Trends in natural resource management in Australia's Monsoonal North: The beef industry

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Acronyms and abbreviations

ACCU	Australian Carbon Credit Units
AE	Animal Equivalents
ALEC	Australian Livestock Exporters' Council
ALFA	Australian Lot Feeders' Association
AMIC	Australian Meat Industry Council
AMPC	Australian Meat Processor Corporation
APVMA	Australian Pesticides & Veterinary Medicines Authority
ARC	Australian Research Council
ARCBA	Australian Registers Cattle Breeders Association
ARS	Australian Rangelands Society
AVA	Australian Veterinary Association
BJD	Bovine Johne's Disease
BMP	Best Management Practices
BoM	Australian Bureau of Meteorology
BSE	Bovine Spongiform Encephalopathy
CCA	Cattle Council of Australia
CFI	Carbon Farming Initiative
CDU	Charles Darwin University
CH_4	Methane
CLC	Central Land Council
CLCAC	Carpentaria Land Council Aboriginal Corporation
CO_2	Carbon Dioxide
COTS	Crown of Thorns Starfish
CQU	Central Qld University
CSG	Coal Seam Gas

Cth	Commonwealth of Australia
CYLA	Cape York Land Council
DAF WA	Department of Agriculture & Food, WA
DCM NT	Department of Chief Minister, NT
DEC WA	Department of Environment and Conservation, NT
DIRD	Department of Infrastructure & Regional Development
DLRM NT	Department of Land Resource Management, NT
DME NT	Department of Mines and Energy, NT
DoA	Department of Agriculture (Cth)
DoE	Department of the Environment (Cth)
DoT NT	Department of Transport, Northern Territory
DPIF NT	Department of Primary Industry & Fisheries, Northern Territory
DPIs	Primary Industries Departments
DSD WA	Department of State Development, Western Australia
EIA	Environmental Impact Assessment
EPA WA	Environmental Protection Authority, Western Australia
ERF	Emission Reduction Fund
ERMP	Environmental Risk Management Plan
ESCAS	Exporter Supply Chain Assurance System
FIFO	Fly-In, Fly-Out (staff that are flown in and out of work sites on a regular basis)
FMD	Foot and Mouth Disease
FMDs	Farm Management Deposits
Fraccing	Hydraulic fracturing to release coal seam gas from parent rock
GBR	Great Barrier Reef
GHG	Greenhouse Gas
IARC	International Agency for Research on Cancer (World Health Organisation)
ILC	Indigenous Land Corporation

IPP	Indigenous Pastoral Program
JCU	James Cook University
KLC	Kimberley Land Council
Lands WA	Department of Lands, Western Australia
LiveCorp	Australian Livestock Export Corporation
LPA	Livestock Production Assurance
MLA	Meat & Livestock Australia
MSA	Meat Standards Australia
N_2O	Nitrous Oxide
NABIWG	Northern Australia Beef Industry Working Group
NABRC	North Australia Beef Research Council
NADO (NT)	Northern Australia Development Office, Northern Territory
NAFI	North Australia Fire Information website
NAIEF	Northern Australian Indigenous Experts Forum on Sustainable Economic Development
NAMF	Northern Australia Ministerial Forum
NBIR	Northern Beef Industry Roundtable
NBIWC	Northern Beef Industry Working Group
NDRRA	National Disaster Relief & Recovery Arrangements
NFF	National Farmers Federation
NLC	Northern Land Council
NLIS	National Livestock Identification System
NQLC	North Qld Land Council
NRM	Natural Resource Management
NRM WA	State NRM Office, Western Australia
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTCA	Northern Territory Cattlemen's Association

OH&S	Occupational Health and Safety
ORS WA	Office of Road Safety, Western Australia
PAW WA	Parks and Wildlife, Western Australia
PCAS	Pasturefed Cattle Assurance System
PGA WA	Pastoralists & Graziers Association of Western Australia
ppm	Part per million
QAAFI	Queensland Alliance for Agriculture & Food Innovation
QDAF	Queensland Department of Agriculture and Fisheries
QDEWS	Queensland Department of Energy & Water Supply
QDoT	Queensland Department of Transport
QDSD	Queensland Department of State Development
QDSI	Queensland Department of Science & Innovation
QEHP	Queensland Department of Environment and Heritage Protection
QFF	Queensland Farmers' Federation
Qld	Queensland
QMRRSP	Queensland Department of Main Roads, Road Safety & Ports
QNRM	Queensland Department of Natural Resources & Mines
QRAA	Queensland Rural Adjustment Authority
RD&E	Research, Development and Extension
RET	Renewable Energy Target
RIRDC	Rural Industries Research & Development Corporation
RMAC	Red Meat Advisory Council
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SDA	State Development Area
SFOs	State Farming Organisations
SWEEP	Strategic Weed Eradication and Education Program (Queensland)
TGS	Tropical Grasslands Society of Australia

