

Australian rangeland futures: time now for systemic responses to interconnected challenges

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Abstract. Australia's rangelands contain wildlands, relatively intact biodiversity, widespread Indigenous cultures, pastoral and mining industries all set in past and present events and mythologies. The nature of risks and threats to these rangelands is increasingly global and systemic. Future policy frameworks must acknowledge this and act accordingly. We collate current key information on land tenures and land uses, people and domestic livestock in Australian rangelands, and discuss five perspectives on how the rangelands are changing that should inform the development of integrated policy: climate and environmental change, the southern rangelands, the northern rangelands, Indigenous Australia, and governance and management. From these perspectives we argue that more attention must be paid to: ensuring a social licence to operate across a range of uses, acknowledging and supporting a younger, more Indigenous population, implementing positive aspects of technological innovation, halting capital and governance leakages, and building human capacity. A recommended set of systemic responses should therefore (i) address governance issues consistently and comprehensively, (ii) ensure that new technologies can foster the delivery of sustainable livelihoods, and (iii) focus capacity building on a community of industries where knowledge is built for the long-term, and do all three of these with an eye to the changing demographics of the rangelands.

Additional keywords: governance, human capacity, Indigenous, livelihoods, remoteness, sustainability.

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Introduction

Today's globalised and highly-connected world sees regional management systems buffeted by unpredictable external influences that equal or exceed the effects of local management. This is increasingly true for Australia's rangelands, about 80% of Australia's landmass that lies out the back of its more closely settled agricultural and urban dominated population and politics. Although the definition of rangelands used to focus on grazing, today rangelands are considered as 'all those environments where natural ecological processes predominate and where values and benefits are based primarily on natural resource areas which have not been intensively developed for primary production' (ARS 2019).

At the global level, six out of eight risks of high importance in the 2018 World Economic Forum Global Risks Report (WEF 2018) are biophysical; they are relevant to the current situation in Australia's rangelands. The Global Risks Report charts the

implications of increasing global connectedness and the changing nature of high risk issues (Table 1). In the 2007 report, no high-risk biophysical issues were listed; most high risks then were economic (WEF 2007). There has been a significant shift in the understanding of biophysical risk over the past decade. The 2018 report's executive summary notes civilisation's growing vulnerability to systemic risks, concluding:

'Humanity has become remarkably adept at understanding how to mitigate countless conventional risks that can be relatively easily isolated and managed with standard risk management approaches. But we are much less competent when it comes to dealing with complex risks in systems characterised by feedback loops, tipping points and opaque cause-and-effect relationships that can make intervention problematic. [...] Just as a piece of elastic can lose its capacity to snap back to its original shape, repeated stress can lead systems—organisations, economies,

Table 1. Global risks ranked as high impact and high likelihood from the World Economic Forum's 'Global Risks Report' in 2018 and 2007 (ranked in decreasing importance within the high risk quadrant)

Italicised entries have direct relevance to Australian rangelands. Sources: WEF (2007, 2018)

2018	2007
<i>Extreme weather events</i>	Asset price collapses
<i>Natural disasters</i>	Interstate and civil wars
<i>Failure of climate change mitigation and adaptation</i>	Oil price shock
<i>Water crises</i>	China economic hard landing
Cyber attacks	Breakdown of critical information infrastructure
<i>Biodiversity loss and ecosystem collapse</i>	
Large scale involuntary migration	
<i>Man-made environmental disasters</i>	

societies, the environment – to lose their capacity to rebound. If we exhaust our capacities to absorb disruption and allow our systems to become brittle enough to break, it is difficult to overstate the damage that might result.'

Improving the functioning of environmental and social systems in the Australian rangelands may provide greater flexibility for adapting to changes, whereas decline of these systems reduces such flexibility. We recognise that risks to Australia's rangeland systems today are global and interconnected, but responses to these are affected by other issues that are regional and partially contained. In this context, the paper explores how policy makers and land managers can chart effective sets of actions that build over generations, rather than disintegrate when inevitable climate, economic and political shocks occur.

The paper provides background and some basic statistics on the Australian rangelands, then describes five key perspectives on change, to arrive at the need to embrace a systemic approach in the next phase of rangelands overview, policy and management, and the consequences of this approach for priority actions.

Background and context

Through its regular biennial conferences, the Australian Rangeland Society (ARS) has made periodic efforts to develop an Australian rangeland 'risk and response' assessment, initially at Port Augusta in 1996 (Blesing *et al.* 1996) and 10 years later at Renmark in 2006 (Foran 2007). At the time of the 1996 Conference, the participants and agenda of the ARS Conference reflected a dominant pastoral industry paradigm. Since then, conference participants and agendas have broadened to reflect a much wider diversity of perspectives on rangelands.

The first assessment in 1996 used a conference-wide foresighting approach where delegates immersed themselves within four possible future scenarios: economic growth, best practice, extra green and partial retreat. As well as constructing narrative storylines they identified technological, social and policy innovations that might help each scenario become reality in Australian society. Examples of these actions were conversion to freehold land ownership to foster the 'economic growth' scenario, an Australia-wide 'Rangelands Commission' for the

'extra green' scenario, and mining royalties flowing back to regions in the 'best practice' scenario. These scenarios were collapsed into 'looking out' and 'looking in' directions for rangelands (Blesing *et al.* 1996). The former asserted the free-market and globalised views that were well established nationally at the time. The latter recognised that the social and resource poverty of many rangeland regions could constrain them to less optimistic futures. Each rangeland region was assigned a direction to help institutions to craft distinct policy approaches to their future social and biophysical realities.

The 2006 Rangelands Conference in Renmark revisited the 1996 exercise through a keynote talk and journal paper (Foran 2007), supported by conference discussions, peer review and contemporaneous futures studies. The 1996 assessment that economic growth, globalisation and the 'looking out' direction would dominate explicit policy interventions had failed to materialise. In essence, the rangelands had been left to respond to forces that were largely market driven; there have been few policy attempts to enhance successful regions, and renewal activities in declining regions have been only partially successful.

Issues given less prominence in 1996 included the continued unacceptable state of Indigenous disadvantage, the emergence of global climate change as an international policy driver and the degree to which singular events (e.g. World Trade Centre attack, September 2001; emergent pandemics like SARS (severe acute respiratory syndrome), 2002–2003; the global financial crisis, 2007–2009) could tip global political culture and economics. The degree to which advances in communications and information technologies would radically disrupt how rangeland business is done was also not yet recognised.

Notwithstanding these issues, the decade 1996–2006 saw success stories in the rangelands, in some cases resulting from integration across institutional, cultural and disciplinary silos. Some of these successes remain operational today, such as fire monitoring (North Australia and Rangelands Fire Information 2018), drought monitoring (BOM 2018), pastoral land condition surveys (Pastoral Land Board 2016), increasing investment by resource companies into ecological research as part of their environmental obligations (e.g. Rio Tinto 2017), sustained international investment into the northern cattle industry (Australian Government 2018c), and monitoring of land cover and tree clearing (Queensland Government 2018). Others, such as the effective Australian Collaborative Rangelands Information System (ACRIS), Rangelands Australia, the Desert Knowledge Cooperative Research Centre and its successor focusing on Remote Economic Participation, have waxed and waned with funding cycles within a general tendency for government agricultural and natural resource departments to decrease the scope and funding of activities in rangelands.

Looking forward again, the 2006 assessment remained perplexed about several key issues.

- The first was the locally-resident rangeland community's inability to drive its own political and economic future, given that the rangelands are spatially and viscerally remote from state and national parliaments and urban populations, and not well represented in decision-making centres. Unexpected remote events can undermine well intentioned local

management, as demonstrated by the temporary cessation of the northern live cattle trade in 2011 due to Australian political concerns about animal welfare issues in Indonesia.

- The second was the growing appreciation of rangeland landscapes as integrated social-ecological systems at the same time as policy organisations suffered decreasing capacity and continuity – this meant that they increasingly focussed on the micro-scale and a single species or single land use. Under such pressures, the broad sweep of complex rangelands issues are simply too large for activists and policy makers alike to engage with.
- The third issue was the need for a new framework of understanding, one that embraced our increasingly complex knowledge, but led to narratives that cross boundaries and timescales to help policy makers understand complexity sufficiently while offering tested recipes for action.

Research and development corporations such as Meat and Livestock Australia and Australian Wool Innovation now lead and fund much of the grazing-related rangelands research and development, and the red meat industry is implementing a sustainability framework covering animal welfare, profitability, environment and social issues (Australian Beef Sustainability Framework 2017). Meanwhile, coalitions have formed outside government, such as the Rangeland NRM Alliance (2018), which integrates the management activities of 15 Regional Natural Resource Management (NRM) Organisations across rangelands Australia, and the Outback Alliance, which includes not only land management interests but cross-sector actors such as the Royal Flying Doctor Service, Pew Charitable Trusts, the Indigenous Desert Alliance and the Isolated Children's Parents Association among a growing set of members. Thus, some past efforts have endured, ensuring that future policy and management innovation need not start from scratch.

Looking again at rangeland futures in 2018 in this third decadal review, we are reminded that, 'In an age of diminishing nature, there are few large places left in the world that are still as environmentally intact as the Outback, that offer such a sense of space and allow us to reflect on our fit to the natural world' (Pew Charitable Trusts 2014).

Key rangeland information

Compiling information on demography, land use and the socio-economy of the rangelands is problematic. Rangelands still tend to be defined by what they are not (e.g. not high production landscapes) rather than what they are. Most classification systems are focussed in populated areas, so there is little consistency between boundaries adopted for different purposes. As a consequence, for example, the total area of rangelands is estimated at 81% based on an environmental mapping (Australian Government 2005), but 75% when based on industry (Australian Government 2017a). Because different types of data are collected on different boundaries and with different criteria (most notably, environmental as opposed to social), some rather heroic assumptions have to be made to present defensible information on the rangelands. These data challenges were extensively canvassed by the Australian Collaborative Rangeland Information System (ACRIS) (Bastin and the ACRIS

Management Committee 2008; see pages 11–71), which aimed to report both biophysical and social change data and used three regionalisations as appropriate – the Interim Biogeographic Regionalisation for Australia (IBRA), natural resource management (NRM) regions, and statistical local areas (SLAs) (p. 19 of Ch 2). The use of SLAs allows statistics to be related to the remote and very remote categories used by the Australian Bureau of Statistics (e.g. ABS 2016a). For reporting, ACRIS defined a rangelands boundary based on the IBRAs (at sub-IBRA level) but with as much alignment with SLAs and NRM regions as possible; this puts 81% of Australia in rangelands, or about 80% where precision is not needed. We have adopted this definition for general discussion, and where we provide more detailed statistics we note the data sources (refer to Appendix 1 for details and assumptions); Fig. 1 illustrates the difference between the ACRIS rangeland boundary and one based on remote and very remote areas. These difficulties highlight the need for agencies responsible for data collection and presentation to create a universally agreed and applied set of criteria for reporting on rangelands.

