“This country just hangs tight”: Perspectives on managing land degradation and climate change in far west NSW

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Short running title: This country just hangs tight

Summary text (for the online version Table of Contents): Land degradation and climate change are contested concepts, with global-scale expert views often diverging from local landholder perspectives. This study finds that the culture of adaptation displayed by rangeland communities provides a strong basis for responding to these challenges, even if their impacts fall outside the lived experience of such communities. Expert and scientific knowledge needs to build upon, and be integrated with, local knowledge, perspectives and cultures of adaptation rather than being seen as a substitute.

Abstract

Discussions of land degradation often display a disconnect between global and local scales. While global-scale discussions often focus on measuring and reversing land degradation through metrics and policy measures, local scale discussions can highlight a diversity of viewpoints and the importance of local knowledge and context-specific strategies for sustainable land management. Similarly, while scientific studies clearly link anthropogenic

climate change to land degradation as both cause and consequence, the connection may not be so clear for local rangelands communities due to the complex temporal and spatial scales of change and management in such environments.

In research conducted in October 2015, we interviewed 18 stakeholders in the far west of New South Wales about their perspectives on sustainable land management. The results revealed highly variable views on what constitutes land degradation, its causes and appropriate responses. For the pastoral land managers, the most important sign of good land management was the maintenance of groundcover, through the management of total grazing pressure. Participants viewed overgrazing as a contributor to land degradation in some cases and they identified episodes of land degradation in the region. However, other more contentious factors were also highlighted, such as wind erosion, grazing by goats and kangaroos and the spread of undesired 'invasive native scrub' at the expense of more desirable pasture, and alternative views that these can offer productive benefits.

While few participants were concerned about anthropogenic climate change, many described their rangeland management styles as adaptive to the fluctuations of the climate, regardless of the reasons for these variations. Rather than focusing on whether landholders 'believe in' climate change or agree on common definitions or measurement approaches for land degradation, these results suggest that their culture of adaptation may provide a strong basis for coping with an uncertain future. The culture of adaption developed through managing land in a highly variable climate may help even if the specific conditions that landholders need to adapt to are unlike those experienced in living memory. Such an approach requires scientific and expert knowledge to be integrated alongside the context-specific knowledge, values and existing management strategies of local stakeholders.

Introduction

Land degradation is a contested concept that lacks readily identifiable attributes and has been the subject of conflicting and confusing definitions over time (Reynolds 2001, Reynolds *et al.* 2007). Different implications for analysis and management have resulted from

hundreds of different definitions to identify land degradation, such as a decline of the land's usefulness, capability, resilience (Jones 1996), or more recently, ecosystem services (Reed *et al.* 2015). The absence of systematic identification of critical biophysical and socio-economic variables that cause land degradation dynamics has hampered efforts to categorise and map various forms of land degradation at different scales (Reynolds & Stafford Smith 2002*)*; leading to disparities in the estimated extent of land degradation reported in the literature (see Oldeman *et al.* 1991, Safriel 2007, Bai *et al.* 2008, Gibbs & Salmon 2015).

Temporal and spatial scales of analysis are key factors in assessing land degradation. In dryland ecosystems, large fluctuations in biophysical conditions and precipitation can make it difficult to accurately assess short- and long-term changes (Reynolds *et al.* 2011), including determining whether changes are temporary, permanent, cyclical or part of a continuing directional shift. This is compounded by the interaction between natural and anthropogenic pressures (Herrmann & Hutchinson 2006) and the fact that decisions affecting land management occur simultaneously at different levels (Fleskens & Stringer 2014), from individual landholders to large-scale administrative policies and global responses to climate change.

While the United Nations' definition of land degradation (UNCCD 1994) recognises that human and environment systems are inextricably connected, the interpretation of the phenomenon remains a matter of perception, perspectives and scale (Reynolds *et al.* 2007, Warren 2002). Perceptions of land degradation are formed from the views of observers concerned about a deteriorating landscape and its impact on the livelihoods of land users; local people may perceive land degradation in an entirely different way to scientists and policy makers (Stocking & Murnaghan 2013). A large evidence base of research (such as MacLeod & Taylor 1994, Kersten & Ison 1994, Stafford Smith *et al.* 2007, Waudby *et al.* 2012, Gobindram *et al.* 2018, Williams 2018) shows how perceptions of land degradation, its drivers and land management responses vary between stakeholders, influenced also by

social and local contexts. Similar evidence has been reported recently for climate change (Li *et al.* 2014, Hou *et al.* 2012).

Global assessments suggest that degradation in Australia's drylands is more prominent than in other similar ecosystems of the world (Bai *et al.* 2008, Cherlet *et al.* 2018). To worsen matters, recent studies predict the impacts of climate change will disproportionally affect Australian rangeland communities, particularly through increased droughts, floods, and associated financial debts (Hughes *et al.* 2016).

Land degradation and climate change have a complex relationship as both causes and consequences of one another (Cowie *et al.* 2011), but they are often studied separately and without consideration of social contexts (Reed & Stringer 2015). Research has established links between rangeland degradation and increased vulnerability to climate change (Webb *et al.* 2013, 2017); the United Nations' climate summit of 2014 has also hailed "restoration of degraded ecosystems as an auspicious solution to climate change" (Suding *et al.* 2015, p. 638). However, challenges still arise when circumstances have changed (through climate change, for example) to the extent that returning land to a past condition is not a valid option (Stafford Smith 2016). Recent policy pathways propose addressing land degradation and climate change concurrently through interventions such as climate-smart agriculture (Zougmoré *et al.* 2014, Webb *et al.* 2017) and carbon farming (Walton *et al.* 2014).

This research paper aims to identify potential mismatches between local and scientific understandings and perspectives on land degradation and climate change, in order to advise the design of future on-ground stakeholder engagement, interventions and policy development in rangeland management. A region of the far west of New South Wales (NSW) is used as a case study. According to the NSW State of the Environment report (NSW EPA 2012), major issues within the case study region include wind erosion, water erosion and mass movement, shallow rocky and disturbed terrain, as well as some areas of salinisation and waterlogging. Climate change predictions at 2030 for the region indicate that average and severe fire weather will increase, rainfall will decrease in spring and increase in autumn,

and there will be approximately 12 more 'hot days' (days above 35°C) on average per year (NSW OEH 2014).