TNRM	Territory NRM
TS-CRC	Tropical Savannas Cooperative Research Centre
Turn-off	Livestock sent to market
UQ	University of Queensland
UWIR	Underground Water Impact Report
WA	Western Australia
WA BC	Western Australian Beef Council
WAFarmers	Western Australian Farmers Federation

About the author

Gabriel Crowley has over 20 years' experience assisting natural resource managers meet their planning, management and conservation goals.

Her interest in natural resource management began on Cape York Peninsula in 1992, when she worked with pastoralists to reverse the decline of open grassy woodlands that have high conservation and pastoral values to development of fire and grazing management guidelines. She undertook similar collaborative work with landholders on Kangaroo Island for Glossy Black-Cockatoo conservation. Returning to northern Australia in 1998, she worked in Queensland Parks and Wildlife and the Tropical Savannas Cooperative Research Centre to support sustainable land management through production of fire and wildlife management guides and web-based tools.

She subsequently led the development of:

- Northern Territory's 2010-2015 Integrated Natural Resource Management Plan
- Queensland Government's $10M Reef Policy Science Program to inform best practice cane farming and cattle grazing and prioritise investment in research gaps (2010-2011)
- Meat and Livestock Australia's 10-year Research, Development and Engagement Plan to improve fire management on northern grazing lands (2013)
- The research plan to inform Natural Resource Management across northern Australia (2014).

This report and its companion volume *Trends in natural resource management in Australia's Monsoonal North: The conservation economy* are a continued expression of her commitment to support the information needs landholders and Natural Resource Management groups.

Gabriel is an Adjunct Principal Research Fellow with The Cairns Institute at James Cook University, Cairns, Australia.

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Disclaimer

Executive summary

This report describes trends in the beef industry in the Monsoonal North. It aims to provide the region's natural resource management (NRM) groups with an understanding of how best to support the industry, undertake the changes required to improve its environmental sustainability and economic viability, and to provide it with resilience in the face of increasing development pressures and climate change. This report charts the industry's history and development; describes its current condition and the pressures and drivers it is experiencing; and explores how these are likely to change in the near future.

The region: The Monsoonal North covers 20% of Australia's land surface across the tropical savannas. It shares a monsoonal climate, extensive intact ecological systems, generally poor soils and limited development. Its river systems carry nearly half of the runoff. The region has a large Indigenous population; most land is either under Indigenous ownership or subject to Native Title; and the highest proportion of Indigenous people live in the region's north and north-west.

The region also faces a number of shared issues, particularly the challenges of intensifying climatic extremes and pressure to exploit Asia's growing demand for agricultural produce, which is placing pressure on land and water resources.

The industry: Cattle production is northern Australia's most important agricultural industry. Two-thirds of the Monsoonal North is currently used for extensive cattle grazing. Through most of the region, cattle are grazed at low stocking rates on native pastures, with introduced pasture species being restricted in extent. Most enterprises breed animals for the low-value live export trade or for fattening and finishing on better pastures or in feedlots.

Cattle numbers in Queensland, Northern Territory and Western Australia have doubled since 1965, and fluctuated with changes in demand and climatic conditions. In 2009, the Monsoonal North held around 5.7 million head of cattle. High export demand from Asia and drought destocking has seen the region's cattle numbers fall and prices rise through 2014-15. In the longer-term, continued growth in global demand, a reduced Australian dollar and high global prices, and improved incomes are forecast for Australian beef producers. Since 2009, each of the three northern governments have released policy documents that included targets to increase the herd size by between 1 and 5%, with the greatest planned increases on Aboriginal land in the Kimberley. Between 2009 and 2014, the Northern Territory herd grew by more than the projected 5% increase. Herd size in Queensland has recently diminished because of drought, and the current government's stance on herd-building is unclear.

Nevertheless, long-term growth is expected to increase the northern Australian herd by a further 80% by 2050.

Recent growth in the northern cattle herd has been achieved through intensification (spreading grazing pressure using water points and fencing) and development of underutilised properties, notably on Indigenous lands. Indigenous pastoralism is growing rapidly, with developments in all parts of the sector from cattle breeding to slaughter.

