sector will need to feed more people without degrading the ecosystem services on which production depends. Eastern Australia, coming out of a decade of drought, is at the leading edge of this challenge. Measures to adapt agriculture to increasing climate variability are urgently sought. One particularly promising measure is an adaptive grazing decision-making practice called holistic management (HM), typically involving high-intensity, short-duration rotational grazing and the encouragement of pastures with low chemical input needs. Here, we use photo-elicitation to compare the landscape perceptions of HM graziers with those of more conventional graziers, based on their choice of photo targets and the stories those photographs elicited. During that process, HM graziers described their use of adaptive farm management techniques to gain outcomes for production and ecosystems alike, demonstrating a system-based understanding of their farms conducive to farming under increased climate variability. We conclude that HM grazing should be encouraged so as to adapt the industry to climate change. More widespread uptake of HM practices – for public benefit as well as personal – depends on incentives to reduce start-up costs and expand the instruction of HM principles, first targeting those with high adaptive capacity, and removing policies that delay adaptation.

1. Introduction

Globally, livestock grazing covers the largest area of any land use (Asner et al., 2004; Erb et al., 2007), with considerable ecological impacts (Foley et al., 2005; MacLeod and Moller, 2006; Tscharntke et al., 2005). Grazing is anticipated to expand and intensify as global population grows and demands more protein (Foresight, 2011; McAlpine et al., 2009; Tilman et al., 2001, 2002). Grazing expansion and intensification would involve significant environmental costs even under 'normal' climate conditions (Dorrough and Scroggie, 2008; McAlpine et al., 2009). In a context of rising and irreversible global temperatures (Intergovernmental Panel on Climate Change, 2007), increased grazing pressure presents novel challenges to the ecosystem services that sustain agricultural production (Beaumont et al., 2011; Pretty et al., 2010; Zhao and Running, 2010).

Adaptation is commonly suggested as a way to reduce vulnerability to changing climatic conditions (Jones et al., 2007). Most agricultural adaptations include some degree of changed farming practices and modified government policy settings (Howden et al., 2007; Smit and Skinner, 2002). There is increasing research on adaptive capacity in agricultural systems in relation to external conditions, such as resource availability and institutions (Grothmann and Patt, 2005; Hogan et al., 2011; Nelson et al., 2010). However, relationships to the internal conditions of the those involved, such as personal adaptive capacities, values, and perception are poorly understood (Fazey et al., 2007; Marshall, 2010; O'Brien, 2009).

Any given agricultural policy context seeks to influence farmers in a number of ways, but farmers still have enormous freedom to choose their day-to-day management practices. For instance, regulations specify export quality standards but the specific practices by which those expectations are met (or not) are up to the farmer. Farmers' choices will depend, in part, on their landscapes: how they see, understand, and value those landscapes, and how they feel their landscapes reflect upon them (Barr and Cary, 2000; Marshall, 2010; Rogge et al., 2007). We use landscape perceptions as a generic term for this multiplicity of meanings and messages that people derive from their landscapes, and which then drive behaviour (Gobster et al., 2007; Stern, 2000). When making management decisions, farmers will draw upon those landscape perceptions,

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among other things, to balance monetary reward with other valued outcomes like aesthetics, stewardship, identity and lifestyle.

This paper examines how farmers using different management practices perceive their working landscapes, and how those perceptions relate to their responses to – and outcomes under – climate pressures, using a mid-drought case study from the Australian sheep-wheat belt in New South Wales. Climate change and responses to climate change can both have negative impacts on the environment (e.g. biodiversity; Paterson et al., 2008) and humans who depend up on it, such as by causing irreversible damage to valued places and identities such as farm landscapes (Adger et al., 2009). Farming could cease to be viable in certain areas under climate change, resulting in spontaneous farmland abandonment and reforestation through natural succession, formerly suppressed. Similar long-term landscape outcomes, however, could result from intentional adaptation or mitigation activities such as large-scale tree planting (Hunziker and Kienast, 1999; Jackson et al., 2007; Soliva and Hunziker, 2009). Alternatively, pro-active adaptation could maintain consistent landscapes while employing very different practices. Human values will limit these choices (O'Brien, 2009). Farmers manage for meaning, as well as a living, and since much of that meaning is embodied in their farm landscapes, landscape is a useful lens through which to explore the process of agricultural adaptation.

Australian farmers and agricultural policy makers rarely dispute the reality or seriousness of a changing climate. Public dialogue regularly acknowledges the urgent need to adapt to 'increasing climate variability' (Standing Committee on Primary Industries and Resources, 2010). The most dramatic prediction for Australia is that precipitation will become more unpredictable in amount and distribution (Hughes, 2003). The 'Big Dry' drought prevailed over the southeastern sheep-wheat belt for most of the last decade (Cai et al., 2009; Leblanc et al., 2009), breaking only in 2010, and water is projected to become even more scarce in Australia by 2030 (Intergovernmental Panel on Climate Change, 2007). While this most recent drought may not be exclusively the result of climate change (Chiew et al., 2011), the extended episode provides an opportunity to examine how farming will fare under the increasing water scarcity predicted to occur as a result.

Evidence is growing that management practices and climate change are harming the ecosystem services upon which Australian farmers depend, and threatening the long-term viability of their way of life (Hogan et al., 2011; Preston and Jones, 2006). A range of biophysical problems have either persisted or intensified in Australia during the drought, including erosion, weed invasion, tree decline and biodiversity loss (Fischer et al., 2010; Prober and Smith, 2009; State of the Environment Advisory Council, 2006). Scattered tree decline, for instance, is removing the stock shelter that will be increasingly needed to ensure the health of livestock as well as wildlife (Close and Davidson, 2004; Fischer et al., 2010; Gibbons et al., 2008; Manning et al., 2009). More heat-tolerant livestock breeds are typically also less productive (Howden et al., 2007). Such challenges, paired with declining terms of trade, have caused hardship in many rural communities (Edwards et al., 2009; Nelson et al., 2010). Given these challenges, it is important to find ways of responding to changing climate conditions that do not prolong negative social and ecological impacts (Fazey et al., 2010).