The underlying premises of this research are that land degradation is a contextual process (Warren 2002) that is dependent on the various perceptions, values and interests of its observers (Hobbs 2016) and that land management practices are reflective of changing system functions, including climatic changes (Whitfield & Reed 2012). The research explores the diversity of views that exist among relevant stakeholders of the region on how landscapes degrade, how climatic variability is perceived, and how these perceptions influence land management responses.

Method

Study area characterisation

The far west case study area is in the Western region of NSW (Figure 1). Evidence suggests that it was managed sustainably for tens of thousands of years by the indigenous owners preceding significant perturbations from the introduction of agricultural and industrial changes (Fanning 1999, Marx *et al*. 2014). European exploration of the area in the 1840s introduced the rapid expansion of pastoral leases and reports of over 15 million sheep in the Western Division in the 1880s and 1890s which, coinciding with drought and rabbit plagues, preceded a swift and severe transition to a significantly degraded state, supporting just over 3 million sheep in 1902 (Fanning 1999). Pastoralists recognised the severity of the degradation in one of Australia's first Royal Commissions in 1901 (LaFlamme 2011, Green 1989). Mining and domestic uses also encouraged timber harvesting and clearing surrounding the settlement of Broken Hill. In the 1930s, however, the degraded area surrounding Broken Hill also became the site of one of the first ecological restoration projects in Australia and indeed the world (Jordan & Lubick 2011). Over a century later, the same land uses still dominate, although the practices are arguably better adapted to the land's conditions and capacity.

[Figure 1 here]

Currently, predominant land uses include grazing (sheep, cattle and goats), metal ore mining, tourism, conservation, and some new renewable energy generation. Apart from some opportunistic annual cropping, nearly all of the region's pastoralism makes use of native vegetation, which is predominantly chenopod shrublands (saltbush and bluebush communities) and mulga communities, among others (NSW OEH 2016).

Among other characteristics, the region's climate variability, sparse population and remoteness displays a similarity to outback Australia's hypothesised 'desert syndrome' (Stafford Smith 2008). Its high non-annual climatic variability and reliance on volatile export markets mean that risk and uncertainty are particular considerations (Greiner & Gregg 2011).

Research approach

Drawing from grounded theory, the research was designed inductively, where theories are discovered and drawn from an analysis of the generated data (Hall 2008). The emergence of concepts and refinement of the theory through reinterpretation is central to the approach.

Significant drivers of land degradation are social, economic and political, necessitating an integrated approach (Escadafal *et al.* 2015), so this case study seeks to fill a gap of qualitative data, noting that qualitative research is best suited to complex, contextual and nuanced circumstances (Mason 2002). Exploring a case study allows researchers to take a real-world perspective of a particular complex social situation, making use of multiple sources of data and working within many contextual variables (Yin 2014). Data collection followed a participatory approach, consisting of interviews in the form of 'conversations with a purpose' (Mason 2002), allowing a flexible approach and appropriate context. We regard the data as an 'interpretation', recognising that the intervention of a researcher and their observations play a critical role in the results, theories and conclusions gained from interview data (Hall 2008). Semi-structured in-depth interviews allow participants to be active in directing the content of the results, with questions guiding the topics but crucially, respondents being able to frame their answers in their own terms about issues relevant to them. To avoid becoming "too influenced by the perspectives of the informants" (Hall 2008, p. 80) and to strengthen findings through triangulation, we also make comparisons to similar

163 academic studies and documentation of the case study area where available. In the tradition
164 of grounded theory, this information was sought after the interview process to avoid overly
165 affecting the generation of the data.

166 Participants were selected as people who could be potentially affected by policy changes,
167 and people in charge of implementing policies relevant to the topic and study area (following
168 Guest *et al*. 2013). Although more difficult, we intended to elicit multiple perspectives to add
169 richness to the data and explore potential areas of conflict or consilience. Researching
170 perceptions of different stakeholders helps to address adaptation to land degradation and
171 climate change, as awareness of indicators and conflicting priorities are significant barriers to
172 the adoption of changes (Reed & Stringer 2015). Interpretive social science approaches can
173 aid in understanding how prior lay knowledge has shaped perceptions and consequent
174 actions (Connor & Higginbotham 2013).

175 A total of 18 participants were selected through a snowballing technique via numerous points
176 of entry. They were interviewed in October 2015; including 10 pastoralists (P01-P10), 4
177 employees from various levels of government (G01-G04) and 4 local residents (one
178 Aboriginal person and three opal miners, L01-L04). Although land degradation applies to all
179 land uses, the self-exclusion of the mining companies, corporate agri-businesses, and other
180 stakeholders has led to a focus on pastoral land use for this case study. Among the
181 pastoralists, property size varied from 16 000 hectares to 75 000 hectares, running different
182 combinations of stock: predominantly sheep (merino and/or dorpers) and cattle (8
183 pastoralists); sheep and goats (1 pastoralist) and a domesticated goat enterprise (1
184 pastoralist); although, harvesting unmanaged goats opportunistically is common practice as
185 well. Although only one interviewee identified as Aboriginal, several Aboriginal people were
186 approached in the fieldwork. They showed signs of consultation fatigue (frustration about the
187 frequency of being consulted without meaningful outcomes) and we acknowledge their
188 reasons for nonparticipation. While opal mining is a contained and small-scale operation, the
189 miners' views still add depth to an understanding of the land's capacity for rehabilitation post
190 disturbance. Further, the miners' perspectives are those of locals, who have social

191 connections with pastoralists in the region and absorb knowledge and observations over
192 time. Because local community members and land managers are not solely responsible for
193 meeting sustainability goals in rangelands, we included some policy-centred stakeholders
194 (see Waudby *et al.* 2012).

195 Pre-arranged interviewees were sent a letter of information outlining the research project and
196 its aims. Where possible, interviews were conducted in person and mainly at the participants'
197 properties or workplaces. The three interviews over the phone were between 30-45 minutes,
198 whereas in-person interviews lasted between 45 minutes and several hours.

199 Preparation for the semi-structured interview process included the creation of an interview
200 guide containing questions and potential probes to follow up responses. Open-ended
201 questions allowed for unanticipated responses and imposed criteria were deliberately
202 avoided. The design of the interview guide took into consideration the findings of Reeve and
203 Black (1994), where 'inconsistent' attitudes about land degradation by New England farmers
204 challenged attempts for uni-dimensionality (as is typically sought by Likert scale question
205 types).