Markets: Most beef grown in northern Australia is sent to Asia, with Indonesia being the largest buyer of live cattle. Despite a long-established framework for assuring animal health and welfare within Australia, widely-publicised animal mistreatment in Indonesia resulted in the temporary closure of the live-export market in 2011 until animal welfare could be assured throughout the supply chain. This closure demonstrated how dependence on a single market exposed the northern beef industry to market volatility. Bilateral and multilateral trade negotiations by the federal government are now progressively broadening market access, with agreements favouring Australian beef now in place or close to finalisation with most significant beef markets.

Enterprises: Cattle enterprises in the Monsoonal North have been struggling because, in real terms, cattle prices have declined, while input costs have remained stable. In addition, escalating land prices through the 1990s and 2000s encouraged many land owners to increase their mortgages to levels that became unsustainable once land prices fell. This has implications for environmental management. In comparison to pastoralists in a good financial position, those in debt have less resilience to cope with drought; are less likely to adopt practice improvements needed for improving enterprise viability and environmental conditions; and are more likely to suffer adverse health effects.

Many enterprises, especially those with small herds, derive more income from off-farm work than they earn from cattle operations. While large cattle enterprises allow economies of scale, increasing cattle herd size seems less important to profitability than does improving herd performance.

Performance: Except on Mitchell Grass pastures and small areas of intensively managed pastures, cattle performance in the Monsoonal North is substandard when compared to the rest of the country, and is affected by poor quality pasture quality. Breeding performance is typically poor; with low pregnancy rates; high foetal and calf death rates; and many cows are lost. However, the achievements of the top 25% of the industry indicate there is great potential to improve performance on the remaining properties.

Health and well-being: Pastoral production is a stressful occupation, involving financial insecurity and isolation; and pastoralists have high rates of injury, disease, accident and suicide. Recent years have brought additional challenges associated with falling land prices, market instability and drought. In the Burdekin Dry Tropics, proposed coal mining is increasing stress levels for many pastoralists.

Supply and demand: Domestic demand for beef in Australia stagnated because per capita beef consumption has fallen, but global demand is escalating with population growth and economic development. Demand for beef is expected to keep increasing until at least 2050, with greatest growth occurring in China.

Australia was the world's top beef exporter until 2003. Only Brazil and India currently export more beef than Australia does. Australia's disease-free status gives it access to markets that are closed to these exporters. Australia's dominance of the live-export trade to Indonesia also helps provide a disease free buffer to its north. Australian beef producers are disadvantaged by protectionist measures employed by both beef importing countries and exporting countries. The Australian Government has been engaging in international trade agreements that will overcome some of these barriers and increase market access.

Market requirements and consumer preference: A high percentage of Brahman genes in the herd makes northern cattle attractive for slaughter and feedlots in tropical countries. However, slow growth rates and long transport distances mean most beef is sold in the low end of the market. Ethical, health and environmental concerns have contributed to the decline in domestic meat consumption, and are influencing consumer preferences in global markets. These concerns are driving practice improvement throughout the Australian beef supply chain.

Challenges: Industry viability is constrained by lack of infrastructure, including feedlots, intensive fattening pastures, saleyards and meatworks, inactive ports and poor quality roads, all of which combine to make freight expensive, pushing up input costs. Considerable advances have been made in alleviating these constraints by building meatworks in Darwin, Arnhem Land and the Kimberley. However, lack of competition through the supply chain may be depressing returns at the farm gate. The ports of Darwin and Townsville are operating at record capacity, but some northern ports with export facilities (Port Hedland, Weipa, Mourilyan and Mackay) have not operated for several years.

Water for cattle operations and irrigated crops may be at risk if extraction for these and other activities is not sustainably allocated. While broadscale irrigated cropping is likely to be restricted to a small proportion of the region, its requirements for water resources and fertile soil may deprive the pastoral

industry of some of its most productive pasture land. Extraction for mining and irrigated agriculture is of particular concern. This has become a contentious issue with several coal projects in Queensland's Galilee Basin. Mining also has the potential to disrupt pastoral operations by removing land from production for both mineral extraction and infrastructure. Again, this is a significant issue in Queensland, where several landholders will be affected by the rail corridor servicing mines in the Galilee Basin. The disruption caused by mining poses a risk, not only to the financial viability of pastoral enterprises, but also to the health and welfare of pastoralists and their families. If well managed, however, mining and agricultural development can also have co-benefits, improving regional economies and providing employment and infrastructure.