Our population estimates were determined using the people resident in remote and very remote zones (ABS 2016a), which are contrasted with other non-urban areas which are often termed 'regional' in Australia. On this basis, although rangelands cover about 80% of Australia's land mass, they are home to just under two per cent of the population (see Table 2). The 'remote' category includes the major centres located within the rangeland boundary – Mt Isa, Charters Towers, Alice Springs, Broken Hill, Port Augusta, Kalgoorlie, Kambalda, Broome, Port Hedland and Karratha (but excludes adjoining cities such as Darwin and Townsville that might be included in a biophysical boundary – see Fig. 1). In addition to the 394 000 people resident in the rangelands at census in 2016, we define a broader 'rangeland community' to include people living in regional and urban areas who are involved in making decisions about the rangelands, delivering services there, who used to live there, or otherwise possess an empathy for them.

Notwithstanding the challenges in measuring precisely the economics of the rangelands (Appendix 1), it is clear that the natural resources are rich and generate significant wealth through diverse industries – recent figures for the larger ones in terms of annual value are mining and gas (AU\$172bn total sales and services and \$96bn value added), cattle and beef (\$5bn total sales), tourism and other visitor expenditure (\$3bn value added) and sheep and wool (\$0.5bn total sales). The annual value of smaller industries (e.g. kangaroo harvesting, bush foods, rangeland timbers, feral animal harvesting, inland fisheries) is likely to be about \$0.5bn per year, with the income from carbon farming becoming equivalent to that earned from grazing sheep in some regions (Appendix 1; when dates are not given, statistics are from around 2016 but precise sources are provided in the Appendices).

Although there is variation in the data from different sources, pastoralism – grazing animals on native vegetation on long-term 'pastoral leases' – remains the dominant land use (hatched areas within the rangelands boundary in Fig. 1). This use still occupies over one-half (55%) of the rangelands area with ~6000 private holdings (Table 3; Appendix 2). Indigenous land tenures of various types cover around 59% of the rangelands, and overlap

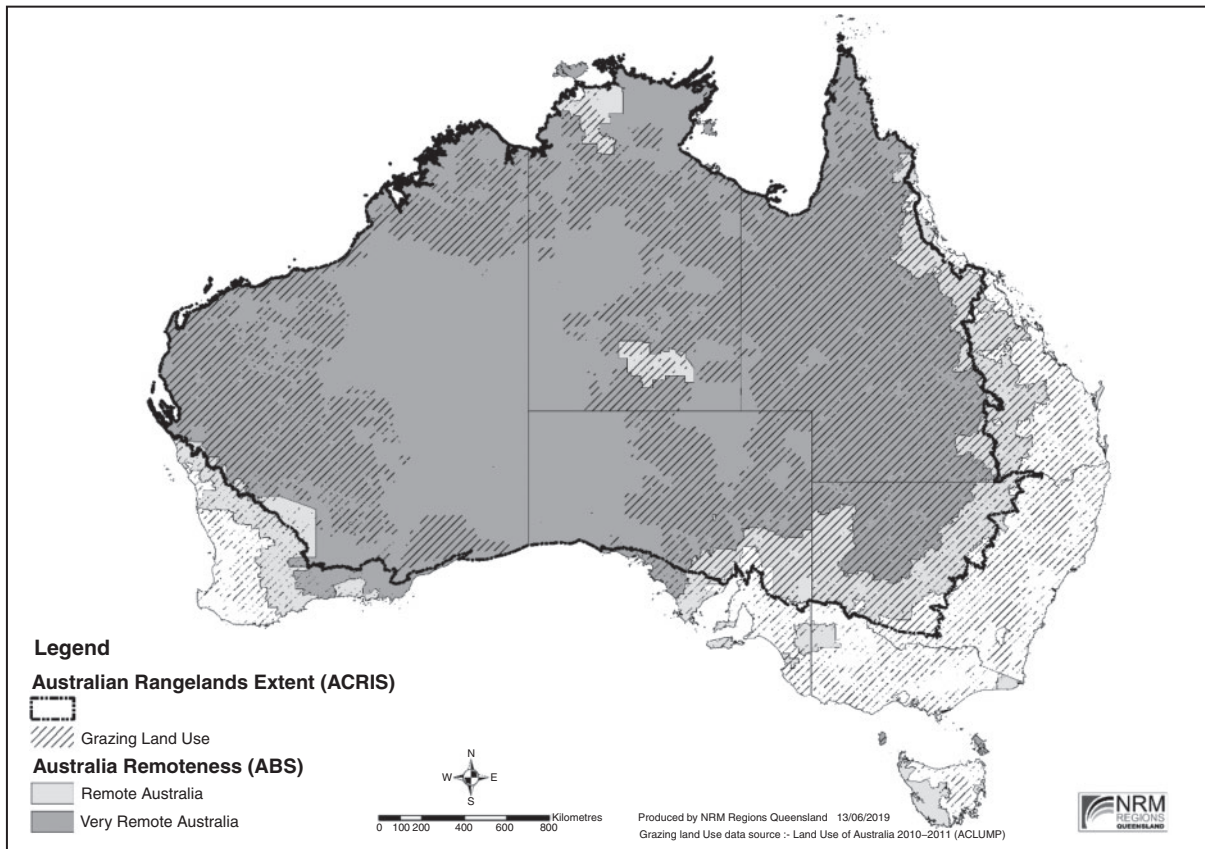


Fig. 1. Two perspectives on the extent of rangelands, drawing (see main text) on the biophysical boundary used by Bastin and the ACRIS Management Committee (2008) (black heavy line) and the social definition of remote and very remote areas by ABS (2016a) (shaded areas); the overlaid cross-hatching shows land uses associated with grazing (usually extensive pastoralism within the ACRIS boundary) (source: ABARES 2017).

Table 2. Resident population in the Australian rangelands
 Source: ABS (2016a)

Australian States →		NSW	NT	Rangeland population ^A			Total	Australia
				SA	Qld	WA		
2001	Total population	66 391	94 156	61 929	155 004	80 963	438 167	18 769 249
	Indigenous population	8347	41 203	6601	26 397	19 557	99 642	660 709
	% Indigenous	12.6%	43.8%	10.7%	17.0%	24.2%	22.7%	3.5%
2016	Total population	52 670	89 444	62 797	124 050	81 341	393 762	23 401 892
	Indigenous population	9052	45 585	4093	31 800	22 227	109 499	649 171
	% Indigenous	17.2%	51.0%	6.5%	25.6%	27.3%	27.8%	2.8%

^AEstimate based on remote and very remote categories as defined by ABS (2016a).

with pastoral, conservation and mining tenures in many regions; however, a significant portion of these Indigenous tenures (15% of total land area) is now held under exclusive native title. Conservation land is around 11% with mining and defence occupying much smaller areas.

In the first decades of this century, human population in the rangelands as defined here declined 11% from around 438 000 to 394 000 (while the total Australian population increased 25%) (Table 2). In the same period, the Indigenous population in the rangelands increased by 9% to 109 000 and now makes up 28% of

the rangelands total, compared with 2.8% for Australia as a whole. The trend to increasing Indigenous population is reversed only in South Australia: this is due to the general movement of Indigenous people into larger population centres, which are mostly outside the rangelands in that state. The rangelands unemployment rate in 2016 had increased by a third (36%) compared with 2001, and was 34% higher than for the rest of Australia (Appendix 3).

Rangeland livestock numbers aggregated for natural resource management regions (MLA 2017a, 2017b; Appendix 2) reveal

Table 3. Land tenure and uses in the Australian rangelands

Sources: State of the Environment Committee (2011); National Native Title Tribunal (2018); Aboriginal Lands Trust of Western Australia (2018); Aboriginal Lands Trust of South Australia (2018); ILC (2017); Australian Government (2017a, 2018a). Note: some values in this national summary table differ slightly from those that would be obtained by adding up values in Appendix 2 due to different sources and available categorisations, as noted in the text

Tenures and uses	Area (×1000 km ²)	% of rangeland
Grazing tenures (pastoral leases of various types)	3450	55.4%
Number of landholdings used for grazing in the rangelands	6000 holdings	–
Department of Defence estate	30 ^A	0.5%
Conservation estate (National parks and Reserves)	657	10.5%
Land held by Indigenous people under national and state land rights legislation	1179 ^A	18.9%
Determined Native Title (exclusive possession)	917	14.7%
Total area of rangelands	6232 ^B	100%
Indigenous protected areas (44% of National Reserve System)	600 ^A	9.6%
Determined Native Title (non-exclusive possession ^C)	1583 ^A	25.4%

^AEstimates from relevant sources.

^BApproximate total of areas above, given a diversity of sources and estimation methods, and some ambiguity in definitions and timing; note that areas below this row are not exclusive.

^C~80% of this overlap with pastoral leasehold land in WA and SA.

Table 4. Domestic livestock in the Australian rangelands

Sources: MLA (2014a, 2017a, 2017b, 2017c). DSE, dry sheep equivalent

Livestock	Year	Northern rangelands	Southern rangelands	Total number	Total DSEs
Cattle	2000 ^A	7.19 m	0.81 m	8.00 m	64.00 m
	2012 ^A	7.80 m	1.32 m	9.12 m	72.96 m
	2016 ^B	6.39 m	2.2 m	8.61 m	68.92 m
Sheep	2000 ^A	3.20 m	11.70 m	14.90 m	14.90 m
	2012 ^A	2.30 m	4.70 m	7.00 m	7.00 m
	2016 ^B	0.01 m	4.50 m	4.51 m	4.51 m

^AReported in MLA (2014a), derived from ABARES survey data.