206 Questions were structured according to broad topics about: (1) the participant and their
207 connection to land management; (2) their perceptions about the region's environment and its
208 degradation, climate change, possible sustainable land management and restoration
209 practices; and (3) the role of the government for land management. Information was not
210 given specifically about the relevance of anthropogenic climate change to land management
211 and degradation.

212 Some questions were asked of all participants, but those who were more engaged or had
213 more time were asked additional questions or more tailored questions based on their
214 previous responses or the flow of the interview. The loosely structured nature of the interview
215 process was intended to place fewer demands on the participants, particularly regarding
216 topics like drought that may be distressing (Kuehne 2014). Interviews that were more
217 opportunistic (given their point of entry or availability) tended to be less structured.

Photo-elicitation methods were used to a limited extent in the interviews. Some participants provided photos to accompany their verbal responses, while others gave vivid descriptions or were able to point to various physical landscapes (as many of the conversations took place in a relevantly situated context). In other cases, interviewees were unable or unwilling to provide photos and it was not logistically possible to lend cameras to participants as has been done in other studies (for example, Kong *et al*. 2014).

In accordance with grounded theory, interview results were organised and sorted through coding which emerged initially from the research questions but mainly from the data itself. QSR NVivo 10 was used to create and manage these codes. The results from interview data were read literally, interpretively and reflexively during the analytical process (Mason 2002). We organised data into particular themes to present a storyline through a combination of open coding (segmenting), axial coding (linking connections and contexts) and selective coding (highlighting central codes and relating and integrating others) (Bryman 2012). Discourse analysis was also used to situate the responses within wider discourses dominant in the society and relevant organisations (Hall 2008).

Results

Table presents a summary of interviewees' perspectives on potential land degradation processes and responses in the case study region. Alternative perspectives are also presented where views differed on degradation processes and appropriate responses. Participants' comments on land degradation and climate change are presented hereafter (discussed in more detail in Berry, 2017).

[Table 1 here]

Perspectives on land degradation drivers and processes

Stakeholders had varied perspectives about the meaning, prevalence and seriousness of land degradation in far west NSW. Some people related degraded land to production values

(degradation as "*all those things that make it unproductive"*, G02) or mismanagement ("*It's country that's been abused",* P10). Others nominated "*man-made degradation just from overgrazing"* as well as "*natural land degradation through droughts and floods… Which I suppose the landscape's been like that forever and a day. It's just … we're probably not used to it"* (P04). Other pastoralists did not consider natural processes to be land degradation, referring to eroding creeks in particular: "*one bank will fall in on one side and then it will slowly silt up around the corner and I'm not sure whether it's land degradation or just a function of country"* (P02) and "*most people tend to view erosion as just a part of the landscape… creeks move"* (P03).

Interviewed landholders mostly thought that their land was in a better condition than it had been several decades ago. However, one participant argued that comparing current land condition to that of past degradation events can overlook less visible factors like soil productivity: *"Things are way improved since the '30s, but essentially, that's like an improvement in the more obvious physical manifestations of degradation… gullies, lots of erosion, fences washed away, or exposed sand dunes, but there's this more subtle, more insidious form of land degradation which is a reduction in the productive potential of soil, which is getting worse I think"* (G04).

Several land managers discussed wind erosion as the most dominant influence on the landscape. However, some pastoralists and opal miners discussed how it is not just a degrading process but facilitates regeneration as well: *"I think it balances itself out in country like this because, even though we had that massive dust storm and that was dirt from somewhere else, and some of that wind was horrific, it still brought in new seed. It still brought in new dirt. So to me, it might strip but it replenishes as well"* (P09); "*We are in for some interesting dust storms. And that dust comes and … it also brings seed with it. So really we don't need to do anything, Mother Nature works for us"* (L04).

Participants raised overgrazing as a key cause of land degradation, which some connected to financial pressures related to drought (*"that's when places get unstuck to me, they don't get rain, they don't get feed, but people on the land try to hold their stock numbers up… they*

overgraze, and then those perennials are gone, which is hard to get back again", P04) or insecure land tenure, including sub-leases (*"if you've got a short lease then you're not going to put a lot [of infrastructure] on it. But you are going to put a lot of stock on it, before you depart",* P09).

More frequently, participants discussed overgrazing in light of total grazing pressure, considering not just livestock but also native and feral animals. There were contrasting perspectives towards kangaroos, rabbits and goats as pests or resources, depending on the circumstances.

Many participants viewed kangaroos as pests, or at least undesirable on their property for the sake of their vegetation and management plans. They noted the dissonance between their view of kangaroos as pests and that of urban Australian and international communities: *"People might think that they're on our emblem and that they're beautiful furry creatures but they compete for food"* (P03). Kangaroo management was also seen as being hampered by a weak market for kangaroo meat: *"There aren't enough kangaroo shooters, because there isn't enough money being paid per kilo to shoot the kangaroos, because our overseas markets have slumped. So kangaroos are a massive problem"* (P03).

As with kangaroos, most interviewees saw rabbits as a pest, but some recognised their resource potential: *"That Calicivirus… did devastate but … I do see more of them more frequently again now… most people harvest them, and sell them for meat. So they're actually sometimes worth more than your sheep and cattle"* (P09).

Rangeland goats inspired strongly divergent views regarding environmental damage and financial value. The prevailing view was that goat prevalence had increased, which was often viewed as a problem, for example: "*they're absolutely everywhere… a huge problem"* (G04), "*the most destructive of all the animals"* (G01) and "*every tree gets cropped up as high as a goat can reach*" (L03). However, the high financial value of goats appears to have enhanced their acceptability among land managers: *"we don't really consider goats as pests – we consider goats as a resource"* (P10); "*I don't see goats as a problem anymore*. *Probably 10-15 years ago they were, but they're fairly much under control now. The price of goats has*

just skyrocketed within the last few months so people are making a more active effort" (P03). Goats were also seen to survive better during droughts due to their ability to browse on perennial shrubs: "*sheep'll die, goats'll keep going"* (G03).