Weeds, fire, pest animals, disease and cattle theft all impose financial burdens on northern pastoral operations. Production losses caused by weeds have been estimated at costing the industry around $1,000 million/year; pest animals: ca $36 million/year; disease and parasites: ca $390 million; and cattle theft between $1.5 and $2 million a year in Queensland alone. No industry-wide estimates are available for impacts of fire, cyclones or other natural disasters. Conversely, pastoral managers perform important roles in control of weeds, fire, pest animals and diseases that would not be undertaken if no one was living on the lands they manage.

Climatic and seasonal conditions are also serious constraints, particularly in inland Queensland, where periods of drought of two or more years are not uncommon. Conversely, extended periods of above average rainfall may encourage pastoralists to stock land beyond its long-term carrying capacity, and develop unrealistic impressions of what average conditions are. This could be an issue in the Kimberley if the elevated rainfall of the last few decades is not sustained.

Climate change is already being felt in the region. Temperature have risen by up to 1.0˚C since 1910, with further increases of up to 5˚C expected by the end of the century. Droughts, cyclones, wildfires and flooding rains are likely to intensify over the next few decades, and continue to intensify until at least the end of the century. Carbon dioxide enrichment may increase forage production, but reduce its quality and stimulate woody thickening, as woody plants are favoured over tropical grasses. In most climate change scenarios, whether rainfall remains roughly the same or decreases, pasture growth and safe stocking rates in the Monsoonal North are expected to decrease, with the worst scenarios predicting decreases in pasture growth and safe stocking rates of between 50% and 60%. Climate change will also have adverse impacts on each stage of the supply chain, with effects ranging from increasingly uncomfortable work conditions to increased frequency of flood and cyclone damage to infrastructure.

Policy environment: Many organisations have an influence on the direction of the pastoral industry. Individually, or as part of cross jurisdictional alliances, national, state and territory governments promote industry sustainability and herd-building. The preferred approach is to improve trade relations; simplify regulation; invest in roads; and provide a conducive business environment to attract infrastructure investment. The *Developing Northern Australian White Paper* and the *Agricultural Competitiveness White Paper* further these objectives.

Under Australian national legislation, the Red Meat Advisory Council was established to represent the interests of beef and other meat producers, and is reported to by various state farming organisations that work closely with the industry as advocates and information and extension providers. Research and marketing is largely driven by Meat and Livestock Australia (informed on northern issues by the North Australia Beef Research Council) and extension is delivered by state agencies, state farming organisations and NRM groups. The emphasis of both research and extension is on practice improvement, rather than herd building. The Australian Government funded Indigenous Land Corporation is also playing a pivotal role in the northern grazing industry by assisting Indigenous people acquire, develop and manage pastoral properties. Finally, the policies and assessments made by financial institutions can both determine the level of debt that a pastoral enterprise can acquire and the cost of repayment, and influence whether developments seeking external funding are seen as viable.

The Australian Government is committed to climate change action by virtue of signing international agreements. Its commitments to reduce emissions will help moderate the long-term impacts of climate change. Both the Western Australian and Northern Territory Governments have also made climate change commitments and the Queensland Government is currently revitalising its climate change agenda.

Regulatory environment: Legislation and regulation govern much activity on pastoral properties, most of which are pastoral leases coexisting with Native Title. This type of land tenure allows pastoralists to undertake most activities that can be justified as core business to a pastoral operation, including pastoral-related activities that reduce carbon footprints. Diversification into other activities requires the consent of Native Title holders, which is usually negotiated through Indigenous Land Use and Access Agreements.

Pastoralists have the right to water stock and clear vegetation for pastoral uses, but conditions vary between jurisdictions and water use for agricultural development requires a permit. There is a lack of

clarity about whether permits can be granted for non-pastoral uses (including diversification into broadacre cropping) in Western Australia and Queensland.

Pastoral leases also come with a range of legislated responsibilities. Leaseholders in each jurisdiction are to manage weeds, pest animals and diseases and to report notifiable cattle diseases to the relevant authority. They must use National Livestock Identification Scheme tags to ensure their cattle can be traced through the supply chain, and adhere to animal health and welfare standards. In addition, as employers, pastoral operators must follow conditions laid down by Fairwork Australia. Graziers in the Burdekin catchment are required to manage their properties to minimise reef pollution.

The rights of miners to access land and water override those of pastoral leaseholders. While legislation facilitating exploitation of mineral and gas and fuel resources purports to safeguard other interests (notably environmental matters and water access), few mining proposals have been rejected because of environmental or pastoral concerns.

Practice improvement: Much effort has been invested in identifying the best practices to improve the profitability and environmental sustainability of the northern beef industry. Key areas of knowledge advancement include:

- Improving land condition
- Improving diet through exotic pastures and supplementary feeding, especially at finishing
- Improving reproductive performance by culling non-productive animals, vaccinating against reproductive diseases and improving diet quality
- Increasing liveweight gain through early weaning and improving diet quality
- Spreading grazing pressure by increasing fencing and water points.