^BEstimated from data in MLA (2017a, 2017b), apportioning WA rangelands total data pro-rata based on data from MLA (2014a): Southern WA has ~16% of WA rangeland cattle.

that, in 2016, the rangelands were supporting slightly less than nine million cattle and five million sheep (Table 4). Since the year 2000 cattle numbers have declined slightly in the northern rangelands and tripled in the southern rangelands. Sheep numbers have declined by two-thirds in the southern rangelands and sheep were virtually absent from the northern rangelands by 2016. Total domestic stocking numbers in 'dry sheep equivalent' terms has declined slightly by 7% over the same period but seasons, market conditions and political decisions could change these trends, year on year.

Five perspectives

In considering how change is affecting the rangelands, at the 2017 ARS conference in Port Augusta and in discussions since, we have heard the perspectives of different participants articulated through several lenses. We now discuss five perspectives that seemed to dominate: climate and environmental change (adaptation and biodiversity crises), the southern rangelands (declining resilience under climate change and changing markets), the northern rangelands (long promise of northern development), Indigenous Australia (major landholders and dominant demography in the more remote areas), and governance and management (capacity to handle the slow drivers of change). These perspectives encompass more conventional rangeland issues such as stocking rates or interactions among land uses, and provide a backdrop to discuss how the rangeland community can come to comprehend and manage systemic risk.

Climate and environmental change

Perspectives on the state of the rangelands wax and wane. The history – before the 1980s – of environmental interventions by government is that most were driven by externalities and not primarily by the needs of the land itself. Examples include revegetation of the Ord River Catchment to reduce sediment movement into Lake Argyle (1960s–1990s), the implementation of the Brucellosis and Tuberculosis Eradication Campaign (BTEC 1970–1997), which resulted in significant improvements in grazing management across northern Australia, and dust suppression activities around major centres – Alice Springs, Broken Hill and Kalgoorlie (latter part of the 20th century).

During the 1980s–1990s there was great concern about declining ecological condition, leading to the development of the draft national strategy for rangelands management (National Rangelands Management Working Group 1996). The information on trends brought together by the Australian Collaborative Rangelands Information System (ACRIS – Bastin *et al.* 2009) suggested that there were signs of stable or improving landscape function on ground-based monitoring sites in many – but not all – areas across the period 1992–2005. This suggested that issues of productivity for grazing were being addressed relatively well, with warnings about high stock numbers in some regions where seasonal conditions were declining (Figs 2, 3; these figures can be difficult to interpret, but this summary is explained and justified in the source). In contrast, evidence in ACRIS suggested that biodiversity was continuing to decline, most notably in the less studied northern Australia. In addition, while established industries like grazing and mining have been developing consistently better practices, it was not clear that these were being echoed in small-scale emerging industries such as harvesting of sandalwood or bush tomatoes (Stafford Smith and McAllister 2008). Further, within this overall encouraging picture, there remain regions where trends in the important ecological indicators are still downward or not well understood (DAFWA 2017; Office of the Auditor General 2017).

In the 2000s, work on the impacts of climate change started to expand, and the question arose as to whether these would undermine any improving management, both through the direct effects on productivity (Harle *et al.* 2007; Eady *et al.* 2009; McKeon *et al.* 2009) and in terms of its effects on rangelands

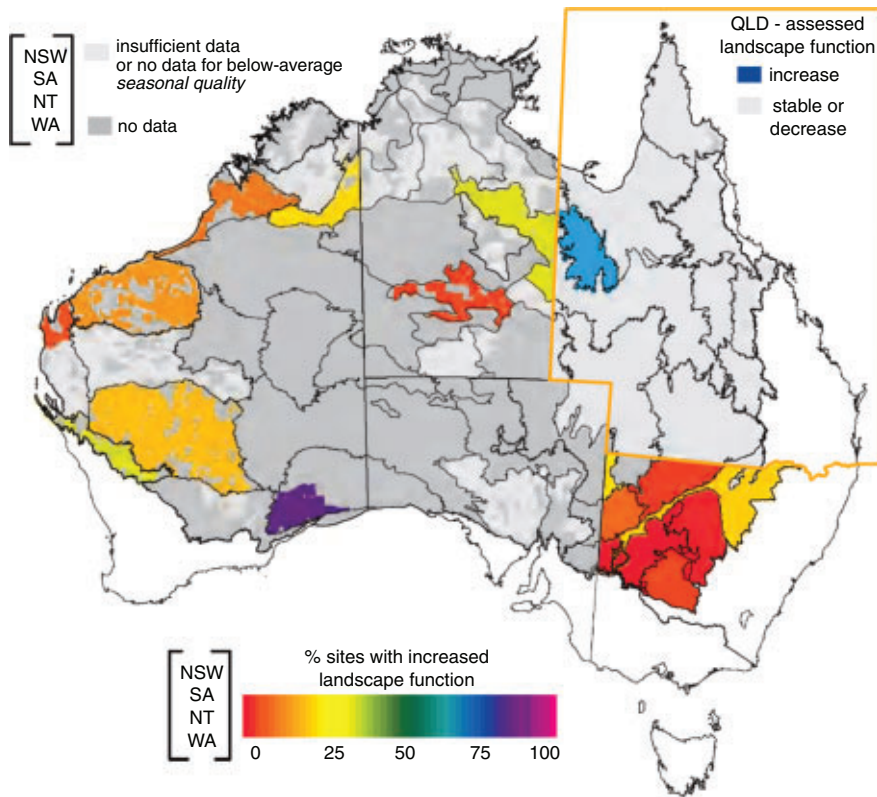


Fig. 2. Increase in landscape function following below-average seasonal quality (1992–2005). Red and yellow colours show regions (i.e. most of those with any data) where a high proportion of sites improved in rangeland function despite experiencing dry conditions, except in Queensland where a different methodology showed most sites as not improving (grey); grey polygons in states other than Queensland include regions with no grazing (see unhatched areas in Fig. 1) that were not monitored, as well as areas that did not experience below-average seasonal quality in the monitoring period. Source: fig. 3.8 in Bastin and the ACRIS Management Committee (2008).

liveability more generally (e.g. Race *et al.* 2016a, 2016b). These issues are neatly summarised by Howden (2017) in his John Milne Memorial Rangeland Journal Lecture at the 2017 ARS Biennial Conference. He noted that projections of increases in atmospheric CO₂ concentration and of temperatures are robust and universal. Changes in mean rainfall remain uncertain but slightly more likely to increase than decrease in the wet season in the northern rangelands. The southern rangeland analyses gave an uncertain direction of change in summer, but a more likely decrease in winter rain. Although increases in CO₂ are likely to provide significant positive responses in plant growth and water use efficiency, modelling in northern Australia suggests these may be roughly balanced out by reduced productivity due to increased temperature (McKeon *et al.* 2009). In addition, there will be important increases in rainfall variability (Hennessy *et al.* 2008; Cai *et al.* 2014) and consequently in droughts, especially in the southern rangelands, which are likely to result in a net decrease in livestock carrying capacity. This resonates with the two major droughts experienced in eastern Australia this century already. Howden (2017) also highlights increases in days with extreme fire weather and heat stress to both livestock and humans. McKeon *et al.* (2009) suggest public policy should have regard for the implications for: livestock enterprises, regional

and remote communities, potential resource damage, animal welfare and human distress. It is clear that a 'set and forget' approach to better management based on past conditions will not work in the face of these on-going changes.

Growing concern about environmental changes also creates opportunities. Climate policy has created new livelihoods in managing carbon. The potential for emissions reduction and sequestration from the Australian rangelands is assessed at 100 million tonnes of carbon dioxide for 40 years (Eady *et al.* 2009; Gavin 2017). Currently, over 450 projects and 34 million tonnes of annual abatement are rangelands-based (Emissions Reduction Fund 2018), providing an income source that at times may rival or even exceed traditional grazing enterprises. Although the renewable energy resources are considerable (Pittock 2011), current investments are at moderate scales in national and international terms. A wider view on the value of environmental management has also legitimised and resourced initiatives to create new livelihoods, such as the widely acclaimed Indigenous Rangers Program (Mackie and Meacham 2016) (see below), payment for environmental stewardship and private land conservation funded by philanthropy. The combination of pressures from climate change, the impacts of wider environmental change and the effects of globalisation on

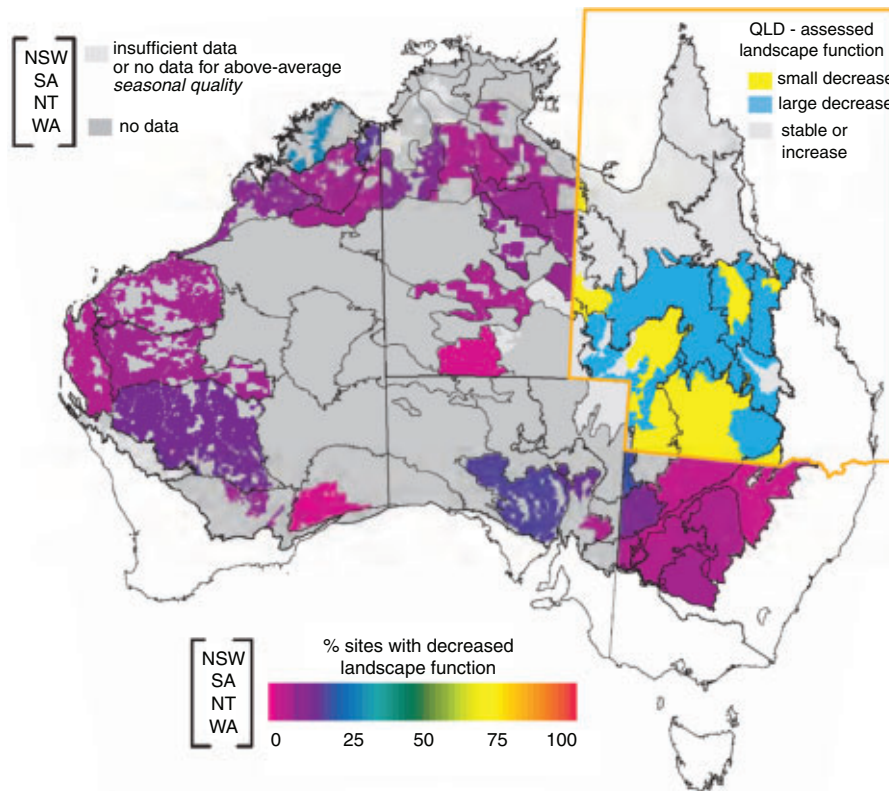


Fig. 3. Decrease in landscape function following above-average seasonal quality (1992–2005). Redder colours show regions (i.e. very few of those with data) where a high proportion of sites declined in rangeland function despite experiencing wet conditions, except in Queensland where a different methodology showed more declines (yellow and blue); for grey polygons outside Queensland, see Fig. 2 caption. Source: fig. 3.8 in Bastin and the ACRIS Management Committee (2008).

enterprise returns mean that increasingly land managers in the rangelands must decide whether they are attached to place, in which case they may need to diversify into new livelihoods (within or outside the rangelands), or to their current livelihood which, particularly in the case of pastoralism, means practitioners may have to consider whether they need to relocate or redesign to maintain these activities. Policies need to enable the range of decisions involved in these changes.