A recent study of scattered tree decline in the Australian sheep-wheat belt found that many of its participating graziers had made relatively recent transitions (<10 years) to a grazing system called holistic management (HM) (Fischer et al., 2009; Sherren et al., 2010a). HM typically involves practices like rotational grazing and reducing chemical fertilisers (Savory and Parsons, 1980) that have been suggested as important for adapting grazing to climate change (Howden et al., 2007). A key element of that larger study was to investigate how graziers valued their landscape using photography and follow-up interviews (photo-elicitation) (Sherren et al., 2010b, 2011b). Consistent with Richards and Lawrence (2009), HM graziers revealed a different way of seeing and talking about their production landscapes than those grazing more conventionally. Specifically, HM graziers described different landscape preferences, decision-making practices and experiences of the extended drought, then still in progress. Photo-elicitation data (the photographs graziers took and how they discussed them) permitted us to quantify how the landscape perceptions of holistic managers differed from those grazing more conventionally. We could then explore more qualitatively what those differences might reveal about the kind of thinking required to adapt grazing to climate change and how to foster it.

This paper aims to address three key research questions: (1) What do agricultural managers using different practices perceive to be their most significant farm landscape features? (2) How do agricultural managers using different practices relate to those landscape features? (3) What are the implications of these different landscape perceptions for sustainable agricultural management and adaptation to climate change? The first two questions are addressed through the photo-elicitation results, while the third is addressed in the discussion.

2. Methods

2.1. Case study

We studied an area of one million hectares in the upper Lachlan River catchment of New South Wales (NSW), Australia, in the grassy-box woodland ecosystem type in which grazing is the most viable agricultural activity (Fig. 1). The farming industry in the study area was dominated by sheep, beef cattle and grain, and thus was broadly reflective of the wider temperate grazing zone or 'sheep-wheat belt'. We worked in a relatively wet part of the sheep-wheat belt, according to the Australian Bureau of Meterology, with annual precipitation in our study area between 600 and 866 mm, by comparison with 304 mm at the western (lowest) extent of our catchment. A key aim of the ecological research that preceded this work was to identify the best grazing management practices for supporting tree regeneration. We established sites on 33 farms (31 farmers) to count trees and seedlings and correlate these with farm management practices as well as observed biodiversity (Fischer et al., 2009, 2010). Farms were thus chosen to represent a range of stocking levels (long-term typical stocking rates ranging from 2 to 12 dry sheep equivalent per hectare) and rotation regimes (keeping stock in any given paddock from about 10 to 365 total days per year). Some of our case farmers grew some crops, but they did no irrigated cropping.

Within that range of grazing regimes, many farmers were using a decision-making framework called holistic management (HM). In a livestock grazing context, HM usually involves intense bursts of grazing pressure followed by extended recovery time (Savory and Butterfield, 1999; Savory and Parsons, 1980; Stinner et al., 1997). Terminology is generally a challenge (Briske et al., 2011): HM and 'cell' grazing are similar, and we use HM here, but both are different from rotational grazing. Fundamentally, HM grazing is based on an explicit decision framework combining goal-setting, monitoring practices and adaptive management of the land base (Savory and Butterfield, 1999; Stinner et al., 1997). In practice, the implementation of HM grazing in Australia varies between individual farmers, but often involves: high-intensity short-duration grazing rather than continuous grazing; cessation or reduction in chemical fertiliser use; an emphasis on native pastures; and, monitoring those pastures through the keeping of 'grazing charts' that provide a means of anticipating feed availability and periods of drought

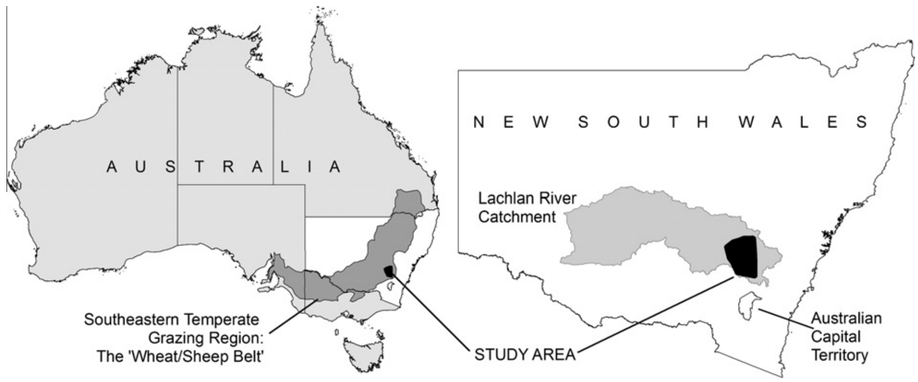

Fig. 1. Map of the study area.

(Earl and Jones, 1996; McCosker, 2000). This last tool is used to match stocking level to carrying capacity. By contrast, more conventional graziers often keep stock in paddocks for extended periods, or year round; use exotic or annual pastures; and rely upon regular applications of chemical fertiliser to foster them. These are two extremes within a diversity of grazing management practices seen in Australia.

2.2. Photo-elicitation

Photo-elicitation is a method of social science research where the inquiry proceeds through the researcher and the research subject(s) mutually interrogating photographs on a given theme that were captured by one of them (Harper, 2002). Photo-elicitation developed in anthropology at a time when cameras were expensive, and thus the photographs were usually captured by the researcher (Collier, 1957). Today it is more common for the research subjects to take the pictures with single-use or cheap digital cameras supplied by the researcher. In capturing photos, subjects respond to research instructions such as Beilin's (2005, 2001) request – which we echoed – that her participants capture "significant" landscape features. Follow-up interviews or discussions are more or less structured, depending on the study, but use those photographs as prompts, sometimes along with additional materials like maps (Harper, 2002). Photo-elicitation is now commonly used in studies of place, tourism and fields like agriculture and planning where local landscape is an important driver of attitudes and behaviour (Beilin, 2005; Castleden et al., 2008; Collier, 2001; Garrod, 2007; Stedman et al., 2004; Van Auken et al., 2010).

Landscape values differ dramatically when subjects are resident stewards (Vouligny et al., 2009): as Aldo Leopold wrote, "the landscape of any farm is the farmer's portrait of himself" (Meine, 1987). Our interest in landscape perceptions and visualisation was a good fit for image-based methods (Sherren et al., 2011a). We used photo-elicitation specifically because it placed the farmer rather than the researcher in the position of expert and in control of the story that emerged, something other scholars have also noted (Beilin, 2005; Castleden et al., 2008; Harper, 2002). Photographs also provide a manageable and sensitive way of exploring complex issues around farm landscapes, which can be personal for farmers; having captured the photographs we used as prompts, the farmers were prepared for the discussions that transpired. Finally, personal construct theory suggests that the values that emerge through the completion of such constrained tasks as photo-elicitation can sometimes be more true to deeply held personal beliefs than direct questioning in surveys or interviews (Dalton and Dunnett, 1992; Harrison and Sarre, 1975). A more detailed description of this photo-elicitation study, and a fuller discussion of the photo-elicitation method, can be found elsewhere (Harper, 2002; Sherren et al., 2010b).