Improvements to herd management are largely compatible with practice change required for reducing adverse impacts on biodiversity, carbon footprints and Great Barrier Reef water quality. Improved animal performance increases animal growth rates (meaning fewer animals are required to produce the same volume of meat), and therefore also reduces the methane emissions generated. Good herd performance in rangelands is also dependent on moderate stocking rates to maximise forage quality, especially by improving the cover of productive perennial grasses. Improved ground cover also reduces soil loss (when cover is at least 50%) and gully formation (when at least 75%).

Resilience to climate change will be built by undertaking the practice improvements identified to improve pastoral productivity and land condition. Of particular importance is the ability to adjust

stocking rates in relation to seasonal conditions. At the industry level, decision support, including improved access to climatic information, is required to assist pastoralists make the best decisions for their circumstances.

Diversification: Another approach to increasing enterprise resilience is diversification. Options being canvased include small-scale irrigation of pasture crops for finishing cattle on the property, grain and oil seed crops, biodiversity conservation and carbon abatement. Conservation efforts on some properties attracted subsidies in return for entering into conservation agreements. Biodiversity offsets may widen opportunities for on-property conservation, particularly in Queensland, where a formalised offset scheme is being developed. A small number of pastoral properties in the region are also receiving funding for fire management to reduce carbon emissions. A range of other emission reduction opportunities are at various stages of development, including reducing emissions from pastoral operations through improved herd management and adjusting cattle diets and storing carbon in soil or vegetation.

Natural resource management implications: As practices to improve performance are adopted and/or diversification options are pursued, careful management will be required to avoid potential adverse environmental impacts. Best-bet options for improving environmental outcomes along with pastoral productivity include:

- Avoiding the use of "transformer" grasses (with high biomass and fuel loads), or at least ensuring they do not escape from improved pasture plantings
- Protecting areas of high biodiversity values when increasing extent and/or intensity of grazing, in particular protecting biodiversity values on riparian corridors when planning irrigated cropping projects
- Ensuring wet season supplementary feeding does not weaken native perennial grasses
- Ensuring early dry season burning does not lead to vegetation thickening and biodiversity decline.

The NRM implications of the current trajectory of the pastoral industry are mixed. Herd building will put more pressure on the natural environment. However, performance improvement has many benefits by reducing the number of hooves and mouths required to produce a kilogram of meat. If well managed, mosaic agriculture can contribute to herd performance while taking pressure off pastures and the natural environment during the wet season, but managed poorly could result in further degradation of alluvial environments and over stocking of adjacent areas.

The environmental footprint of diversification into agriculture would similarly need to be managed carefully. However, increasing income from various forms of ecosystem service delivery, particularly on lands that are marginal for grazing, would be a boon to both pastoral enterprises and the environment.

Central to all this change are the pastoralists themselves. And with all that is required from them and all the stresses and strains they already have to bear, many will be in no position to take up improved practices, let alone participate in conservation activities. Pathways out of debt must be found before resilience in the face of change can be achieved, and pastoralists must be supported in the adoption of new practices, rather than have it mandated.

Introduction

This report describes trends in the beef industry in the Monsoonal North. It aims to provide the region's natural resource management (NRM) groups with an understanding of how best to support the industry, undertake the changes required to improve its environmental sustainability and economic viability, and to provide it with resilience in the face of increasing development pressures and climate change. It charts the industry's history and development; describes its current condition and the pressures and drivers it is experiencing; and explores how these are likely to change in the near future.

The Monsoonal North is an area of nearly one and a half million square miles kilometres of northern Australia, or 20% of Australia's land surface (Figure 1). The region shares a monsoonal climate (with markedly wet summers and dry winters) and similar development history. The beef industry is the region's most extensive land use, and most important agricultural industry. Sixty-one percent of the land is under pastoral lease, and significant proportions of Aboriginal lands are also used for grazing. Cattle production is currently largely based on the grazing of native pastures, a practice that can be sustainable and productive when well managed. However, overgrazing and poor herd management have led to pasture degradation in many places. Growth in the industry without practice improvement is likely to see further degradation, affecting the viability of many enterprises.