Southern rangelands

The southern rangelands as discussed here describe an approximate geography bounded to the north by the Northern Territory-South Australia border as extended west through Western Australia, and east through Queensland. This area supports a range of acacia and eucalypt woodlands and shrublands, and chenopod plains, with salt lakes and hummock grasslands on sands in the Great Victoria, Simpson and other desert areas, and covers ~2.68 million km² (from summing NRM regions in Appendix 2). Pastoral leases are held over ~1.40 million km² (52%) of the southern rangelands, with 0.38 million km² (14%) as conservation lands and 0.6 million km² (22%) under Indigenous title or ‘other protected areas’ (Appendix 2). Active mining use occupies 6000 km² (0.2% of the total area). Most of the Indigenous land – reserves and areas held

under exclusive native title – is located in desert WA, east of the pastoral areas.

Most of the productive lands of the southern rangelands have been grazed for more than 100 years, and grazing remains the dominant industry by area. A substantial proportion of the land and vegetation resources of the grazed rangelands have been altered as a result of grazing by domestic livestock and related impacts associated with fire frequencies, weed infestations, and feral animal grazing. These issues occur to a greater or lesser extent across all southern rangeland regions, although the trends in environmental variables vary over time (Figs 2, 3) (Bastin and the ACRIS Management Committee 2008; State of the Environment Committee 2011; DAFWA 2017).

Goats have become a supplementary resource with a mixture of wild harvesting and domestic management. In 2016 the pastoral areas in the southern rangelands supported an estimated 0.5 million managed goats and 3.6 million feral goats. There are also some 34.0 million kangaroos, principally red, eastern grey and western grey kangaroos (Australian Government 2011). Numbers of kangaroos and other macropods have expanded with pastoralism due to establishment of permanent waters and control of dingoes (Australia’s native dogs), especially in areas inside the 5600 km long dingo fence (which seeks to exclude dingos from the main sheep grazing areas of NSW, Qld, SA). Collectively, the southern rangelands now support ~29 million

dry sheep equivalents (DSEs), of which managed herbivores comprise just under half (13.4 million DSEs, MLA 2018a).

Southern rangelands are of declining importance in the overall pastoral economy, relative to the more productive northern savannas. Many family-sized businesses in the southern rangelands continue to struggle, given low productivity rangelands, limited business size, and shortage of capital (MLA 2014a). In 2012, less than 45% of pastoral businesses in the southern WA rangelands were solely reliant on income from grazing enterprises (URS Australia Pty Ltd 2013).

The economic difficulties of the wool industry in the 1990s and early 2000s, including the increasing difficulty in controlling dingoes have resulted in a gradual shift to cattle, and have also led to three major interventions aimed at building economic strength in grazing businesses, addressing environmental issues, and diversifying the regional economies. These interventions were: the Gascoyne-Murchison Strategy in WA, the South West Strategy in Queensland, and the WEST 2000 and WEST 2000 Plus programs in western NSW (URS Australia Pty Ltd 2001, 2004). They collectively cost the national government about \$90 million and generated mixed results. Among the benefits, artesian bores were capped resulting in substantial water savings (URS Australia Pty Ltd 2001, 2004), significant land was added to the conservation estate in WA (Brandis 2008) and financial incentives encouraged landholders to improve land, stock and business management in western NSW (Hacker *et al.* 2010; URS Australia Pty Ltd 2015). Long-term observers in NSW noted that the Western Division performed much better through the 'millennium drought' (1997–2010) than in previous droughts, at least partly thanks to WEST 2000 and WEST 2000 Plus. Unmet objectives included restructuring non-viable properties (a repeat of previously failed efforts in SW Qld and Western NSW), and addressing invasive native scrub problems in the NSW and Qld regions (MLA 2014a; URS Australia Pty Ltd 2015).

Survival of a grazing industry in the southern rangelands that is economically rewarding and environmentally responsible will require rapid uptake of technologies, many of which already exist. These can improve landscape and business productivity while addressing the challenge of climate change (Howden 2017), unmanaged herbivory and the need to fill gaps in the conservation estate (for the WA situation see Brandis 2008). With a predicted further reduction in state agency interest, the main supporting bodies will be Regional NRM Organisations (which are largely dependent on cyclical, short-term, national government funding), and the rural research and development funders, Australian Wool Innovation and Meat and Livestock Australia (which are supported by producer levies matched by national government investment).

There are brighter prospects for alternate land uses – such as stewardship of ecological resources (Waters and Hacker 2008), private philanthropic conservation (the Australian Wildlife Conservancy is now Australia's largest private owner of land for conservation with more than 4.65 m ha under management: AWC 2018), renewable energy (wind and solar) generation, increased eco-tourism, off-farm income from servicing the mining industry and carbon farming (Outback Ecology 2012; Waters *et al.* 2016, 2018).

Northern rangelands

The northern rangelands comprise the Kimberley and Pilbara regions in WA, the whole of the Northern Territory and most of Queensland inland from the higher rainfall areas, and north of the south-western woodlands. This large area of ~3.83 million km² (see Appendix 2) supports eucalypt woodlands in the northern wetter areas, savanna woodlands, extensive tussock grasslands through the Northern Territory and into central west Queensland, and hummock grasslands on sandy plains and dunefields. Pastoral land is dominant, covering 1.97 million km² (51%) of the northern rangelands; exclusively held Indigenous lands and 'other protected areas' comprise 0.99 million km² (26%), with conservation lands of 0.29 million km² (8%) and active mining 2400 km² (Appendix 2). Over 80% of the grazing land area is controlled by Australian entities, with the NT currently having the highest proportion in foreign control at 30% (ABS 2017).

Cattle numbers vary from eight to nine million with most in Queensland (65%) followed by the Northern Territory (25%) and Western Australia (10%) (MLA 2014a; MLA 2017b). More than half of the annual cattle turnoff is currently processed in Australia. Short-term projections see a small increase in numbers and live exports stabilising around 800 000 annually (MLA 2018b). For family owned enterprises, performance is fragmented – the top quarter of properties have half the animals and area grazed, while the rest suffer limitations of size, resource quality, biological performance, indebtedness or skills that constrain transformation options (MLA 2014b; Holmes 2015). Corporate owned enterprises are generally larger and meet stringent biological and financial goals, and possibly improve the northern cattle herd's overall performance. Three of the red meat industry's thirteen strategic priorities (MLA 2016) are pertinent to northern rangelands: live export productivity, protecting and promoting our industry, and stewardship of environmental resources. A rangelands-focussed investment plan concluded with, 'The 20 year outcome is . . . 100 per cent increase in grazing business profitability, rates of productivity growth in the extensive grazing industries of more than two per cent per year, with 90 per cent of grazed land having ground cover above regional erosion thresholds at the most vulnerable time' (MLA 2014a).

In the absence of long-term and consistent rangeland surveys, the ecological health of the northern rangelands might be described as 'serious but stable'. Drought years cause regressions and then above average rainfalls give biological space for landscape renewal. For example, systematic surveys in the Northern Territory show that around 80% of monitoring sites are in good or fair condition but this benign view does not apply across the whole northern region (Pastoral Land Board 2016, 2017). In parallel, altered fire regimes due to gamba (*Andropogon gayanus* Kunth) and buffel (*Cenchrus ciliaris* L.) grasses aid landscape stability but decrease plant biodiversity. Around one-third of endangered vertebrate species occur in the rangelands with few solutions for their recovery currently obvious. The 'sweet spot' between biodiversity retention and viable pastoralism is not evident, particularly given interactions with other threatening processes such as invasive species, changes in fire regimes and climate change, and additional reservation of land to achieve conservation objectives is required. Encroaching native and introduced woody species, partly driven by rising CO₂ levels

(Archer *et al.* 2017), are not controlled by burning, partly due to the complexity of trading off management objectives (Cowley *et al.* 2014). Uncertainty around policy stances as regards rangelands (e.g. repeatedly running hot and cold on northern development) is restricting strategic investment and leading to industry fragmentation. The hollowing out of rangeland communities, the absence of Indigenous employment and the withdrawal of government services surround these land-based issues; as a consequence, the latter will be difficult to solve through better local management alone.

The regional futures proposed by Holmes (1996) can be simplified to 'two speed northern rangelands'. Over the next two decades, better managers, often on the more productive landscapes, will continue to optimise biological and financial efficiencies while increasing their ownership of these better grazing lands; many others may struggle from drought to drought, and revert to little more than cattle harvesting operations with increased risks to landscape integrity, animal welfare and biosecurity issues. Furthermore, the region could change rapidly through new irrigation schemes: the identification of 85 potential large dam sites and 1.4 million ha of potentially irrigable land could overwhelm today's constrained views of productive potential (Petheram *et al.* 2018) (although we think that development on this scale is unlikely). Development aside, the critical issue remaining will be the ability of the region as a whole to retain its social licence to operate (also without affecting that of the grazing industry nationally, as recognised by the industry's Australian Beef Sustainability Framework (2017)), and meet urban expectations for landscape condition, animal welfare and environmentally assured products.