One landholder viewed goats as pests "*whether they're worth money or not"*, adding that the fact that they are lucrative is *"probably a good thing*" because it means people have an incentive to get them (P08). In contrast, a goat grazier argued they had not only financial value but had benefits for blue bush compared to sheep, "*and it's starting to come back, so that's our little thing that we're happy with. Because we can say that that's growing, and we're seeing hundreds and hundreds of them starting to grow in the paddocks that there's no sheep*" (P01).

Several interviewees identified "woody weeds" or invasive native scrub (INS) as a driver of land degradation. Pastoralists pointed out that INS reduced productivity: *"where you've got natural grasslands, that were once native grasslands, which were open country, is replaced by woody shrubs, that have no grazing, or very little grazing benefit at all, and that is said to be the largest definer of land degradation"* (P10); *"There's things that you keep an eye out for, like invasive scrub, if you can get rid of it, you can… It's more a matter of it being useless because nothing eats it, and it's taking up room, and nothing grows under it."* (P07).

In contrast, other pastoralists observed that INS helped to maintain groundcover and provide food for some stock: *"I don't consider woody weed a weed. Because it actually helps to keep the ground down… to me they are like a good wind break… Plus, when it's dusty, they catch the soil as it's going through as well… And there are animals that will eat it anyway."* (P09). The rejection of negative terminology (including "invasive" and "weed") for INS was supported by other participants (*"It's absolute lunacy to clear them. I mean, they provide so many ecosystem benefits",* G04), as was the view that they provide better protection against wind erosion than grasses ("*sand moves a bit and then you've got nothing"… this country just hangs tight"*, P06). Participants discussed how the recent inclusion of INS in carbon farming initiatives had contributed to shifting perceptions: *"There was a long time there when*

they wouldn't include invasive native scrub or woody weed in the carbon offsets, now they are… people are getting paid for their mulga and woody weed and stuff like that" (P03).

With regard to introduced species, some were clearly framed as weeds, particularly mesquite: *"We don't have money and we don't have access to funds to do [weed control for mesquite], and that can be quite frustrating… it's becoming an increasing problem*" (G02). In other cases, introduced species that some landholders regard as weeds, such as buffel grass and kikuyu, were regarded by others to have instrumental value for preventing soil erosion (P03).

Participants drew clear connections between the management and quality of the water and the land – it was obvious that *"land is attached to the water"* (P06). For a Wilcannia resident: "*if we just let the water run to a level that keeps pushing all that salt and stuff along to where it's supposed to be going, well then we wouldn't have a lot of issues on the land. But we're going to have a lot of problems out here*" (L01). In Broken Hill, water levels and availability are *"a very real concern for the future of the town"* (G01). Participants discussed the historic overuse of water (P06, P07) and that there is *"a fight on between whether that water gets used for production or whether it gets used for ecology"* (L04). The perceived mismanagement of the Darling River and Menindee Lakes inspired a resounding concern from many of the participants. Responsibility and blame was variously placed on the Murray Darling Basin Authority, cotton irrigators upstream, demands from South Australian water users downstream, as well as dams on farming properties along the water catchment.

Perspectives on action to respond to land degradation

> *"I've seen some of the worst looking ground, through the mid-'90s when we had the big drought through there, is some of the best looking ground now. So it got totally, totally decimated and now it looks fantastic…"* (L03)

Stakeholders who perceived that land degradation was caused by human mismanagement also tended to argue that it could be prevented or ameliorated through sustainable land

management. These interviewees often brought up the complementary ideas of groundcover management and total grazing pressure management, which were seen as important for both conservation and production. For example, one pastoralist stated, *"You've got to take every opportunity you can to remain viable… keeping a certain level of groundcover and maintaining the feed you have got, knowing when to take stock off and put stock on… that's the big thing in this area"* (P05). Other participants discussed the connection between grazing pressure, groundcover management and soil conservation by expressing goals of *"excluding most species"* (P10), *"getting rid of the undesirable animals"* (G02) and *"getting rid of all those animals that eat the grass, and disturb the soil"* (G04).

Management tools identified for managing total grazing pressure included fencing, placement of water points and choice of livestock. Multi-species fencing was seen to aid *"matching livestock to available feed"* (G02), while others highlighted the significance of *"where water points are placed in a paddock"* (P03) and *"moving waters, making more water points, making paddocks small, spreading the stock out so there's little bits all over the place… now we've split them up and it has helped, for sure"* (P04). Livestock selection decisions included a reported switch from merino to dorpers and damaras among some pastoralists in the region, for reasons such as their wider diet, meat-focussed production value, reduced overhead costs, greater heat-tolerance and resilience in the climate (G02). However, others saw these same attributes as an environmental threat and a maladaptive practice: *"the thing about merinos was, when you got into a big drought, you had to get rid of your sheep because the merinos just couldn't cope, which was a good thing because the country got a bit of a rest. But with the dorpers, they just keep pushing"* (G04). Similar concerns were raised about goats.

Grazing regimes were also discussed as a land degradation response. Some participants saw rotational grazing as inappropriate for reasons including unpredictable rainfall patterns (*"it's actually too dry most of the time, you can't rely on rainfall",* P09), dispersed and limited water supplies (P06), scarce vegetation (*"if you put a heap of stock in one paddock, then you'd make a dustbowl"*, P09), logistical infrastructure challenges including keeping other

grazers out of resting paddocks (P08), and costs associated with the large scale of their properties (implementing it would be *"very intense and… very costly"*, P03). Alternatively, one interviewee discussed how many landholders use agistment to rest their properties: *"… one of the things landholders are doing is, in good seasons, putting stock in the Western Division, and when things dry off, they truck them off and fatten them up in the Central Division or in the Eastern Division, where there's more pasture. And that's kind of like a transhumance …except they're using a truck, to move all their sheep*" (G04). Responses show that instead of prescribed regimes like rotational grazing, pastoralists preferred adaptable grazing management that suits them and the environment, such as adjusting stocking rates according to pasture availability or keeping stocking rates low.

For restoring degraded grazing land, the interviewees commonly held the opinion that natural regeneration was the best option: *"We let it do it by itself"* (P07). While they were aware of the long timeframes involved, there was a perception that the environment could, and would, repair itself eventually in appropriate conditions: *"[It] all sorts itself out after a while"* (P06), "*I think it's more by resting than reforestation and replanting"* (G01) and *"Just let it sit and let it regenerate back through"* (G03). This view was also reflected in the dismissal of manually planting seedlings, based on unsuccessful previous attempts (P09) and water constraints (*"That's useless out here. …you can't hand water, it's too big an area, and the rainfall is so uncertain."* G02).