We asked all 31 of the graziers who participated in the ecological work (see Section 2.1) if they were interested in taking part in a follow-up photo-elicitation study about landscape values, and all but one consented. On September 12, 2008, we sent disposable cameras and reply-paid envelopes to 30 graziers, with instructions to photograph 'significant' features of their farm landscape. The potential for bias in this sample as a result of their participation in ecological field work has been largely debunked (Sherren et al., 2010b), but it is worth mentioning here that the photography is only one part of photo-elicitation. If farmers were motivated to capture certain features because of what they thought we were interested in (i.e. trees), the interviews provided another chance for the true priorities of participants to emerge. Between September 24 and November 21, twenty-five cameras were returned. We developed the photos, and visited each grazier for an interview. The recorded interviews consisted purely of discussing each photograph in turn: what it contained; why it was taken; and any other thoughts it evoked. Transcripts of the interviews, with scanned photos inserted, were then circulated back to each grazier for editing. We organised and coded data using *Microsoft Access* and *NVivo* software (QSR International Pty Ltd., 1999–2009). First, we identified and classified each individual feature that graziers talked about in each photo, such as a tree or a view. Second, we linked each target feature to every distinct narrative or story in the transcript that it had elicited. Third, we classified all the narratives to develop key themes. Primarily, our analysis here is based on tables comparing counts of targets and narratives by two cohorts of grazier: HM and non-HM. Selected interview quotes, mostly from HM graziers, are also used to explore in more depth a few complex issues that are less easily summarised quantitatively.

3. Results

Approximately half of the farmers who participated in photo-elicitation practiced HM, and these tended to be at an earlier family or career stage than those practicing more conventional grazing

Table 1
Summary of case graziers, by stage of life and management style, as volunteered during interviews.

Stage of life	HM	Not HM
Young family and/or early career (approx. 30–44)	7	1
Older children and/or mid-career (approx. 45–54)	3	7
Adult children and/or late-career (approx. 55+)	2	5
Total	12	13

(Table 1). No personal questions were asked in interviews, so we characterised graziers based on stories they volunteered about their stage of life; specifically, if they had young or adult children, and if they were starting their farm business or were about to retire. Similarly, we classified graziers as HM if they volunteered that they had undertaken formal training in the principles and that they had initiated the process of converting to the system, however recently. They were in various stages of that transition, but typically the stock of these HM graziers spent a maximum of 3 months in any one paddock, usually spread over multiple shorter grazing events (in line with Fischer et al., 2009). Consistent with Richards and Lawrence (2009), who found women played a more prominent role in cell grazing, our interviews with HM graziers were also more likely to involve both husband and wife; the wives of non-HM graziers usually worked off-farm and were not present.

While the types of targets photographed by the two cohorts of graziers were largely similar, the stories told by HM graziers about those targets were very different in aggregate from those told by non-HM graziers.

3.1. What do agricultural managers using different practices perceive to be their most significant farm landscape features?

Broadly speaking, the two grazier cohorts chose to photograph similar landscape features. In descending order of popularity, these were: trees, the human domain (i.e. houses, equipment, family members), pastures, the land base (i.e. geology, hydrology), and landscape views (Table 2). For instance, nine graziers in each cohort captured landscape views, and those landscape photographs made up a similar proportion (~6%) of each cohort's set of targets.

Table 2
Photograph target popularity, in five broad classes, by cohort. The number of overall captures is listed, the percentage that target comprised of each cohort's share of photos, and the number of graziers that captured each.

Target type	# Targets	% Targets		# Graziers		
		HM	Not-HM	All	HM	Not-HM
Trees	**320**	**21.7**	**28.4**	**25**	**12**	**13**
Sparse woody vegetation	108	12.0	12.4	22	12	10
Regeneration	105	12.4	11.3	23	11	12
Woody vegetation patches	70	5.0	10.8	22	10	12
Dead or coarse woody debris	37	4.7	3.6	14	7	7
Pastures	**192**	**24.8**	**19.6**	**25**	**12**	**13**
Paddocks (as a unit)	91	10.8	9.7	20	10	10
Ground cover (continuous)	83	12.0	7.2	22	12	10
Weeds	18	2.0	2.7	9	4	5
Landscape views	**54**	**5.6**	**6.5**	**18**	**9**	**9**
Human domain	**208**	**21.7**	**25.3**	**25**	**12**	**13**
Farm infrastructure	57	5.9	7.0	17	9	8
Livestock	45	4.5	5.6	17	8	9
Homesteads and gardens	39	4.7	4.1	17	8	9
Dams	35	3.8	4.1	16	8	8
Family and community	12	0.7	2.0	5	3	2
Artefacts of previous residents	11	1.1	1.4	7	3	4
Contour banks	9	0.9	1.1	7	3	4
Land base	**129**	**13.8**	**15.3**	**23**	**10**	**12**
Erosion, salinity	42	5.4	4.1	16	7	9
Natural hydrology	42	3.8	5.6	14	8	6
Geology, topography, soil	25	1.1	4.5	10	3	7
Animals and insects	17	3.2	0.7	8	5	3
Weather	3	0.2	0.5	3	2	1
Total	915	100	100	25	12	13

Land base and human domain targets showed only slight differences between cohorts (Table 2). HM graziers were more likely than non-HM to photograph animals and insects, while non-HM graziers were more likely to target geology, topography and soil. HM graziers were also less likely to capture images of the human domain than non-HM; only homesteads and gardens were slightly more prominent for HM graziers (Table 2). One difference between the two cohorts, invisible using our classification, was the specific features captured under the category of farm infrastructure (Table 2). HM graziers photographed moveable water points, temporary fences, and portable solar panels – consistent with the needs of their management approach – whereas non-HM graziers captured more large equipment and silos. Livestock animals were of less interest to HM graziers than non-HM graziers.