Dale (2018) more optimistically calls for an evidence-based co-management approach involving national, state and territory governments, pastoralists, miners, Indigenous corporations and civil society. This could provide a northern-wide framework which strategically joins the 'planning and regulatory phase of policy and project development' with the 'stomach for developing, implementing and monitoring a longer term cooperative management framework and the deployment of fair and equitable adjustment programs'. Whether distant politics and variable local capacity make this sort of future likely will be re-visited in discussing rangelands as systems below, but the history of cyclical pushes to develop northern Australia raises questions about the persistence and impact of many such efforts.

Indigenous Australia

Indigenous people numbered between 770 000 and one million when Europeans first settled in 1788 (Williams 2013). Although they affected the landscapes, they would have travelled lightly across what we call rangelands today, with higher and possibly more sedentary concentrations in areas of rich soils and around permanent waters. By 1996, as a result of land rights legislation passed by the national, Queensland, South Australia and Western Australian Governments in the 1970s and 1980s, Indigenous people had control over, or shared rights to, large areas of the Northern Territory, South Australia and Western Australia and ~20 per cent of the Cape York Peninsula (Cape York Land Council Aboriginal Corporation 2014; National Native Title Tribunal 2018).

Through legislation for Native Title (in 1993 and 1998), the Wik Decision of the Australian High Court in 1996, and land acquisition by the Indigenous Land Corporation (ILC 2017), the estimated total area of rangelands for which Indigenous people have either sole or shared rights and responsibilities has expanded to ~3.74 million km², or 61 per cent of the total rangeland area (see Native Title land in Fig. 4 and Table 3). Within this area, an estimated 600 000 km² are being managed through the Australian Government's Indigenous Protected Areas' (IPA) Program. However, pastoral or agricultural interests still control and use the majority of productive rangeland in a livestock grazing and management sense.

At the 1996 ARS Biennial Conference, Indigenous rangeland issues were largely ignored, the focus being on European land management and science. Where Indigenous people had some responsibility for their lands, they were provided with little research support, although in Central Australia a 'Technical Advisory Group on Aboriginal Lands' was operating across several agencies (Foran and Walker 1985). Soon after, however, the national government's National Rangelands Strategy had clear Indigenous representation and the Central Land Council established a land management section. Today, fire and weed management and native species conservation are well developed in most Land Councils and Native Title Representative Bodies (Central Land Council 2017).

Indigenous peoples have progressively obtained different forms of tenure to their lands, along with management responsibilities. Several of the Native Title representative bodies (e.g. Land Councils, Prescribed Body Corporates, Native Title Services) have become significant strategic players in implementing environmental, socioeconomic and cultural policies and plans for the peoples they represent. Native Title has been the catalyst for many valuable agreements between resource companies and Prescribed Body Corporates that are supporting education and employment in mining operations in the rangelands and environmental stewardship (e.g. BHP 2017; Rio Tinto 2017).

The opportunities presented by Indigenous Land Use Agreements (ILUAs) and IPAs, with support from regional NRM organisations, non-government organisations (NGOs) and corporate partners have provided Indigenous communities and groups with a significant voice in collaborative land management, and even greater involvement and resources in economic, cultural and social development and community governance.

Traditional Indigenous land owners are keen to 'work on country' and Indigenous ranger groups are involved in mitigating threats from uncontrolled fire, weeds and feral animals and are blending their traditional ecological knowledge with western scientific knowledge in undertaking citizen science and making a sound contribution to the knowledge about rangeland ecosystems. Excellent examples include the management of desert lands in the East Pilbara by the Kanyirminpa Jukurrpa (2017); the West Arnhem Land Fire Abatement Project which is providing an income stream for traditional owners (Conoco Phillips Australia 2018); and promotion of Indigenous tourism experiences (Tourism Australia 2016).

Set against these positive aspects is the loss of control over the flow of social benefits. The consequent depopulation of

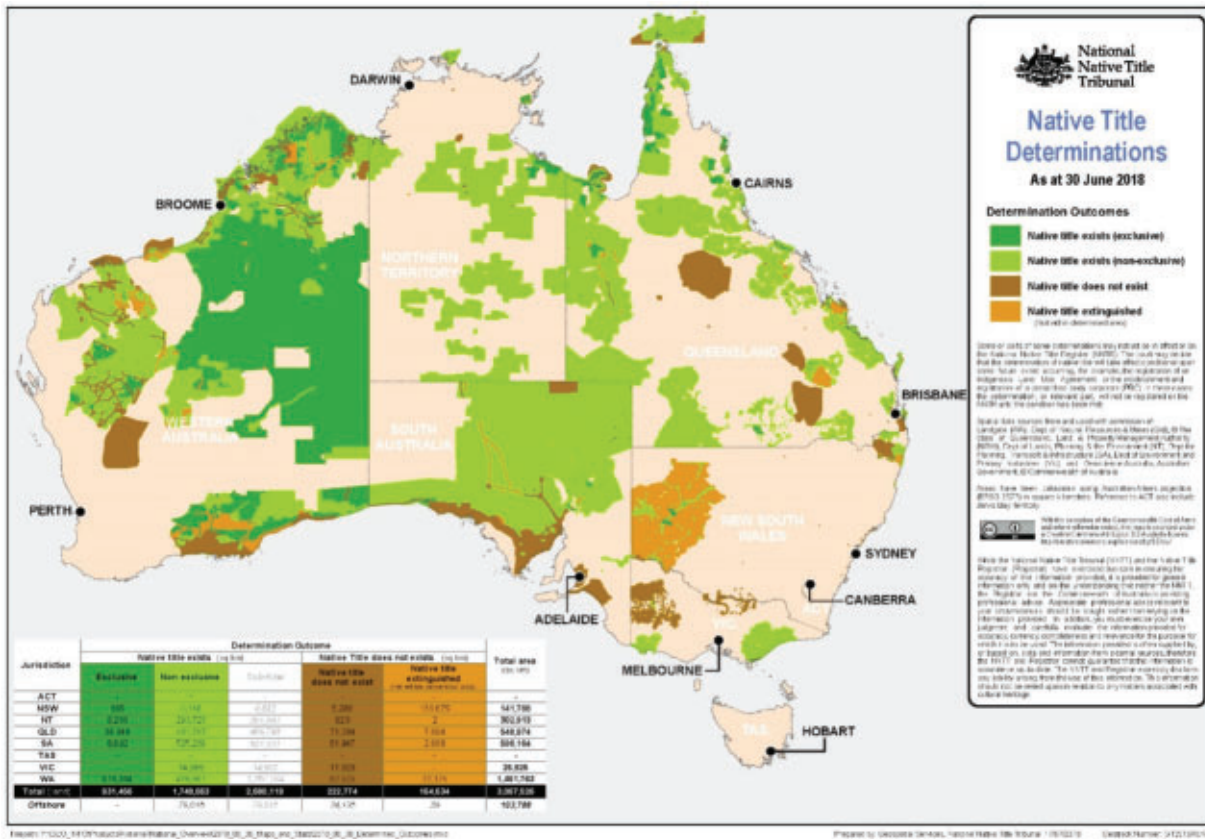


Fig. 4. Map of Native Title determinations at 2018 (National Native Title Tribunal 2018, map reproduced with the kind permission of the National Native Title Tribunal).

traditional lands leads to social issues in larger urban centres of immigration, where inadequate preparation has been made to provide livelihoods and meaningful lives for the expanding youth population (Doel-Mackaway 2017; Ipsos and Winangali 2017). Recent reports from the Ngaananjatjarra lands in central Australia suggest increases in real poverty and depopulation to the point where stores in remote communities are becoming unviable (Joyner 2018). Large scale drivers of change (from distant policy that is poorly attuned to remote areas) are systematically undermining the local success stories.

Nevertheless, Native Title has been a ‘game changer’ in the rangelands, even though challenges remain in settling claims and in addressing aspirations in areas where Native Title has been extinguished. Further, Indigenous people in the rangelands have yet to reach national standards in education, health and employment (Australian Government 2018b). However, significant benefits are flowing in improved management on Indigenous lands and growing capacity and confidence in managing Indigenous futures. As a consequence, for example, Indigenous people in two northern Queensland catchments were not averse to new irrigation developments that might create livelihoods on their depopulated traditional lands, as long as they could be partners in the planning and investment (Barber 2018). Future developments thus require recognition of what has been, and can be, achieved by the traditional owners in rangeland

management, skilful governance, and ongoing collaboration with other rangeland people.

Governance and management

Over the past two decades, a level of governance and management capacity has been established at local and regional levels that has not previously been seen in the rangelands of Australia (Balent and Stafford Smith 1993). Perversely, at the same time, globalisation and the centralising tendencies of efficiency-driven, centralised policy has reduced the ability for this local and regional governance to be fully realised (Walker *et al.* 2012).

In 1996 major rangeland stakeholders were pastoral lessees, Indigenous peoples, mineral, oil and gas producers, and local, state, Northern Territory and national governments. Governments had a strong role, often with limited consultation and constrained scopes. Although states retain a dominant role in natural resource management, the national government had been empowering local and regional levels through the Landcare movement in the 1980s. Through the 1990s it increasingly controlled funding criteria for Landcare and natural resource management activities and established the national network of regional NRM organisations; over time more responsibility was devolved, but often without matching levels of rights or resources (e.g. Curtis *et al.* 2014). State governments’ administered, rather loosely in

some cases, pastoral lands, guided by groups of pastoral lessees, and provided some research and extension services. Apart from dedicated Aboriginal Lands, Indigenous peoples' interests were generally ignored. Local governments had little involvement in rangeland management matters.

In 2018 national, State and Northern Territory governments, and the broad community, are expecting high standards of governance from a wide range of advisory boards and committees. Many local and regional government bodies have expanded outside their traditional briefs of 'roads, rates and rubbish' and have established strategic plans for their rangelands to sell their natural attractions to tourists, encourage investment into agricultural activities and attract potential new residents (e.g. Pilbara Development Commission website; <https://www.pdc.wa.gov.au/our-focus/strategicinitiatives>, accessed 27 June 2019). Regional NRM organisations and Native Title representative bodies were required to have in place the elements of a planning-centric approach (Brisbin 2018), namely: expert boards or committees, policies and plans, continuous monitoring, and be able to demonstrate fairness and effectiveness. There are now 15 well governed regional NRM organisations in the rangelands (of the 56 across all Australia), such as Desert Channels Queensland and Rangelands NRM in WA, that act as delivery agents under the regional stream of the National Landcare Program. These rangelands Regional NRM Organisations come together under the umbrella of the Rangelands NRM Alliance.