The decision to let land rest and repair itself is sometimes called "locking it up", away from livestock or other uses (P02, P10). While natural regeneration is preferred, several pastoralists challenged the idea that this is "passive" management: *"If everyone walked off of the rangelands now, they'd be overrun by pests and weeds…"* (P03), *"just by locking country up, doesn't mean the country's going to get any better"* (P01), "*instead of shutting places off you're better off leaving it to the owner actually in residence, to manage it, as a conservation area. It's far cheaper, and generally speaking they're on-site and they know what they're doing"* (P06).

Some landholders held the view that they should receive some form of economic compensation for the public benefits of locking up land as a restoration or conservation activity: *"if restoring your landscape means that you cannot run stock on it, people need to be compensated for it… It is a voluntary lack of income"* (P03). One landholder cited an example of this from a previous conservation program in the area under which he was financially supported to exclude grazing from a hill on his property: *"they were paying us not to use it"* (P07). However, he also noted that he had not actually been using the hill for grazing because it was "*just too rough"* (P07).

Land managers discussed active rehabilitation of eroded areas, particularly through waterponding (a technique developed in western NSW to repair scalded soils through shallow banks of water) and contour furrowing (where sloping land surfaces are mechanically furrowed to enhance productivity through water harvesting). Several participants discussed waterponding in a positive light (P05, P10, G02), often as if it were commonplace: *"A lot of people are doing things like waterponding and a lot of rangeland rehab… People are just doing what they can with what they have"* (P03). Contour furrowing was also reported to have positive impacts, but some participants noted its limitations: *"Some people in the hillier country, they can do contour furrowing to control the bare earths on slopes, they can slow the water down… the blue bush [has] started growing along the contours"*, P04) and *"We did the furrowing… which was really good and you can tell where it's been done, and how much it's benefitted that country. But I think you have to know your country too… you can't furrow up everything because you think, 'oh, that'll make it all grow', because it doesn't work like that"* (P08).

Along with the restriction of certain practices based on land type, participants also emphasised the resources required for waterponding and contour furrowing. These resources included the time required for establishment and maintenance (P10) and the need to consider economics: *"[Rehabilitation is] really useful but the land's got to be worth the money… we are not limited by technology. We have five or six technologies that are really*

appropriate to repairing degraded lands in western NSW – it comes down to economics" (G04).

Perspectives on climate change

Several participants framed the constant fluctuations of the climate as a natural cycle: *"I'm sure things are cyclic, things come and go"* (G01), *"It's a cycle. That's why when they say climate change, I don't take notice of that…"* (G03), *"my father-in-law who's been around for a very, very long time tells me that it changes every 15-20 years anyway"* (P03). Consequently, participants tended to minimise the impacts made by people since the industrial revolution: "*I've been here for 50 years and I haven't seen any evidence of it at all"* (L03), *"climate's been changing out here for a long time regardless"* (L02), "*we may increase it, we may speed it up a bit, but my view is 'well, climate will change'"* (P03), *"climate has always been changing, and if it didn't change, we couldn't exist"* (L04).

One pastoralist reflected that natural changes in the climate are *"an ongoing process of the globe"* causing mass species evolutions and extinctions over time, *"so I suppose the human species will probably come and go too…"* (P04). Those unwilling to accept the anthropogenic frame of climate change labelled different natural processes as 'weird' or 'strange'. For example: *"I'm not a great believer in global warming as such, because it doesn't seem to really be happening… [but] the last 15 years here has been as weird as anything else. We seem to be going from a drought to a flood backwards and forwards… there's no continuity"* (P07).

Perspectives on action to respond to climate change

Support for action on climate change was low among participants. A prevalent idea was that there are more immediate issues, for example: *"I think probably climate change is in the back of people's minds but … people have got enough to worry about, without being bombarded with stuff about climate change"* (P03). Others (L04, P03, P09) felt that blame was unfairly

targeted towards country people, while urban people and big business were bigger culprits. One pastoralist who supported renewable energy rationalised this based on reasons other than climate change: *"I'm probably not a 'pure' climate change sceptic… I think it's a cycle… [but] I think that having renewables is an excellent idea… The things that they do, to try and fix what they perceive as climate change, in some ways, are good for the planet anyway so why not do it"* (P08).

Despite the reluctance of participating landholders to view their land management actions as direct responses to climate change, participants often highlighted an adaptive approach to land management more broadly. This adaptive capacity was presented as *"pragmatism"* (P07), "*common sense*" (L03), a recognition that environmental health and farming livelihoods are necessarily connected (P10, G01, G02) and notions of stewardship (such as *"we are the caretakers",* P09). One pastoralist shared that he is *"not concerned about [the environment] at all. It's just a matter of managing with the climatic seasons that come to us… That's all you can do, just work with the climate"* (P04).

A participating scientist highlighted the adaptive capacity of landholders in the statement that *"Landholders, not government people, landholders have proved the lesson: fewer and better quality animals, use technology to monitor your drought, move your animals around, get rid of them early…"* (G04). A Local Land Services worker also discussed the greater ability of landholders to drive adaptation relative to government employees: *"we have got some leaders and innovators … and they're the people that have the ability to go to old mate next door who's still using his great-grandfather's management style, and say 'you need to wake up to reality'. I can't do that as a government employee"* (G02).

Discussion

Rather than a unified story of land degradation pressures and corresponding responses, the perspectives uncovered in the far west NSW case study showed a spectrum of ideas, both between and within particular stakeholder types. The widespread view that land was in better

condition than in the past is consistent with the findings of Waudby *et al.* (2012) in South Australia. However, the results also highlighted the need to look beyond obvious indicators such as vegetation cover and visible erosion for less visible characteristics such as soil productivity.

Many of the land degradation factors identified by participants align with previous studies. The importance of wind erosion is reflected in the 2012 NSW State of the Environment report (NSW EPA 2012). Similarly for pests, rabbits are recognised as a cause of land degradation (Gill 2014), as are goats, with Pople and Froese (2012) observing that the drought of the 2000s "did little to dampen" the overall increase in goat abundance. The prevailing view of kangaroos as pests aligns with a 2015 stakeholder survey in the region (Western LLS 2015), in which 85% of respondents listed kangaroos as a pest problem (significantly more than the 68% of respondents in 2012). This contrasts with earlier research from the South Australian rangelands (Thomsen & Davies 2005, 2007), where landholders recognised kangaroos as a resource and saw commercial use of kangaroos as one of the few potentially profitable rural industries with minimal environmental consequences.