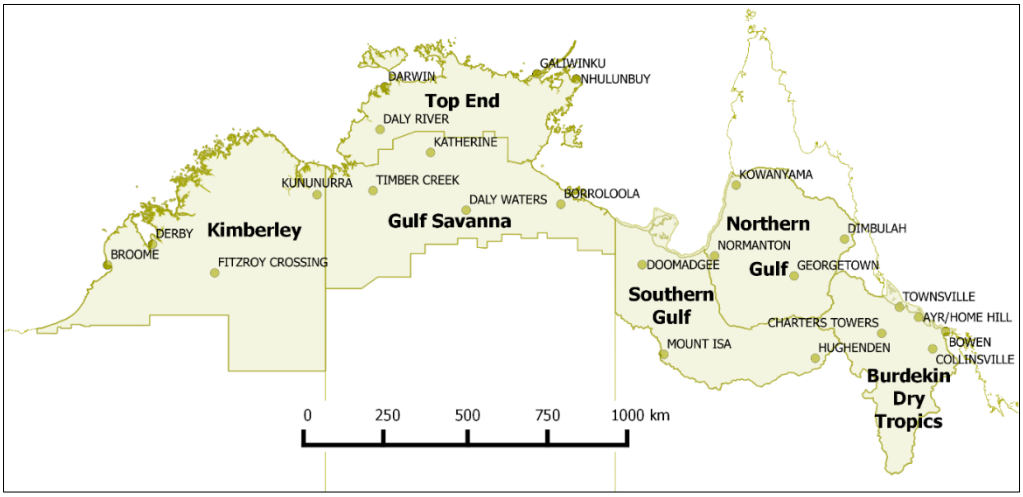


Figure 1. The Monsoonal North showing natural resource management regions and subregions

The region also faces a number of shared issues, particularly the challenges of intensifying climatic extremes and pressure to exploit Asia's growing demand for agricultural produce, which is leading to a jostling for the use of land and access to apparently copious water resources. Indigenous ownership of land is also increasingly being legitimised with the resolution of Native Title claims. So on the one hand, ownership of many pastoral properties is being resumed by Indigenous communities, and on the other, the nature and extent of pastoralism is likely to change as enterprises intensify and diversify, or are replaced by other agricultural industries. Each of these changes bring with it different challenges to the viability of the industry and the environmental condition of tropical landscapes. But many pastoralists have little capacity to consider the implications of these changes, as they are daily confronted with market volatility, financial worries, complex management arrangements, exacting regulatory requirements, health concerns and the difficulties of getting cattle to distant markets on substandard roads.

Efforts to improve industry sustainability must, therefore, be aware of both current circumstances and future directions. It is hoped that by improving understanding of the industry, its current and future challenges, and its opportunities, this report will assist chart a path to a more sustainable and resilient future.

The region

Climate

The region extends across the band of northern Australia that experiences a highly summer-dominant rainfall. Its climate is generally very hot and humid[1]. Average temperatures mostly range between 18 and 27°C in winter and between 27 and 33°C in summer, with slightly cooler temperatures in coastal areas in summer and slightly cooler temperatures inland in winter. Annual average rainfall ranges from 400 mm in the inland to in excess of 2,000 mm in the north and east (Figure 2). Rainfall is strongly influenced by the intensity of the wet season and monsoon, and by tropical cyclones. In the eastern parts of Queensland, moist onshore south-east trade winds also bring rain through much of the year. This pattern is overlain by the wet dry cycles of the El Niño-Southern Oscillation. In the El Niño part of the cycle, rainfall tends to be depressed in eastern and central areas; in La Niña years, significant rainfall during the wet season typically build-up presages an early wet season onset[1].

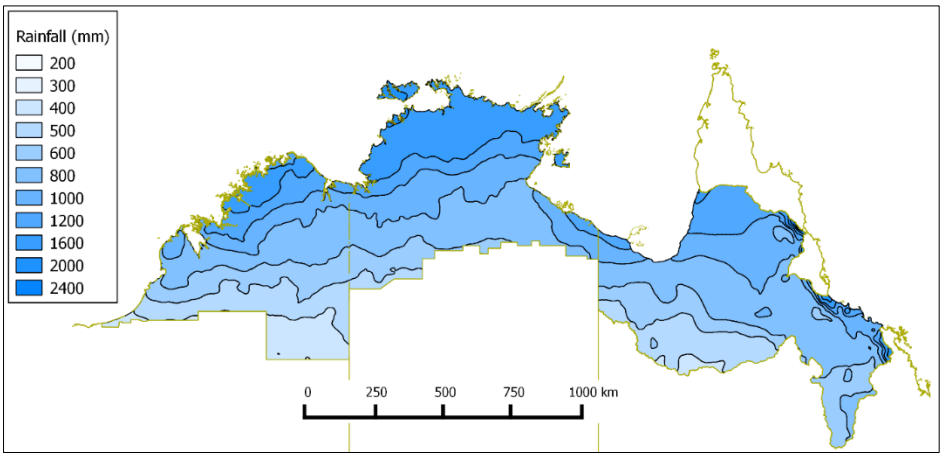


Figure 2. Annual average rainfall in the Monsoonal North

Source of data: Australian Bureau of Meteorology (2015)[2]