The most notable differences were found in the tree and pasture target classes, which together made up over half (56%) of all targets. Trees made up a much larger proportion of non-HM farmer photos than HM farmer photos, but the difference was largely in the number of photos non-HM farmers took of large patches of trees; sparse trees, tree regeneration, and dead or fallen timber attracted similar amounts (Table 2).

The pattern reversed for the pasture target class, where HM farmers took more pictures than non-HM. Two subtle subclasses of pastures were identified during coding. Paddocks, when discussed as an 'indivisible' unit of management, were more often the focus of non-HM graziers; ground cover, when discussed as something that varied continuously and independent of paddock boundaries, was of more of interest to HM graziers. Although weeds accounted for a similar proportion of photographs in the two cohorts, the two cohorts of farmers discussed weeds very differently (see following section).

3.2. How do agricultural managers using different practices relate to those landscape features?

In the last section, we found that two target classes demonstrated the biggest quantitative differences between our grazier cohorts: trees and paddocks. Next, we analysed how the two cohorts discussed these two kinds of features.

3.2.1. Tree features

We identified four subclasses of trees, including: dense tree patches; sparse trees (including paddock trees and scattered trees); dead trees and downed timber; and, regeneration (Table 3).

The stories non-HM graziers told about patches and woodlands were mostly about excluding stock from them, and the resulting natural regeneration happening as a result of that protection, often by contrast with the clearing that had historically taken place in the area (Table 3a). In comparison, while half of the HM graziers also talked about having fenced off their patches and woodlands, the second most common narrative elicited was that those woodlands were occasionally grazed for feed or to reduce fire risk.

Both cohorts spoke about the beauty of scattered trees in their landscape, but HM graziers were much more likely to identify other benefits of scattered trees, including for biodiversity, emotional well-being and stock protection (Table 3b). Several HM farmers described their concern about the possibility of a gap in habitat supply due to the ageing of their existing farm trees and a lack of tree regeneration:

> That paddock tree there it'll probably be dead in 30 years time and if we don't start planting them now then there'll be no big old trees ... there'll be no more hollows. ... the paddock trees are actually a very good resource for stock shelter and also for birds and animals. So for both purposes we need to start

Table 3
Key themes coded for four different woody vegetation targets by grazier cohort. All themes coded to at least three graziers of any one cohort are included. To emphasise patterns visually, the numbers in bold indicate themes that were coded to at least half (6) of each cohort; comparative values are not bold (if the theme was coded to close to half, e.g. 4 or 5) or grey (if only 1–3). Hyphens indicate zeros.

Category	Commonly elicited themes	HM		Non-HM	
		# Graziers	% Narratives	# Graziers	% Narratives
(a) Dense tree patches		$n = 10$	$n = 33$	$n = 12$	$n = 73$
	Protected	5	21.2	**7**	**21.9**
	Regenerating naturally	1	3.0	**9**	**13.7**
	Grazed	4	12.1	4	5.5
	Historically cleared	1	3.0	5	8.2
(b) Sparse trees		$n = 12$	$n = 79$	$n = 10$	$n = 81$
	Protected	1	1.3	4	6.2
Benefits	Beautiful	**6**	**12.7**	**7**	**13.6**
	Biodiversity	**6**	**16.5**	3	4.9
	Stock protection	4	6.3	4	4.9
	Emotional well-being	5	8.9	2	2.5
State	Ageing	5	7.6	**6**	**11.1**
	Declining	4	8.9	5	19.8
	Healthy and fertile	4	6.3	5	6.2
	Native tree species	**6**	**12.7**	2	2.5
	Not regenerating	5	6.3	2	3.7
(c) Dead trees and downed timber		$n = 7$	$n = 21$	$n = 7$	$n = 23$
	Retaining coarse woody debris	**6**	**47.6**	2	8.7
	Biodiversity benefits	**6**	**47.6**	2	8.7
(d) Regeneration		$n = 11$	$n = 84$	$n = 12$	$n = 75$
What	Linear strip (e.g. fenceline)	**8**	**19.0**	**7**	**21.3**
	Species (e.g. over- and understorey)	**8**	**14.3**	2	2.7
	Around water body	5	8.3	3	8.0
	Small area	–	–	3	5.3
Benefits	Habitat	5	7.1	4	6.7
	Soil stability	4	7.1	3	9.3
	Attractive	2	2.4	3	4.0
	Wind protection	1	1.2	3	5.3
Cost	Agency sponsorship	4	4.8	**6**	**16**
	Landholders bearing the cost	4	6.0	2	2.7
Failure	Plantation	4	10.7	**6**	**12.0**
	Natural regeneration	4	6.0	2	5.3
Success	By stock exclusion	**7**	**16.7**	5	13.3
	Through rotational grazing	4	6.0	1	1.3
	Will reintegrate in grazing rotation	4	4.8	–	–

Where an odd number of graziers exist in the cohort, the 'half' criterion is rounded down.

> planting them now because if we wait until they're all gone then it'll just be worse. (Husband, HM Farm 5)
>
> Tall old established trees are quite precious to us ... they're precious for biodiversity and the bird life ... it's going to be a hundred years before these [seedlings] look like these trees and ... there's not a lot in between the two stages in tree growth and what happens to the animals and birds when these ones go before these ones are established enough to support them? (Husband, HM Farm 22)

HM graziers were also more likely to identify tree species as native and to note the lack of tree regeneration *in situ*. Non-HM graziers were more likely to discuss the ageing and decline in health of the existing tree stock, as well as to discuss protecting them (Table 3b).

Dead trees and downed timber elicited very different stories in the two grazier cohorts. Among the HM graziers, photographs of coarse woody debris almost exclusively elicited the biodiversity benefits of retaining such debris in the landscape (Table 3c). This is in contrast to a scatter of narratives about fire risk, pest risk and firewood supplies that several non-HM graziers associated with downed timber (although none of these themes were common enough to feature in Table 3c).