More locally, many pastoral businesses are now improving the standard of local management and business governance by using educated and multi-skilled work teams and implementing flexible and reduced stocking rates. Jackie Williams of Mt Barry Station provides a case study of coherent station management (Williams 2017). The development of some of these skills has been actively supported by industry funding bodies. Australian Wool Innovation Ltd (AWI) commenced the Bestprac program in 1997 to support pastoral wool, sheep meat and cattle producers improve their business and production performance. In South Australia at least, many of these properties continue to improve business practices using private consultants to help set up management advisory boards. These firms now plan ahead, are more prepared, more resilient and more profitable (David Heinjus, pers. comm.). Similar approaches have been funded by Meat and Livestock Australia. Of course, there remain many properties that do not meet these standards, as noted earlier. Many local Indigenous bodies have also experienced significant levels of governance training.

By comparison, external governance of the rangelands as a whole remains problematic. In the late 1990s there was a major national consultative effort to establish a National Rangelands Strategy; despite being fully drafted, this languished and was then published as a set of National Principles and Guidelines for Rangeland Management in 1999 (ANZECC and ARMCANZ 1999), but even this weakened concept was never implemented, and it is now forgotten in policy developments. However, the past decade has seen a partial convergence of pastoral and environmental views of land management (e.g. Hacker 2013).

Part of the drive for the national rangelands strategy had been from the states' land administrators who recognised the inconsistencies between systems for land tenure across Australia

and the consequences this has for many other aspects of management and governance. This has not been resolved. For example, Western Australian land tenure reform has stalled for nearly two decades. There remains little consistency in detail across state borders (see e.g. the disjunction between Queensland and the rest of the rangelands in Figs 2, 3). Efforts to establish any NRM groups across state boundaries failed; coordination has now emerged bottom-up by rangelands NRM groups convening together in the Rangelands NRM Alliance (Rangeland NRM Alliance 2018). (By contrast, Native Title has been the one tenure process that has operated with more national consistency.) Thus, ACRIS tried to harmonise the disparate monitoring systems across the states and Territory (Bastin and the ACRIS Management Committee 2008; Bastin *et al.* 2009), but this was defunded in 2014; it remains difficult to report credibly on the state of the rangelands nationally (Sparrow 2017).

Other failures of governance have been documented by Walker *et al.* (2012), who was reflecting on the impacts of distantly-driven action. An example is the Northern Territory 'emergency response' intervention in 2006, in which the national government exercised its powers to send the army and government officers into remote Indigenous communities without consultation or warning, due to perceived inaction on various social issues. The resulting social and health imposition on communities was an extreme example of the effects of centralising policy, with much well intended but locally insensitive action, at least in part resulting in the continuing inability to 'close the gap' in social outcomes for Indigenous peoples (compared with Australia's non-Indigenous population). In parallel there is a continued failure of national policy for drought management, and an unaddressed market failure in service delivery to the pastoral industry (ABC 2014; Roxburgh and Pratley 2015). These and other examples are characterised by top down command-and-control approaches, narrow economic efficiency perspectives, stop-start funding that tends to create competing but small and unsustainable local organisations, and a failure to understand service demands locally. By contrast, effective participation should mean that people have influence on processes that affect their lives (Walker *et al.* 2012). Another problematic issue is the privatisation of government services such as extension and welfare activities, often under one-size-fits-all national procurement and priority-setting policy approaches that fail remoter regions (Walker *et al.* 2012).

Systemic issues and challenges ahead

The past two decades have seen significant advances in understanding the complex social-ecological functioning of rangelands and dryland systems (Reynolds *et al.* 2007; Stafford Smith and Cribb 2009; Stafford Smith and Huigen 2009; Stringer *et al.* 2017). These insights enable the natural resource management and rangeland management views embedded in the five perspectives we have explored to be integrated with the wider issues of settlement services and community coherence, and, in turn, to fit in to a rangelands system of livelihoods, regional economics and governance. (Refer to the system linkages in Fig. 5, and related sources.) The system view highlights how more remote regions function differently to closely settled places, but that they can function perfectly well,

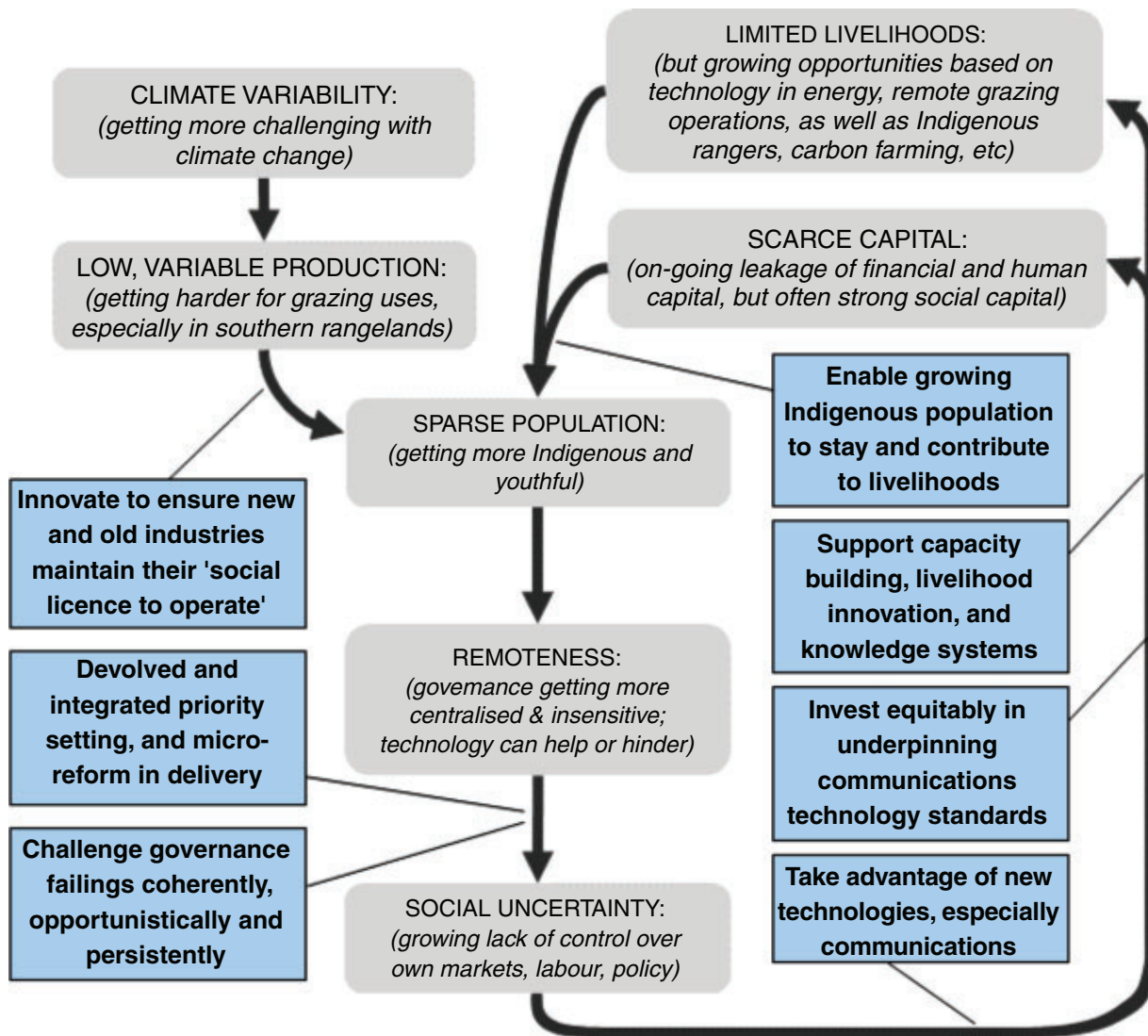


Fig. 5. Aspects of the rangeland social-ecological system (grey cycle, including key trends from text, italics) illustrating some key points for systemic action (blue boxes, see text) to help live with and take advantage of rangeland differences (adapted from fig. 2 in Stafford Smith and Huigen 2009).

socially, economically and environmentally, when this functioning is understood and accommodated. However, the combination of the forces of globalisation – especially increasing connectivity coupled with an emphasis on short-term economic efficiency – and the imposition of policies and processes that are derived from urban environments, undermine the rangeland’s social-ecological function. The system view helps identify multiple points in the system where thoughtful (and often well known) interventions can ensure rangeland functioning is reinforced rather than damaged.

But the challenges are systemic and they require systemic interventions, else individually sensible actions fail because the rest of the system is not supportive. What is a necessary but sufficient set of such complementary interventions?

Building from the foregoing perspectives in conjunction with the systems view of rangelands functioning, we suggest five key

themes for Australian rangelands that lead to a set of priority interventions in the next section.

The social licence to operate

The effects of climate change will exacerbate the two-speed economy in pastoralism (Holmes 1996), but also in mining, tourism and other land uses. Some managers will deliver the majority of product efficiently and sustainably, but their licence to operate (and that of the wider national industry at times) will be undermined by others who do not contribute to overall productivity and lack the necessary natural, financial and managerial resources to deliver acceptable stewardship. The latter situation can be seen in the images of starving animals during drought, illegal land clearing and water harvesting, unacceptable conditions in remote communities, the inauthentic

engagement of people in cultural tourism, poor health and safety practices, and un-rehabilitated spoil heaps from miners. Modern remote sensing and communications technologies mean that poor management can no longer hide from public view. All industries will need to address this issue more rigorously, and industry and government standards, that meet community standards, will need to be developed and implemented.