Cyclones cause significant wind damage, flooding and coastal erosion in the region in most years, most usually between November and April[3]. On average, 4.7 cyclones affect the Queensland coast each year, with cyclone frequency being almost twice as high during La Niña years as in El Niño years. The Gulf of Carpentaria averages two cyclones a year, while the Arafura and Timor Seas average one a year. The frequency of cyclones affecting any single location is much lower than these regional frequencies. Most of the region experiences a cyclone once in every eight years. The highest frequency is in the northwest, with Broome experiencing a cyclone once every four years. Nearly half the cyclones in the northern region and Gulf of Carpentaria are in the least severe category (Category 1), with progressively fewer cyclones of increasing intensity. Less than 5% of cyclones are classed as Category 5.

Soil and vegetation

Soils in the Monsoonal North are generally infertile, with deficiencies in nitrogen, phosphorus and sulphur[4]. Poor soils present significant challenges to agricultural development[5]. The region is often referred to as tropical savanna, which classically means that the grass layer is an important component of the vegetation under a lightly-treed area[4]. However, this belies the diversity of vegetation communities (Figure 3). While much of the region is vegetated by different forms of eucalypt woodland with an understorey of tussock or hummock grasses, other communities include mesic rainforests on Queensland's near coastal ranges and monsoon scrubs dotted throughout the region across fire-protected refugia. Acacia scrublands become more important in the west and spinifex

grasslands in the inland. Coastal communities are particularly diverse, ranging from marine grasslands and mudflats to mangroves.

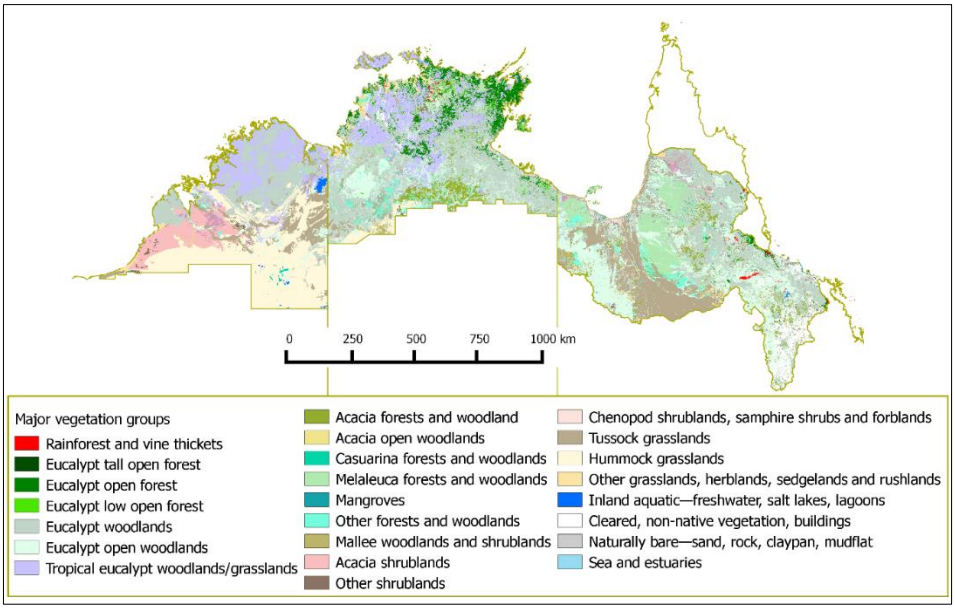


Figure 3. Vegetation of the Monsoonal North

Source of data: National Vegetation Information System Version 4.1[6]