Finally, photographs of regeneration revealed more subtle differences between cohorts. Most photographs of regeneration by either cohort elicited stories of planting linear strips along fences or around water bodies, although a few non-HM graziers also mentioned planting small areas (Table 3d). HM graziers were more interested than non-HM in the mix of over- and understorey species in farm plantings. The aesthetic value of such planting was not of primary importance to either cohort: both planted mostly to protect soil from wind and water erosion and to improve animal habitat (Table 3d). Agency sponsorship for planting was much more important to non-HM graziers, with HM graziers seeming more content to bear the cost. Finally, many graziers discussed regeneration failure, often due to drought. Regeneration success was accredited to stock exclusion in many cases. For HM graziers, however, exclusion was often seen as temporary, and several of them also reported tree regeneration and improved tree health occurring under rotational grazing (rather than only grazing exclusion; Table 3d):

> Here [yellow box trees] are regenerating over the whole place. ... They're [the stock are] not there long enough. Even if they were there for a week or two weeks, they get bored and play with them and break them off, and it kills them. They're quite fragile when young. So the cattle are in, they're grazing the grass down and they're getting out. They're allowing them to regenerate. (Husband, HM Farm 18)
>
> [That remnant vegetation,] it's changed a lot since we've changed our grazing. It used to be a major stock camp under there

because that whole section was one paddock so they could graze and camp under there, so there was a huge nutrient dump under there all the time. So now we've stopped that, those trees are starting to actually look a lot better. (Husband, HM Farm 22)

3.2.2. Pasture features

Two key categories of narrative emerged from photographs of paddocks and ground cover: the farm management activities and external pressures that served as drivers of ground cover; and the responses in terms of pasture composition (Table 4). The narratives within each category differed between the two grazier cohorts.

The key driver of ground cover discussed was livestock grazing. Some graziers of each kind discussed 'total grazing pressure', including kangaroos. Although all farmers involved in the study were graziers, only rotational grazing was explicitly mentioned. Continuous or near-continuous grazing – when animals are kept in paddocks the majority of the year – was never mentioned by name, perhaps because this is seen by those practicing it as the obvious default management. HM graziers were often effusive about the multiple benefits they experienced from rotational grazing, or holistic management more generally (Table 4a), such as a fast recovery after drought:

So we match the stocking rate to carrying capacity. That's all the drought is in Australia, is stocking rate exceeding carrying capacity. ... So we adjust our stocking rate ... to preserve the environment and to preserve [our] perennial grasses because this is [our] main asset. So when the drought breaks you don't continue on it because you've ruined all your grasses. (Husband, HM Farm 18)

One HM grazing couple happily photographed dry dams because of improvements to water infiltration across the farm; less rain run-off in turn meant that farm dams rarely filled. Similarly, a photo of empty hay sheds elicited a narrative about there no longer being a need for feed storage because of reliable ground cover (and hence supply of feed) all year. This experience was not unique:

Certainly our water cycle has improved [with HM]. ... the water holding ability of our soil is a lot greater. We get heavy rain and it stays there. That's what we're trying to do, is keep it where it falls rather than have it run off. (Husband, HM Farm 13)
We're allowing much more ground cover [with HM]. With the set stocking you end up with a little short tight sward which sheds a lot more water. A bit like a bowling green. (Male solo operator, HM Farm 14)

Several non-HM graziers also spoke about subdividing paddocks, or the difficulty of rotational grazing, suggesting some transmission of – and occasionally resistance to – HM concepts.

Cropping was the second key driver elicited by pasture photographs. Most HM graziers discussed ceasing cropping because of perceived negative effects of ploughing and fertilising, such as erosion and run-off, while most non-HM graziers were cropping for silage or sale off-farm (Table 4a). Some HM farmers were finding that land took a long time to recover from a cropping history:

This is one of those paddocks ... that had been cropped and cropped and cropped, and because the water cycle has been completely destroyed on that country [and] because the perennial grass has gone, it's got water holding abilities zilch. So we tend to get a lot of runoff. ... (Husband, HM Farm 13)

Table 4
Key themes coded for paddock and ground cover targets by grazier cohort. All themes coded to at least three graziers of any one cohort are included. To emphasise patterns visually, the numbers in bold indicate themes that were coded to at least half (6) of each cohort; comparative values are not bold (if the theme was coded to close to half, e.g. 4 or 5) or grey (if only 1–3). Hyphens indicate zeros.

Category	Commonly elicited themes	HM		Non-HM	
		# Graziers, *n* = 12	% Narratives. *n* = 163	# Graziers, *n* = 13	% Narratives, *n* = 115
(a) Drivers and activities					
Grazing	Grazing rotationally	**10**	**8.0**	3	2.6
	Multiple benefits of rotational/holistic grazing	**7**	**9.2**	1	0.9
	Stock improve soil and ground cover	4	2.5	1	0.9
	Difficulty of grazing rotationally	2	1.2	4	3.5
	Subdividing paddocks	2	1.2	4	4.3
Cropping	Sowing for silage/forage	1	4.9	**6**	**11.3**
	Cropped (grain)	1	1.2	5	11.3
	Ceased cropping	4	4.3	–	–
	Ploughing degrades the land base	5	3.7	2	1.7
	Cropping has lingering negative impacts	**6**	**3.7**	1	0.9
Weather	Acute impact (drought, frost)	2	3.1	**6**	**7.8**
	Climate change and its risks	4	3.1	1	2.6
(b) Responses and state					
Health	Productive (good, dense)	**7**	**6.7**	**7**	**7.0**
	Sparse or overgrazed	**8**	**9.2**	4	4.3
	Recovering	**6**	**7.4**	1	0.9
Weeds	Poison weeds or pests	2	3.7	5	7.0
	Weeds/undesirable forage species	**7**	**10.4**	**7**	**20.0**
	Better to have weeds than nothing	3	3.1	–	–
Species mix	Native pasture species	**8**	**9.8**	**6**	**6.1**
	Native pastures more resilient	2	1.8	5	4.3
	Diverse or heterogeneous	**8**	**7.4**	2	1.7
	Diversity brings resilience	**6**	**9.8**	2	2.6
	Non-native pastures	5	8.0	3	6.1
	Perennials	4	3.7	2	2.6

Where an odd number of graziers exist in the cohort, the 'half' criterion is rounded down.