Globally, bush encroachment in rangelands (referred to as 'woody weeds' or 'invasive native scrub' by participants) is considered to be the most widespread type of land degradation (Reed *et al.* 2015). Within the western region of NSW, there are 26 species listed as 'invasive native scrub' (NSW Government 2006). However, some studies from western NSW have shown positive ecosystem effects in shrub encroachment levels at the highest recorded concentration in eastern Australia (Eldridge & Soliveres 2014), providing habitat for native fauna as well as understorey plants (Silcock 2014). These divergent views were also found in the case study responses. Distinguishing beneficial natural regrowth from what others consider to be invasive native scrub requires an understanding of what benefits, constraints and trade-offs there are and what varying values are held within the community (Lunt *et al*. 2010).

In terms of management actions, the benefits reported from contour furrowing are consistent with the finding of Wakelin-King (2011) that landholders are generally satisfied with the

technique in certain geomorphic contexts (excluding claypans and floodplains). Similarly, the reported use of waterponding among case study participants confirms that it is a generally accepted practice to retain water for rehabilitating scalded soils (Thompson 2008). However, participants were most generally supportive of 'passive' management techniques (removal of non-ecological disturbances and allowing natural recovery). Depending on the context, Holl and Aide (2011) also recommend this approach, with patience allowing land managers to see the possibilities of the natural recovery process.

The importance of managing stock to reduce land degradation risk is consistent between this case study and previous studies. Stock removal (or reduction) was seen as an effective regeneration method by participants, albeit one that can have costs from ongoing management and foregone income and may require compensation in the form of payments for ecosystem services. However, rotational grazing can be a point of contention. Participants in this case study did not consider it appropriate to this context, despite the fact that it is commonly recommended for rangelands overseas (Liniger *et al.* 2011, Nkonya *et al.* 2011) and Australian results have indicated potential benefits for groundcover and plant diversity on certain rangeland soil types (Waters *et al.* 2017).

Landholder criticisms of rotational grazing in this case study were consistent with the arguments of Briske *et al.* (2008), who state that rotational grazing is often promoted for rangelands without appropriate evidence. This is also supported by McIvor (2013), who found that anecdotal evidence of positive rotational grazing results is not mirrored in the scientific literature and may be related to other changes around monitoring, financial management and improved decision-making that often accompany a switch to rotational grazing. Similarly, Bailey and Brown (2011) argue that timely adjustments to grazing distribution is more likely to be effective than rotational strategies in maintaining rangeland health in arid or semi-arid areas. While agistment is a common practice during drought, some research has explored further circumstances in which livestock mobility is suitable in this context (McAllister 2012, McAllister *et al.* 2006), and further future research could explore the

545 economic and policy mechanisms which enable pastoralists to strategically move stock for
546 greater outcomes.

547 The participants' tendency to focus on climate variability or climatic cycles rather than
548 anthropogenic climate change is consistent with results from other parts of rural Australia
549 (such as Baumber *et al*. 2011, Buys *et al.* 2012). Connor and Higginbotham (2013) found
550 that rural Australians in particular rely on their experiences of droughts and changing
551 seasonal patterns to back up their positions towards climate change, without detecting
552 variations beyond the normal vagaries of the climate. This reflects a point made by Weber
553 (2010) that climate change is a phenomenon not well suited to personal observation and
554 evaluation.

555 While the participants generally displayed scepticism around anthropogenic climate change,
556 this does not necessarily mean they are unable to adapt to the changes it may bring. For
557 example, Mazur *et al.* (2013) found little difference between the climate mitigation actions
558 undertaken by rural Victorians who were variously concerned, sceptical or unsure about
559 anthropogenic climate change. Furthermore, Donnelly *et al*. (2009, p. 24) argues that
560 Australian primary producers have "a strong culture of adaptation", which was evidenced in
561 the case study in the way landholders described themselves (and were described by others),
562 as well as through evidence of adaptive stock management, exploration of alternative
563 enterprise options and resilience-building practices such as contour furrowing and
564 waterponding.

565 Reed and Stringer (2015, p. 70) argue that, by being prepared for short term climatic
566 variability and preventing land degradation through sustainable land management, land
567 managers make themselves "better prepared for long term climate change". However, as
568 climate change progresses in rangeland Australia, it is possible that current adaptation
569 strategies developed for a variable and cyclical climate (e.g. adjusting stock numbers in
570 response to seasonal conditions) may no longer be suited to a climate that is changing
571 consistently in a particular direction, such as towards hotter temperatures and more frequent
572 and extreme droughts (Reisinger *et al.* 2014). Predicted changes may be outside of lived

experience for European-style land management in the far west, as paleo-climate records of the region indicate that drought and flood risks over the past 150 years have been relatively stable compared to the longer-term (Ho *et al.* 2015, Tozer *et al.* 2016). While this case study did not provide evidence for determining the thresholds beyond which current practices might cease to be effective, this represents an important avenue for future research in the region.

For government agencies, researchers and other stakeholders seeking to facilitate climate change adaptation in the rangelands, it is important to recognise and build upon the adaptive capacity that already exists amongst landholders rather than prescribe 'one size fits all' solutions. Nelson *et al.* (2010) argue that the far west region of NSW, while projected to encounter the state's greatest impacts in terms of climate variability and changes in pasture growth, also features a range of existing adaptations to the climate that may reduce its vulnerability to future changes. However, it is also important to consider potential barriers to adaptation, such as lack of resources, skills, social acceptance and other stresses facing rural communities (Waudby *et al.* 2012, Hughes *et al*. 2016).

In regions where a consensus of climate change scepticism has been established, it may be necessary to provide opportunities for landholders to adapt without having to 'break ranks' with their neighbours and embrace climate change rhetoric. For example, the case study revealed interest in renewable energy generation and payments for carbon sequestration despite the overall scepticism around climate change. This supports the argument of Kuehne (2014) that other environmental and economic benefits could provide incentives for adaptation to climate change, rather than attempting to shift people's ideological positions.