Younger and more Indigenous

Indigenous peoples are a significant and growing part of the future of the rangelands (Table 2), with a youthful demographic bulge coming through at present, and have at least some influence over how more than half of the rangeland is used and managed. Although there are sad stories of disempowered youth, there are also many success stories from an Indigenous generation that is taking its place in Australian society and making unique and valuable contributions to the management of rangelands. New societal investment in activities such as the Indigenous Rangers Program and carbon farming in remote places is creating livelihoods *in situ*. Capitalising on this trend and ensuring that human capital is retained in rangelands means providing relevant options that enable those who want to stay in the rangelands to do so. This requires continued and expanded appropriate education and training, the provision of support services for enterprise development and community functioning, and the diversification of livelihood options. One opportunity under the control of Indigenous leaders is the prudent investment of the increasingly large capital funds built up from mining royalties. For example, a large part of the commercial real estate in Alice Springs and in several WA towns is now owned by this capital, and increasingly there are opportunities to invest it in new enterprises such as horticulture, Indigenous art and cultural tourism ventures. The future of the rangelands will inevitably incorporate this demographic trend and the accompanying access to economic resources.

Technology opportunities and threats

Disruptive technologies are a double-edged sword for the rangelands. Clearly they have allowed extraordinary changes in communications in remote operations on mines, on pastoral properties and within rangeland institutions. They enable access to remote education, and a better 'mantle of safety' in terms of access to health services in remote areas than the Reverend John Flynn (originator of the Royal (Australian) Flying Doctor Service, based on the pedal radio) could ever have imagined. They also offer new livelihood options in energy production and technology maintenance *in situ*, and allow, for example: Aboriginal art to be sold direct from Yuendumu into New York, links to be developed between traditional owners in Australia and Canada, and internet-based enterprises to be established on remote pastoral properties that sell training, leather goods or even swimwear to the wider world.

The application of spatial information for land management is increasing at a rapid rate, with governments and land managers gaining greater access to remote sensing information in a format they can use to monitor the impacts of management changes and make decisions. The application of this is also increasing for managing grazing impacts, improving infrastructure planning,

managing new enterprises like carbon projects and monitoring and managing threats to the environment. However, poor internet connectivity in large areas of the rangelands limits many of these opportunities.

At the same time, however, communications technology drives the centralising tendencies of both government and the private sector, as services and people are withdrawn from remote and regional areas (e.g. driverless trucks on mine sites, driverless ore trains, on-line banking, shopping and government services, and substitution of technology for labour on pastoral properties). Some services such as quality tourism accommodation seem to become more available in remote areas, but poor communications services mean they still lag increasingly behind the rest of the nation. In short, rangeland residents need to harness the best of new technologies to their advantage, before the more disruptive impacts roll over them – for example, ensuring the benefits from better communications, remote monitoring, on-line services, and marketing via the internet more than outweigh the dis-benefits due to out-migration from remote communities, the insensitive centralisation of service delivery in cities and the impacts of distant market forces (Stafford Smith and Cribb 2009).

Governance and capital leakage

The state of governance within the rangelands has probably never been better, but this is not consistently supported by governance from outside the rangelands, partly exacerbated by global trends towards policy processes that are centralised and less context sensitive. These same trends exacerbate the capital leakage from rangelands that has always occurred – many major buildings in Australian capital cities for example were funded from rangelands wool – and which continues to undermine the ability of rangeland people to re-invest in their own future. There are many symptoms of this issue. Individual initiatives – like royalties for regions, procurement processes, support for economies of scope in small communities, integrated funding sources, enabling remote communities to express their needs better, and many others – could comprise a reform agenda. Behind all these lies a general need to devolve a greater degree of decision-making power and funding control to regional and remote Australia, along with due protection of the public interest and broad upwards accountability. Opportunities to achieve this are likely to occur opportunistically, but the right narrative and approaches need to be available as implementable policy for when those moments arise. In addition, there are some trends that might be harnessed to pre-adapt the rangelands for this change – such as the increasing capital accumulated in Indigenous-controlled funds that are retained in the region, as noted above.

Human capacity and capability

Rangelands human population is low, and reflects two dynamics. Non-Indigenous numbers are declining and generally ageing, while Indigenous populations are younger and growing. Neither component has much political influence except in some urban centres located in the rangelands where service sectors prosper. Youth unemployment is high and the high school to tertiary study transition is half that of city rates (Adult Learning Australia 2018). Many young people leave the rangelands for higher study

and never return. Several important rangeland service organisations are headquartered outside the rangelands – including some of the political offices, industry bodies, regional NRM organisations and Native Title representative bodies.

Wide consultation with rangeland industries, communities and governments in the 2000s (Taylor and Andrews 2012) identified the following priority areas for human capacity development: sustainable production systems and regions, stakeholder engagement, adapting to change, diversification, people management, pest animals, weeds and biosecurity, monitoring and adaptive management, and animal wellbeing and health. They remain important capacity building needs today (Marshall 2015), along with increasing the rate of adoption of technology and research outputs. The Foundation for Young Australians (FYA 2017) anticipates that by 2030 employers will be placing greater emphasis on ‘enterprise skills’ than on technical skills in early-career jobs in agriculture; enterprise skills include digital literacy, financial literacy, creativity, problem solving, critical thinking, communication and teamwork skills.

Human capacity is now spread so thinly that one or two key people leaving a community or region can stall key innovations and drive a spiral of neglect. Fly-in-fly-out experts are expensive and leave little learning behind. Young professional people may choose to spend some years in early careers working in the rangelands before moving to larger centres to raise and educate families, and they often sever their ties with the rangelands. Although simple in principle, keeping people who want to be in the rangelands in place is much needed, but difficult to bring about. There are individual examples which support local livelihoods, such as pastoralists paid to manage nearby nature reserves, Indigenous rangers, nurses, teacher aides, local plumbers and builders, part time researchers from local families as well as the successful Aboriginal Community Researcher program (Ninti One 2018). However, overall, the right training of the right people is in decline, driving a loss of experiential knowledge of rangeland functioning. Promoting capacity building and skill retention is a future policy requirement on which rests both the viability of livelihoods and integrity of the ecological systems.

Systemic responses

These systemic challenges limit the effective contribution of rangelands to national outcomes and create an undesirable dependency on external support. The right responses do not need more funds, rather they require a far-sighted integration of appropriate actions. Isolated projects, however well meaning, are undermined too often by lack of support from other parts of the system. For example, successful pilot investments in new industries fail to scale because of inadequate communications infrastructure, governance support or human capacity building. Similarly, efforts to stimulate enterprises tend to target only supply or demand, not both (Jarvis *et al.* 2018); government initiatives in regional development may conflict with programs to introduce technologies that replace people.

So far we have highlighted contemporary challenges arising in five key areas – maintaining social licence to operate, a population that is becoming more Indigenous and youthful, the

opportunities and threats from new technologies, governance failings that result in leakage of financial and human capital from the rangelands, and inadequate investment in that human capital. Bringing these together with the foregoing five perspectives, and in the context of the developing systems view of rangelands noted above, we now propose a concise set of coherent and self-reinforcing actions that would reduce the dependency of rangelands on national intervention (Fig. 5, actions).

Address the external governance issues of rangelands consistently and comprehensively

Although governance within the rangelands has probably never been better, the disjunction between how the rangelands function and the mental models of governance emanating from capital cities continues to widen as Australia becomes more urbanised. This trend will not change, but concerted and ongoing awareness raising is needed for (mostly well meaning) central policy makers, supported opportunistically by institutional changes which embed:

- (a) Participatory systems that better define investment needs in rangelands and especially that accommodate Indigenous interests. This will include more genuinely devolved responsibility for setting priorities, more integration of Indigenous and non-Indigenous considerations and a focus on micro-reform in regional policy delivery.
- (b) Coordinated and persistent action to ensure that national programs are applied in rangelands that are sensitive to how remote, lightly populated and often Indigenous-dominated regions function. This will require all policy delivery to include procurement that favours local knowledge and networks, policy delivery that is devolved to the local regions and enables local economies of scope and that is integrated to avoid fragmented funding streams that dissipate effort, and a careful consideration of the unintended consequences of any policy-driven initiative.

Ensure that new technologies and processes are available to support livelihoods to diversify and be sustainable, and that meet national needs for maintaining ‘social licence to operate’.

Innovation is crucial to sustaining existing enterprises and developing new activities in rangelands, whether specific technologies such as broadband or autonomous vehicles, or to the on-going improvement of ecological and social understanding of new opportunities such as carbon farming or more efficient livestock production. The risk is that a gap may widen between the rates of innovation in cities and those of the rangelands; the latter needs to maximise the value of any innovation, avoid reinventing the wheel and react quickly to perverse, unintended effects. Key actions are listed below.

(a) Ensure an equitable investment in communications technologies to enable the rangelands to keep up with rates of innovation in cities and allow rangeland enterprises to operate on a ‘level playing field’ with those elsewhere.

(b) Support a sustained innovation system including applied research in rangelands that explores the application of diverse new technologies and processes as part of new enterprise systems, whether carbon farming, water point and pasture

monitoring, fire and biodiversity management, feral animal control, renewable energy, tourism or mining.

Redouble capacity building efforts to enable rangeland inhabitants to live in and manage the rangelands productively for the nation.

Costs of education and training are inevitably higher in remote areas, but the returns on this investment are reduced social dependency and more effective and productive rangeland management outcomes. These benefits will arise from the following actions.

- (a) Educating and training the expanding cohort of Indigenous youth to support them to engage in rangelands life and culture in ways they find meaningful and fulfilling.
- (b) Enabling all rangelands inhabitants to understand their social and physical environment – and how that links to global and national issues – so that they can participate effectively in governance frameworks and can better capture the benefits of innovations and technology.
- (c) Engaging the whole rangelands community in appropriate research and development to support rangelands futures (e.g. rigorously applied adaptive management), while ensuring that knowledge is retained and integrated for contemporary application.

Narrow cost-cutting efficiency measures should not be allowed to undermine these initiatives.

Underpinning all of this is a need for coherent and more positive narratives about the Australian rangelands that recognise their value, their cultures and their different ways of operating as assets in their own right. This is in contrast to the common ‘deficit model’ in which the rangelands somehow do not work as well as cities or farming lands. This will help to encourage rangeland inhabitants to continue to live in and look after the region, and to engender clear-eyed support for this from Australians as a whole.