Weather was the third key driver elicited by photographs of pastures. HM graziers appeared most concerned about long-term climate change (Table 4a). Most saw the drought as a sign of those changing climate conditions, and several described how the drought had inspired them to reassess their then-conventional management practices:

> When I left school, I went to Ag college and everything there was high input systems and fertiliser and chemicals. I came home and I did a lot of that but I didn't make any money. . . . I was scratching my head and then this [course] came along. I thought to myself, well this is probably the answer that I've been looking for, for the last two years when . . . I'm spending $20,000 a year, $100 an acre sowing all this pasture. I was working but I wasn't getting any money back. I thought, this is ridiculous, and thank God I did because you know things only got worse [drier] since. (Husband, HM Farm 17)
>
> The last few droughts have really brought it home to me. . . . We went through the 2002/2003 droughts where we were beginning to realise, well, something's got to change. We did the *Grazing for Profit* course. That certainly influenced my thinking a lot. . . . It hasn't always been the way it is at the moment. (Female solo operator, HM Farm 12)

By contrast, non-HM graziers were focused on pasture stressors like frost and drought which they considered short-term issues. They did not associate drought with long term climate change, and their response was typically to increase their grain or silage storage capacity to endure it. One couple described how, "[they] had to buy a silo. . . . and found it really hard in the drought, having to buy feed for the sheep because [they got] behind so much then" (Wife, non-HM Farm 28). Another claimed:

> Well, we never had droughts before until the last five years. We've had dry spells but we've had nothing like this. So I had to put something in place for that. So I've built myself a hay shed a couple of years ago, and got – I can probably store about 100 tonne of grain down there now, so I can feed 1200 ewes for six months. I can get a little paddock, a little feed lot paddock, and I can just feed them in the little paddock. That allows the rest of the pasture to grass up without walking on it and eroding it. (Husband, non-HM Farm 26)

Pasture condition also was discussed differently by the two cohorts, despite a common interest in productivity. HM graziers were much more likely than non-HM to identify ground cover that was sparse or overgrazed, or recovering (Table 4b). Weeds were of interest to both, but in different ways: most non-HM graziers talked about poisoning weeds or other pests, or temporarily cropping to remove weeds, while a few HM graziers preferred weeds to bare ground (Table 4b). A sizable component of the HM graziers' narratives about pastures explored the idea of species diversity improving overall system resilience. For instance:

> *Husband*: I've got black oats, I've got Patterson's Curse and I've got perennial grasses and some annual dead grasses. . . . The aim is just to have something green so if we get rain tomorrow or next year or whatever . . . then it can grow. If we've got lots of different things at different ages then something will grow. Complexity builds stability. *Wife*: Sort of letting nature taking its course really in that natural succession of plants and varieties coming through . . . . even if a weed comes up first it doesn't matter, eventually a native will overtake that and so that's sort of what we're encouraging. (HM Farm 5)
>
> You need a variety through the year and the natives have responded to the dry years much better than this stuff [improved pasture] has. This stuff is fine when everything's lining up and there's plenty of water. If it gets a bit challenged it's not near as good. It also doesn't allow as much diversity. . . . it tends to be all . . . going fine or nothing going fine. (Husband, HM Farm 14)

This diversity was seen by many HM farmers as contributing to more reliable profits in uncertain conditions:

> Last year [conventional graziers] lost a lot more money than I did but this year they'll make more money than I will. You grow a monoculture – in the good years you'll make a million dollars and in the bad years you might lose $500,000, $600,000. . . . We couldn't handle one of those bad years. . . . I think we're setting ourselves up here for a much better farm in 50 years time. (Husband, HM Farm 5)
>
> [Unlike Property 1] which has got quite a lot of improved pasture, [Property 2] saved us during that drought because of the native pasture . . . we haven't fed stock since '02 really. And [with native pasture] that's no inputs, less carbon emissions; it's a huge thing really when you start to apply it. (Husband, HM Farm 22)

It seemed that HM graziers more directly linked their productivity to the condition of their land base.

4. Discussion

What are the implications of these different landscape perceptions for sustainable agricultural management and adaptation to climate change? The interviews we conducted with HM farmers possessed a remarkable similarity in message that differed dramatically from our conversations with those grazing more conventionally. This is not surprising considering that all of them had received formal instruction in the approach from one of the three courses in HM available in Australia. Concepts such as heterogeneity, biodiversity, resilience and adaptation were espoused alongside production goals. Here, we identify the priorities of HM graziers as revealed by their landscape perceptions and discuss their relevance for adaptation, analyse claims made for and against HM practices, and discuss the policy implications – for sustainable agriculture and climate change adaptation – of encouraging more HM grazing.

4.1. How are holistic managers different?

HM graziers embraced vegetative heterogeneity more than those grazing more conventionally, both across their farm landscapes and vertically within habitat structures. Farm heterogeneity has been shown to foster ecosystem services like habitat and aesthetics that are valuable for livestock, wildlife, graziers and the wider public (Benton et al., 2003; Brosi et al., 2008; Dramstad et al., 2006; Hobbs et al., 2008). HM graziers were much more likely than non-HM to leave coarse woody debris lie for biodiversity benefits. HM graziers also recognised more than non-HM the benefits in scattered tree cover, a tree arrangement that contributes to a more varied farm matrix (Fischer et al., 2006; McIntyre and Barrett, 1992), and their photography and discussions were less focused on dense woodlands than with a diversity of tree cover arrangements. They identified their farm trees by species, and when they planted trees, more HM graziers were interested in building understorey structure for a range of benefits. For instance, shrubs such as acacia are attractive to the birds that provide pest control services, but their seed pods also provide nutritious stock browse in lean times (Fifield, 2006). HM graziers appreciated a diversity of species and life stages in their pasture grass cover. Sometimes, even weeds were welcome: some HM graziers described how the deep tap-roots of some weeds improved water infiltration on previously bare ground, eventually fostering more desirable pasture species through natural succession processes. In short, HM graziers demonstrated a preference for heterogeneous and complex farm landscapes over the more homogenous and simplified ones produced by more conventional farming approaches (Ive and Ive, 2008).

HM farmers in our sample also saw the value of protecting biodiversity (and thus ecosystem services) within spaces used for production, rather than just in protected edges or unproductive uplands. In fact, biodiversity is typically seen by HM graziers as an important driver of their farm sustainability (Stinner et al., 1997); they see themselves as stewards of the ecosystem services that biodiversity arguably provides (Balvanera et al., 2006; Bengtsson et al., 2003; Swift et al., 2004). Broadly speaking, there are two alternative methods of protecting farmland biodiversity: setting aside land specifically for biodiversity (sometimes called land-sparing; Phalan et al., 2011); or farming in a way that conservation can co-exist with agricultural production (sometimes called wildlife-friendly farming) (Fischer et al., 2008; Mattison and Norris, 2005). Our HM graziers appeared to prefer the latter approach, to integrate rather than separate biodiversity conservation and commodity production. While all graziers were doing the linear planting and woodland protection encouraged by land management agencies, HM graziers did not see this as their primary contribution to land stewardship. Rather, they noted how their grazing practices could improve tree health and natural regeneration across their entire farms, whereas non-HM graziers were focussed more strongly on particular parcels of land set aside for conservation activities. This latter approach can be attributed to the institutional arrangements in place in the 1990s. Programs such as *Landcare*, for instance, defined all farm areas as either for production or conservation, and would not fund projects on the former, seeing it as the responsibility of industry rather than conservation programs (Curtis and De Lacy, 1998).