If government agencies or other stakeholders wish to influence landholder views on anthropogenic climate change, an 'entry point' may be landholders' perceptions that the climate moves in cyclical patterns. This follow Weber's (2010) argument that direct personal experiences need to be shown as causally connected to climate change in order to raise concerns among the affected. In contrast, warnings of more 'hot days' above 35°C (NSW OEH 2014) may be effective for coastal city-dwellers, but are of questionable value in areas

where there is already an expectation that summer temperatures will consistently approach 50°C.

Overall, the case study responses showed an alignment between local and scientific knowledge on some factors (e.g. pest impacts, restoration techniques) but a divergence on other factors, notably around climate change. Table 2 summarises how the interview results compare with internationally recommended sustainable land management in response to land degradation and climate change, and provides suggestions for greater recognition of these divergences.

The results align with similar outcomes described by Addison *et al.* (2012) and Whitfield *et al.* (2015) and reinforce the argument of Koning and Smaling (2005) that agronomists, ecologists and participatory researchers need to come together with local stakeholders to develop and use appropriate discourses. From a policy perspective, there is a need for government agencies to carefully tailor information, build upon existing adaptive capacity and recognise barriers in order to avoid potential conflicts and generate what Wilson (2004 p. 481) terms local "policy-making empowerment".

Conclusion

Addressing land degradation in far west NSW appears not to be dependent on top-down solutions or the introduction of outside technologies, but rather on building on existing knowledge to align management practices with appropriate climatic and socio-economic conditions. Unlike the historical degradation caused by "ignorance" and "a false impression" of the land's productive capacity (Green 1989, p. 110), land managers in the case study exhibited extensive knowledge of their country and of appropriate management practices according to environmental constraints (as found by Waudby *et al*. 2012). Furthermore, the culture of adaptation that has developed through managing land in a highly variable climate provides a strong basis for coping with an uncertain future, even if the specific adaptation strategies of landholders may need to adapt to a future climate unlike that experienced in living memory.

The tendency of participating land managers to attribute changes in climate to a 'natural cycle' rather than anthropogenic causes need not be an insurmountable obstacle to effective adaptation. Existing adaption to natural climate variability, as well as substantial economic and social change, has accustomed land managers to practices based on responsiveness and resilience, principles that may also form the basis of sustainable land management under climate change. Land managers also exhibited extensive knowledge of their country and practices appropriate to environmental constraints. Despite this, the local community requires more tailored scientific information and policy tools to prepare for potentially overwhelming circumstances. Engagement on climate change adaptation and sustainable land management should specify the benefits of involvement in ways that are meaningful to local people and recognise their existing adaptive capacity.

This research highlights how effective land management can take place in the presence of uncertainty and differing perspectives on what constitutes degraded land. Sustainable land management does not rest upon undisputed assessments of land degradation. Similarly, belief in anthropogenic climate change may not necessarily be a pre-requisite for sustainable land management where existing adaptive management to a variable climate can be combined with policies to encourage specific responses to hotter temperatures and more intense droughts. Above all, this research shows the importance of care for land and an interrelated care for its people, and the need for scientific knowledge to be integrated alongside local knowledge and values.

Conflict of interest

The authors declare no conflict of interest.

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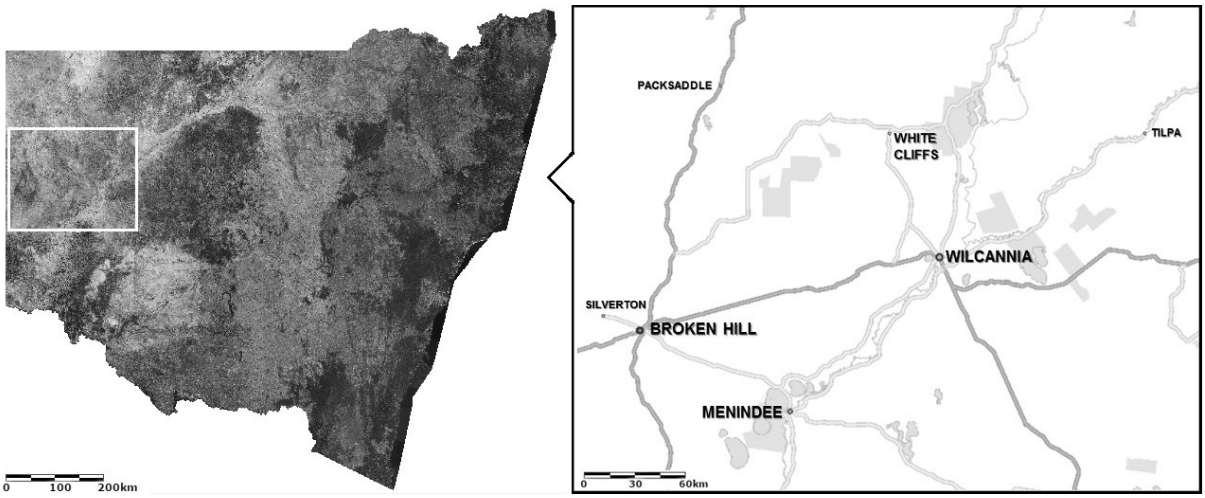

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919 **Figure 1.** The far west NSW case study area (maps modified from the Vegetation

920 Information System Map Catalogue provided by the NSW Office of Environment and

921 Heritage).

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923 **Table 1** Summary of far west NSW local perspectives on land degradation and climate change,
924 management responses, as well as alternative perspectives.