Conclusion

The modest number of people who live in the rangelands, and others in the rangeland community (as defined earlier), have a responsibility for huge tracts of the Australian national estate and a major part of its cultural heritage. The nature of that population and of their operating environment is changing rapidly. Here, we have charted how these issues have changed over recent decades, and highlighted the current set of challenges. Demographic changes, the impacts and opportunities arising from new technologies, and the growing disconnect between central policy processes and regional policy needs speak to a well-defined set of actions that would help to ensure that the rangelands increasingly deliver national benefits at the same time as maintaining thriving local livelihoods. These actions include implementing participatory and sensitive governance processes, enabling new and old livelihoods in rangelands to make the best use of new technologies, and building human capacity towards both these ends. These actions should be pursued both by those who live in the rangelands and by those outside who care about their social, cultural, environmental and economic value to Australia and have some influence to effect positive change.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix 1. Socioeconomic indicators for Australian rangelands, as synthesised from diverse sources

Statistic	Year	Australia	Rangelands	% In rangelands	Source
				<i>Summary demographics</i>	
Population	2001 and 2016 census	See Table 2	See Table 2	100%	Cited as ABS (2016a) population estimated based on Remote and Very Remote categories. Includes all major centres in the rangelands – Mt Isa, Charters Towers, Alice Springs, Broken Hill, Port Augusta, Kalgoorlie, Port Hedland, Karratha, Broome. Source: ABS Quickstats for 2016 census and 2001 census. http://www.abs.gov.au/websitedbs/D3310114.nsf/Home/Census?OpenDocument&ref=topBar
Employment	2001 and 2016 census	See Appendix 3	See Appendix 3	100%	
				<i>Land tenure and land use</i>	
Land tenure	2014–2018	See Table 3	See Table 3	100%	State of the Environment Committee (2011); National Native Title Tribunal (2018) see http://www.nntt.gov.au/Maps/Indigenous_Estates_and_Determinations_AIL.pdf Aboriginal Lands Trust of Western Australia (2018) see https://www.daa.wa.gov.au/about-the-department/boards_and_committees/aboriginal-lands-trust/ , Aboriginal Lands Trust of South Australia (2018) see https://alt.sa.gov.au/wp/index.php/about-us/alt-map/ ; ILC (2017); Australian Government (2018a) https://www.pmc.gov.au/indigenous-affairs/environment/indigenous-protected-areas-ipas Cape York Land Council Aboriginal Corporation (2014) see http://www.cylc.org.au/wp-content/uploads/2018/06/cylc_annual_report_2013-14.pdf
Land use	2017	See Appendix 2	See Appendix 2	100%	ABARES (2017). Presents land use for the Regional NRM Organisations located in the rangelands. (see http://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-reports)
				<i>Sheep and cattle numbers and value of production</i>	
Cattle numbers	2016	22.31	8.61 m	38.6%	Beef Central (2017). Source: https://www.beefcentral.com/production/ag-census-results-point-to-smaller-than-estimated-herd-size/ MLA (2017b). Presents cattle numbers for the Regional NRM Organisations located in the rangelands. (see https://www.mla.com.au/globalassets/mla-corporate/prices-markets/documents/trends-analysis/fast-facts-maps/mla_cattle-numbers-map-2016-17_rev1.pdf) ABS (2018). Value of rangeland production proportional to percentage of national herd in the rangelands. Source: http://www.abs.gov.au/ausstats/abs@.nsf/mf/7503.0
Value of cattle products	2016–2017	\$12.14 bn	\$4.69 bn ^A	Assumed proportional to numbers	
Sheep numbers	2016	67.54	4.51 m	6.7%	MLA (2017a). Presents sheep numbers for the Regional NRM Organisations located in the rangelands. (see https://www.mla.com.au/globalassets/mla-corporate/prices-markets/documents/trends-analysis/fast-facts-maps/mla_sheep-numbers-map-2016-17.pdf) MLA (2017c). https://www.mla.com.au/globalassets/mla-corporate/prices-markets/documents/trends-analysis/fast-facts-maps/mla_sheep-facts-2018.pdf
Value of sheep meat	2016–2017	\$3.56 bn	\$0.24 bn ^A	Assumed proportional to numbers	
Value of wool		\$3.46 bn	\$0.23 bn ^A	Assumed proportional to numbers	
Tourism and visitor expenditure (gross value added) ^B	2016–2017	\$52.6 bn	\$2.72 bn	5.2%	<i>Economic value of other industries and land uses</i> Australian Government (2017b). https://www.tta.gov.au/ArticleDocuments/254/Tourism%20Satellite%20Account%202016-17.pdf.aspx?Embed=Y Australian Government (2017c). https://www.tta.gov.au/Economic-analysis/Economic-Value-Regional-Tourism-Satellite-Account/regional-tourism-satellite-account The tourism and visitor data come from 12 tourism regions that are predominately in the rangelands, but exclude data from the City of Cairns and the Shire of Broome.

Mining and oil and gas (total sales and services)	2014–2015	\$211.87 bn	\$171.61 bn ^A	Estimate 81%	ABS (2016b). Estimate of 81% assumes income from mining and oil and gas distributed evenly across the nation, hence proportional to area of Australia that is rangeland. Source: http://www.abs.gov.au/ausstats/abs@.nsf/mf/8415.0
Mining and oil and gas (value added) ^C		\$118.28 bn	\$95.80 bn ^A	Estimate 81%	
Kangaroo harvesting	2014	\$0.174 bn	\$0.174 bn	Estimate 100%	Kangaroo Industries Association of Australia (2018). The figures shown assume all of the value of the kangaroo industry is obtained from the rangelands. http://www.kangarooindustry.com/industry/economic.aspx
Kangaroo industry (value added) ^D	2014	≥ \$0.200 bn	≥ \$0.200 bn	Estimate 100%	

^AEstimate inferred from percentage of Australian total numbers or area that would be in rangelands, assuming even distribution.

^BTourism Expenditure is calculated as the sum of the expenditure from international visitors, domestic overnight visitors and domestic day trip visitors to the region, as calculated by the Tourism Research Australia (TRA) regional expenditure model (REX). Tourism gross value added (GVA) shows only the 'value' added by the producer to the raw material goods before any addition of taxes, such as GST or wholesale sales taxes. It also excludes excise duties on goods supplied to visitors. Measured at this 'basic price', tourism GVA is directly comparable with other industries' GVA because it is free of the effects of taxes and subsidies on products which can vary between industries (and countries) and over time. Also, the tax and subsidy component of a product's sale price does not represent value added by the producer.

^CMining and oil and gas 'value added' is an estimate of the difference between the market value of the output of the industry and the purchases of materials and expenses incurred in the production of that output. ^D'Value added' as for ^C, for the kangaroo industry this includes the value of reduced damage to vehicles.

Appendix 2. Land use in the rangelands broken down by natural resource management regions (ha)Source: ABARES (2017); URS Australia Pty Ltd (2013). Note: *italics* indicate southern rangelands as used in this paper, others are northern rangelands

NRM region	Grazing on native pastures	Nature Conservation	Other protected areas including Indigenous use	Minimal use ^A	Mining and Waste	Other (mainly water ^B , agriculture and urban)	Total
Rangelands NRM (WA) – northern ^C	35 110 000	32 179 297	90 429 026 ^D	10 000 000 ^D	83 226	4 521 723	224 463 272
<i>Rangelands NRM (WA) – southern^C</i>	52 140 000						
<i>Western NSW</i>	27 914 874	1 749 220	0	439 778	8406	1 340 632	31 452 910
<i>Murray (NSW)</i>	1 332 631	392 983	17 489	135 188	3486	2 307 940	4 189 717
Northern Territory	56 679 067	6 308 969	53 647 661	6 772 513	43 056	11 293 914	134 745 180
<i>APY Lands (SA)</i>	8659	8 931 627	18 700 340	305 832	26 456	182 342	28 155 256
<i>SA Arid Lands</i>	39 759 078	7 413 506	364 508	40 160	526 562	4 074 362	52 178 176
<i>Lower Murray–Darling (SA)</i>	1 315 767	1 151 289	7756	398 955	4270	2 772 317	5 650 354
<i>South West Qld</i>	17 236 488	676 458	360 038	14 931	409	425 443	18 713 767
Desert Channels (Qld)	44 684 504	2 148 062	906 582	45 712	6523	3 235 364	51 026 747
Fitzroy Basin (Qld)	12 153 600	715 244	95 674	408 653	102 674	219 1784	15 667 629
Burdekin Dry Tropics (Qld)	12 647 402	364 765	133 465	342 221	16 070	575 122	14 079 045
Southern Gulf (Qld)	17 588 726	321 635	33 672	135 839	10 487	1 386 820	19 477 179
Northern Gulf (Qld)	14 308 632	1 025 932	202 999	27 450	2994	871 508	16 439 515
Cape York (Qld)	3 546 726	2 361 454	4 248 988	28 649	17 911	473 693	10 677 421
<i>Northern Agricultural Catchments (WA)</i>	476 289	1 159 263	643	1 698 854	10 566	3 982 310	7 327 925
Total	336 902 443	66 899 704	169 148 841	20 794 735	863 096	39 635 274	634 244 093
% Total	53.1%	10.5%	26.7%	3.3%	0.1%	6.2%	100.0%

^ADepending on state and territory, this may be termed 'unallocated crown land'.^B'Water' includes water storages, seasonal wetlands and normally dry salt lakes.^CExtrapolated from figures provided by the Department of Agriculture and Food WA in 2012, as reported in URS Australia Pty Ltd (2013).^DEstimate: ~6.9 million km² in WA formerly categorised by ABARES as minimal use in 2011 has since been determined as exclusive native title.**Appendix 3. Rangeland workforce and employment across all categories in 2001 and 2016**

Source: ABS (2016a). Major rangeland towns included as for Table 2 (see main text)

		Rangeland workforce ^A					Total	Australia
		NSW	NT	SA	Qld	WA		
2001	Total workforce	29 539	38 270	28 918	76 840	38 012	204 314	8 959 315
	Unemployed	2665	1998	1864	3665	1665	10 812	660 709
	% Unemployed	9.0%	5.2%	6.4%	4.8%	4.4%	5.3%	7.4%
2016	Total workforce	22 811	34 892	19 515	58 527	40 572	168 455	11 471 296
	Unemployed	1685	4139	832	4024	2428	15 734	787 452
	% Unemployed	7.4%	11.9%	4.3%	6.9%	6.0%	9.3%	6.9%

^AEstimated based on 'remote' and 'very remote' categories.