Consistent with their training, HM farmers in our sample demonstrated more adaptive behaviour in day-to-day farm management and long-range planning. Successful adaptation calls for social change as well as technological change (Walker and Salt, 2006). Adaptive capacity describes the ability of individuals to change their behaviour in response to changing circumstances. Adaptive individuals must be both adventurous and rigorous as they seek to make sense of what is happening to them and decide how to shift their practices to suit (Fazey et al., 2005). They also require adequate financial, social and intellectual resources. The desire to be resilient, rather than simply survive, is an important piece of the puzzle: without this desire individuals may simply buffer themselves from the change through short-term, reactive, symptom-focused responses (Fazey et al., 2007). For instance, many in our sample of HM graziers reported that they were motivated to adapt their farming practices by growing evidence during the 'Big Dry' that conventional grazing was unviable. By contrast, many non-HM farmers perceived the almost decade-long drought that broke in late 2010 as a temporary state, to be endured by increasing cropping for silage, on-farm storage, 'sacrifice paddocks', and often drought-related 'exceptional circumstances' funding. Their cropping meant they were also more concerned with short-term weather events like frosts. To adapt, HM graziers regularly monitored their ground cover and adjusted stocking rates to suit, reporting more consistent cover and a lack of need to directly feed stock. Adoption of HM grazing thus seems to signal a change in farming mentality from trying to gain control over the land, for example through engineering solutions that aim to reduce temporal variability (Holling and Meffe, 1996), to working within the bounds of natural variability. HM practices call for an acceptance of risk, however, both in the debt incurred to fund their farm investment, and of the experimentation needed to inform their highly adaptive practices (Bohnet et al., 2011; Richards and Lawrence, 2009; Stinner et al., 1997).

Our HM graziers largely made the transition to HM without public support, but they did not do so selflessly, despite the many public benefits they reported. Their primary motivation tended to be to maintain their function and role as agricultural producers, while averting collapse or irreversible environmental degradation, maintaining both a viable business and a desirable lifestyle. Interview-based studies of HM or cell grazing in the US and Queensland have produced interesting narratives of the way that HM or cell graziers change their identities as they shifted to new farming practices (Bohnet et al., 2011; Richards and Lawrence, 2009; Stinner et al., 1997). Consistent with other studies, our HM graziers often saw themselves as 'grass farmers' – fundamentally retaining ground cover to support ecosystem health as well as production – as much as stock producers (Bohnet et al., 2011; Richards and Lawrence, 2009). Many HM graziers saw their stock as unpaid labourers on their 'grass farm', helping to cycle nutrients and mulch soil in order to maintain ground cover. HM farmers appeared to be less sentimental about their 'animal staff' than non-HM graziers who photographed their stock more often. Because the principles of HM require de-stocking to retain ground cover, HM graziers invest less in breeding and genetic lineage. Finally, HM farmers often reported more consistent incomes and less need for costly inputs. Consistent with Bohnet et al. (2011), our HM graziers tended to diversify (e.g. farm stays, educational tours, stock agistment, direct selling) rather than rely on off-farm employment like most of our non-HM graziers.

It is difficult to identify the causality, if any, between a grazier's landscape perceptions – in this paper what features were considered significant and why – and their management practices. In other words, we cannot know for sure if the displayed values are drivers of management style or emerge as a result of that management. Training in holistic management principles appears to foster a different way of seeing and valuing landscapes, but the graziers who undergo the training are also likely more receptive to the systems mindset described above. What is clear from this work is that the way that graziers perceive their landscape is strongly indicative of how they will cope with challenges like drought. HM graziers demonstrated the capacity to adapt their management to align with new conditions, rather than simply to endure until conditions return to 'normal'. This will be important in the context of the increasing climate variability and severe weather risks predicted for Australia under climate change (Howden et al., 2007).

4.2. Why isn't everyone grazing holistically?

Opinions remain divided on the benefits of HM practices for production, producers or ecosystems. Most studies compare rotational with continuous grazing and many find no evidence of improved environmental or production outcomes in the first (Biondini and Manske, 1996; Bock and Bock, 1999; Briske et al., 2008; Dorrough et al., 2008; Taylor et al., 1997). One of our non-HM case farmers, for instance, concluded that HM "does not work" (Male, non-HM Farm 7) after an overseas study tour on the issue. Other scientific studies, however, find that rotational grazing has many positive implications for the ecology of grazing lands, leading to improved soil stability and chemistry, improved tree regeneration, more biodiversity, reduced soil compaction, increased water infiltration, and a more desirable coverage and mix of pasture species (Alfaro-Arguello et al., 2010; Earl and Jones, 1996; Fischer et al., 2009, 2010; Sanjari et al., 2008; Savory and Butterfield, 1999; Teague et al., 2011). The HM graziers in our study believed they were receiving all of these benefits, which were not often discussed by non-HM graziers in relation to their grazing practices. A US study found that HM graziers reported higher quality of life as well as healthier ecosystems (Stinner et al., 1997), but we cannot confirm or refute this on the basis of our data. The wives of the HM couples in our study were less likely to work off-farm, which may give the family more time together but may also involve financial sacrifices.

The lack of conclusive scientific evidence on measurable benefits of HM grazing may result from the relatively short history of such alternative practices and the lag time necessary for the possible benefits of such practices to manifest. The uncertainty may also be caused by research designs: poor replication, relying on grazier anecdotes (such as our study), or too rigid to permit the adaptive management characteristic of holistic practitioners (Briske et al., 2011; Teague et al., 2011). What is interesting, however, is that the practice inspires strong opinions for and against (McCosker, 2000; Richards and Lawrence, 2009). Indeed, some HM practitioners are almost evangelical in their belief in the system (Joyce, 2000; Sparke, 2000).