Concept	Perspectives on land degradation	Alternative perspectives on land degradation	Perspectives on responses to land degradation	Alternative perspectives on responses to land degradation
Wind erosion	Wind erosion removes topsoil; dust storms	Natural process; brings new seed/soil	Maintain groundcover through total grazing pressure; tree planting	Tree planting is useless because they can't be watered; trees will grow naturally when the weather conditions are right
Drought	Natural hazard; financial pressure	Natural process; sporadic time period – the drought will always break	Sell early; transport stock to different region	Adjust stock to more adapted species that persist longer
Floods	Can cause soil salinity and change vegetation	Natural process (part of the landscape)	Adjust stock to suit the vegetation	-
Regional water management	Over-allocation, pollution and algae, impacts to land quality	Water licences suitably strict; not enough water added to the river	Government action to return more water to the system; buybacks	Pipeline from the Murray River for town water supply; non-intervention

Pests	Kangaroos as pest (grazing pressure)	Kangaroos as ecologically adapted meat resource; native wild animals; tourism drawcard	Pest management; TGP; need for professional roo shooters	Develop kangaroo meat market
	Rabbits as pest (grazing pressure, biodiversity threat); plague potential	Rabbits as resource (meat and fur)	Pest management (myxomatosis, calicivirus, trapping)	Opportunistic harvesting
	Goats as problem and pest (grazing pressure, biodiversity threat); reducing soil stability	Goats as lucrative resource – better compared to sheep (not eating blue bush, less trampling of soil); control measure against other woody shrubs	Specified goat paddocks (to reduce goat pressure across property); aerial goat mustering	Specified goat paddocks become completely degraded

Weeds	Invasive native scrub as a major problem (unpalatable infestations rendering land useless, linked to goat proliferation)	Invasive native shrub can be palatable for other species; provision of ecosystem benefits, wind breaks, persistent groundcover, carbon sequestration	Spot treatments by landholders (according to government); better management of government land (according to landholders). Chemical control, goats as control.	Keep them because they are good for carbon sequestration (financial benefit in carbon farming initiatives) and other ecosystem benefits
	Introduced vegetation as weeds (useless, takes up land)	Some can reduce erosion (especially at creeks); can retain more water at creeks	Chemical control, adapt stocking decisions	Control methods are expensive; adjusting stocking decisions could permit more overgrazing

Livestock grazing	Overgrazing is a problem; the land takes a long time to recover	The land will bounce back; sporadic 'overgrazing' is fine	Adjust stocking rate; implement rotational grazing	Rotational grazing not relevant (rainfall too unreliable, intense stocking rate unfeasible and too damaging, does not factor in uncontrolled grazers, too costly and time-consuming); other grazing regimes (continuous, strategic transportation) can work
	Merino sheep are a financial threat - specific diet, less adapted to climate	Merino sheep provide multiple forms of revenue; destocking merino during drought gives land a rest	Dorpers and damara sheep have less costs involved (no shearing, mulesing, crutching), more resilient, more appropriate diet	Dorpers and damara sheep are more adapted to climate (and therefore have bigger potential environmental impact)

Degraded land	Useless and undesirable; result of historical mismanagement	Can be tolerated because the land will bounce back; it's not permanent	Tree planting, contour furrowing, waterponding	Let it regenerate itself; tree planting likely to be unsuccessful; contour furrowing and waterponding are context-specific and expensive
Climate change	More extreme conditions and variability	Climate is always changing (planetary scale); anthropogenic changes not currently experienced (local scale)	Manage existing stressors (such as groundcover, pests and weeds, develop heat tolerance in stock)	No additional response needed

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927 **Table 2** Recommendations of the UNCCD Scientific Conference (from Reed & Stringer,
928 2015, p. 71), compared to far west NSW case study data.

Sustainable land management recommendations for rangelands, considering land degradation and climate change	**Applicability to far west NSW, according to the interview responses**	**Possible implications for general sustainable land management recommendations**
Altering stocking rates to match changes in forage production in response to climate change and/or land degradation;	Already common best practice through total grazing pressure management.	Continue as best practice.
Adjusting the management of herds and water points in response to changing seasonal and spatial patterns of forage production under climate change and inter-annual trends in forage production due to land degradation;	Already common best practice (not necessarily because of anthropogenic climate change).	Continue as best practice.

Managing diet quality (using dietary supplements, legumes, choice of introduced pasture species and pasture fertility management) to maintain herds under climate change and/or land degradation;	Contested. The strength of native pasture is relied upon, without supplements (at pastoral station and regional scales). Rather than maintaining herds on degraded land, it is common practice to sell or transport stock during tougher climatic conditions.	Reconsider whether the maintenance of herds should be prioritised over temporary reductions or changing stocking regimes/species, including the consideration of their dietary requirements and what pasture is available. Recognise that climate variations and land degradation are not linear, and management decisions may need to fluctuate accordingly.
More effective use of rotational grazing systems;	Not perceived to be best practice, due to climatic, ecological, logistical and financial constraints.	Reconsider universal recommendation of the context-specific technique over other grazing regimes.
Managing the encroachment of woody shrubs spreading on productive rangeland;	Common practice, but to some extent contested (depending on whether native woody shrubs are a weed).	Evaluate where certain woody shrub species provide benefits (such as habitat and windbreaks) and where they are more destructive (invasive, unpalatable species), and provide appropriate incentives according to the context.

Using livestock breeds or species that are better suited to new conditions as a result of climate change and/or land degradation;	Common practice, but to some extent contested (fear that better suitability of goats and dorpers may result in more overgrazing). Although kangaroos are suited to the conditions, limited market opportunities prevent farmers from economically relying upon them.	Consider the potential external and cumulative impacts of species' suitability. Facilitate appropriate policy and market contexts for appropriate stocking decisions.
Increased provision of shade from trees to reduce heat stress in livestock through the adoption of silvopastoral systems that can also reduce erosion rates and provide fodder for livestock during drought;	Trees are not integrated into the production system nor seen as feasible to actively increase their provision. However, groundcover is valued and passive regrowth may be acceptable.	Reconsider context and method of increased tree provision, and broaden recommendation to emphasise the benefits of other types of vegetation as groundcover.

Enabling migratory pastoralist activities (though this has to be carefully managed to avoid exacerbating land use conflicts);	Feasible through agistment or management of multiple properties; otherwise current land tenure disables this practice. Short-term leases seen as environmentally undesirable and unsustainable.	Specify context and method of migratory activities, according to land tenure arrangements.
Monitoring and managing the spread of livestock and rangeland pests, weeds and diseases;	Pests and weeds management already common best practice, although the status of some 'pest' species contested as instead a 'resource'. Their spread is best managed through collaborative, targeted approaches. Diseases are not discussed in this research.	Reconsider what determines pests and weeds, not just according to farming productivity. Recommend collaborative management across properties to maximise the effect of control methods.

Improved soil and water management.	Other than retaining groundcover, limited additional options perceived for pastoralists to adopt improved soil and water management. Water management perceived to need policy and governance improvement, at an inter-regional and inter-state level.	Reconsider the limited focus on sustainable land management for local land managers; include recommendations for the wider policy and governance context.

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