It may be that the benefits of HM arise from the holistic decision framework, rather than the specific tool of rotational grazing on which scientists have focussed (Briske et al., 2011). Systems thinking has been identified by some as characteristic of the higher-order thinking needed to adapt to change (Fazey, 2010). Our interviews have clearly shown that HM graziers think more systemically about their grazing systems. It may be this different kind of thinking rather than any specific element of HM practices that has positive effects on livelihoods and the environment.

Holistic management is currently a marginal activity. While it is gaining in popularity (McCosker, 2000; Richards and Lawrence, 2009; Sanjari et al., 2008), the scale of the transition is difficult to assess. In a large-scale adoption survey implemented in early 2010 throughout the grassy-box ecosystems of the Australian sheep-wheat belt, over a third of respondents reported rotating stock to some degree, but only four per cent reported having done one of the courses available in Australia to impart holistic management skills such as *Grazing for Profit* or *ProGraze* (Sherren et al., in press). Others also estimate uptake at ten per cent or lower (Oliver et al., 2009; Richards and Lawrence, 2009). At its current scale of uptake, the destocking undertaken by individual HM graziers to maintain ground cover does not disrupt the supply of either pasture or commodity, but further work is warranted on the macro-level impacts of scaling the practice up.

4.3. What messages does this work hold for policy-makers?

Evidence is building of the potential role HM could play in the task of adapting grazing to climate change in Australia and other 'brittle' ecosystems which are on the leading edge of climate change impacts. According to Savory and Butterfield (1999), brittle ecosystems are dry and low in soil biota, and need herbivores to assist with plant succession and nutrient cycling (see, for instance, Badini et al., 2007). The perennial pastures that are encouraged through HM practices have been shown to hold more soil carbon (Sanjari et al., 2008; Teague et al., 2011), contributing to the carbon sequestration that is becoming increasingly important for averting severe climate change. One of our HM farming couples was awarded a '2009 Carbon Cocky of the Year' award for the way that fostering perennial ground cover through holistic management had contributed to carbon sequestration on their property. Australian of the Year 2008 and Chair of the Copenhagen Climate Council, Tim Flannery, also advocates the holistic management of the world's rangelands because of its capacity through use of perennials and low tillage to return and maintain more carbon in the soil (Flannery, 2010). Such practices also require less chemical fertiliser and less tillage, resulting directly in lower carbon emissions. Finally, any positive adaptation for climate change should increase capacity to adapt to unanticipated changes as well (Fazey et al., 2007, 2010), and a Canadian study found HM graziers were also more able to adapt to other rural crises like bovine spongiform encephalitis (McLachlan and Yestrau, 2009).

Based on the anecdotal evidence reported in this paper, and our earlier findings (Fischer et al., 2009), we believe HM holds significant promise for the challenge of adapting agriculture to climate change. While no single strategy is likely to be appropriate on its own, we believe significant public benefits may be achieved by encouraging broader adoption of HM grazing practices. Some of the significant barriers to changing to HM practices could be eased by government intervention. Most importantly, the cost of transitioning to HM has been estimated at AUD$75 per hectare for fencing and water supply (H. Clayton pers. comm.). Stakeholder workshops and surveys suggest that free materials, information and training, and short-term financial assistance would be the most welcome policy instruments (Schirmer et al., submitted for publication). All the HM graziers we spoke to had done one of the available courses, and making these courses more accessible therefore also could be valuable. Ongoing support through social networks and extension mechanisms are necessary to help farmers sustain the change to HM, once they are inspired to make it (McLachlan and Yestrau, 2009).

Personal adaptive capacity may be a bigger challenge than incentives because HM requires the confidence to experiment, which is an intellectual and a social challenge. Indeed, HM graziers described their transition as having called for a complete 'paradigm shift'. Hogan et al. (2011) recently identified three farmer archetypes with respect to capacity to adapt to climate change: comfortable climate change-deniers uninterested in change (26%); struggling transitioners with low adaptive capacity because of poor health, high debt and a lack of support (19%); and cash-poor long-term adaptors (55%). Graziers in this last group (also identified by Bohnet et al., 2011) are the most fruitful targets for policy programs encouraging HM, being young, healthy, socially supported, and actively seeking out information to help them manage climate risk and ensure long-term sustainability.

Finally, perverse policy mechanisms (such as extended drought relief (Thompson and Powell, 1998) and insurance (Müller et al., 2011; Smit and Skinner, 2002)) and trust in technological fixes (such as increased storage and climate forecasts (Marshall, 2010)) can delay farmer adaptations by removing the financial incitements to change and can degrade the land base at public expense. It is important to review and remove these in order to make progress on the larger goal. Notably, a recent report from the Australian government on adapting farmers to climate change encourages the development of a strategy to "evaluate and disseminate farmer driven innovations such as the use of perennial grasses, [and] holistic management grazing . . . that have a significant capacity to increase the resilience and productivity of farm enterprises" (from the press announcement upon the report's release: Standing Committee on Primary Industries and Resources, 2010).

5. Conclusions

We used photo-elicitation to explore how graziers using different management practices in the upper Lachlan River catchment of New South Wales perceived their production landscapes and what this may indicate about their adaptability to climate challenges. Half of the participants were using or making transitions to holistic grazing management practices, and their interviews revealed how those practices were based on very different ways of thinking about grazing systems. HM grazier landscape perceptions demonstrated how they considered the stewardship of biodiversity, farm heterogeneity and system resilience to be fundamental to their long-term agricultural production, and almost a duty in light of increasing climate variability. These landscape perceptions appear to be conducive to adaptive management behaviour.

On balance, it would appear that HM grazing is well aligned with the biophysical essence of Australia, which is less fertile, more variable and drier than the European systems where currently dominant Australian farming practices originated. Further research is warranted on the sectoral impacts of more widespread HM grazing. HM practices do seem to provide numerous public and private benefits appropriate for adapting Australia to its climate future, however, such as biodiversity, water infiltration and carbon sequestration through perennial grasses and sustained scattered tree cover. The literature is dominated by adaptations to climate change that are dependent on technology or specific policies (such as climate forecasting and increased storage). By contrast, HM grazing is a proactive, low-tech approach that is largely independent of the policy context and what neighbours may choose to do. HM calls for adaptive management, which places HM farmers in a strong position to adapt to climate change. New policies could be introduced to explicitly encourage HM approaches, but it may be enough simply to remove those policy settings that delay adaptation.

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