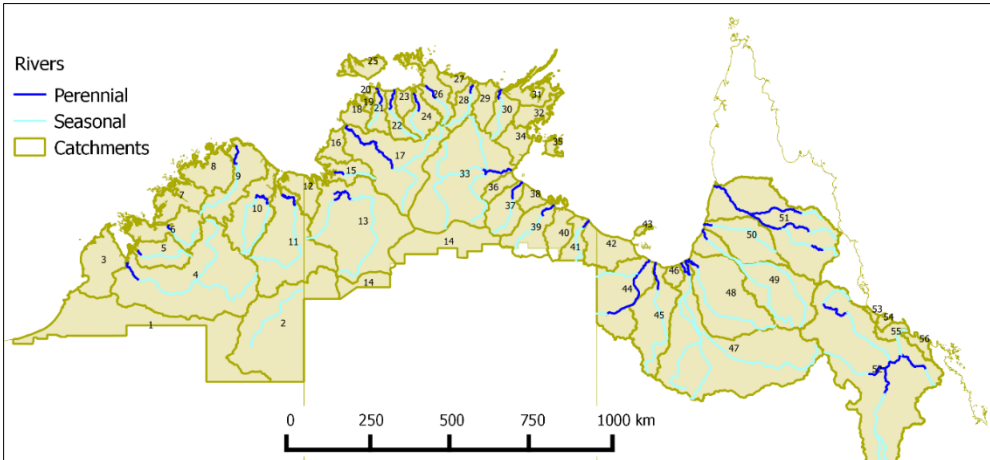
Biodiversity

Northern Australia is recognised for its high biodiversity values and intact landscapes[7]. The region's terrestrial, freshwater aquatic and marine ecosystems support an abundance of plants and animals unique to the region. However, biodiversity decline is a serious concern, with high rates of extinctions among critical weight-range mammals[8] and the health of coral reefs in decline. Although only a small proportion of the region has been cleared of its native vegetation, biodiversity is increasingly impacted by inappropriate fire regimes, weeds, exotic herbivores, including livestock, exotic predators, pathogens and disease, groundwater and surface water extraction[8]. Its rivers and estuaries are largely in good condition[9,10]. However, degradation of marine systems is a concern with marine debris being a particular problem across the north[11,12] and run-off pollution in the Great Barrier Reef[13].

Depopulation and social dysfunction are now recognised as a significant threat that reduces the environmental management capacity[8]. Climate change is already affecting marine systems, with increasing frequency of coral bleaching events[14]. As it intensifies, it is expected to exacerbate these problems as it puts more pressure on systems already under stress[15,16].

River systems

The region's rivers account for close to half Australia's river discharge[17]. However, only a small proportion of rivers are perennial and flow is mostly highly seasonal, with about 90% occurring between December and March[18,19]. There is considerable pressure to capture some of this flow for agricultural development[20]. The Burdekin and associated rivers in the north-east drain to the Great Barrier Reef (GBR), so their management impacts on GBR water quality (Figure 4). All other rivers drain to the northern coastline with rivers to the west of Cape York Peninsula from the Timor Sea Drainage Division.



Label	Name	Label	Name	Label	Name
1	Sandy Desert	19	Darwin / Blackmore R	38	Rosie R
2	Mackay	20	Elizabeth / Howard R	39	McArthur R
3	Cape Leveque Coast	21	Adelaide R	40	Robinson R
4	Fitzroy R	22	Mary R	41	Calvert R
5	Lennard R	23	Wildman R	42	Settlement Ck
6	Isdell R	24	South Alligator R	43	Mornington Is
7	Prince Regent R	25	Bathurst & Melville Is	44	Nicholson R
8	King Edward R	26	East Alligator R	45	Leichhardt R
9	Drysdale R	27	Goomadeer R	46	Morning Inlet
10	Pentecost R	28	Liverpool R	47	Flinders R
11	Ord R	29	Blyth R	48	Norman R
12	Keep R	30	Goyder R	49	Gilbert R
13	Victoria R	31	Buckingham R	50	Staaten R
14	Wiso	32	Koolatong R	51	Mitchell R
14	Wiso	33	Roper R	52	Burdekin R
15	Fitzmaurice R	34	Walker R	53	Black R
16	Moyle R	35	Groote Eylandt	54	Ross R
17	Daly R	36	Towns R	55	Barratta
18	Finniss R	37	Limmen Bight R	56	Don R

Figure 4. Drainage basins of the Monsoonal North

Source of data: Rivers: Geoscience Australia (2004)[21]; Catchments: Australian Surveying and Land Information Group (2000)[22]

Land use and tenure

Nearly two-thirds of the Monsoonal North is pastoral lease, and one-fifth is Aboriginal land (Figure 5, Table 1). Distribution of land tenures varies across the region. Pastoral leases dominate the Queensland NRM regions and the Gulf Savanna and constitute almost half of the Kimberley. The Kimberley also has large areas of Aboriginal pastoral leases and Crown Land. The highest proportion of Aboriginal land is in the Top End. Most of the freehold land is in the Queensland NRM regions, where there is very little Aboriginal land outside Aboriginal pastoral leases.

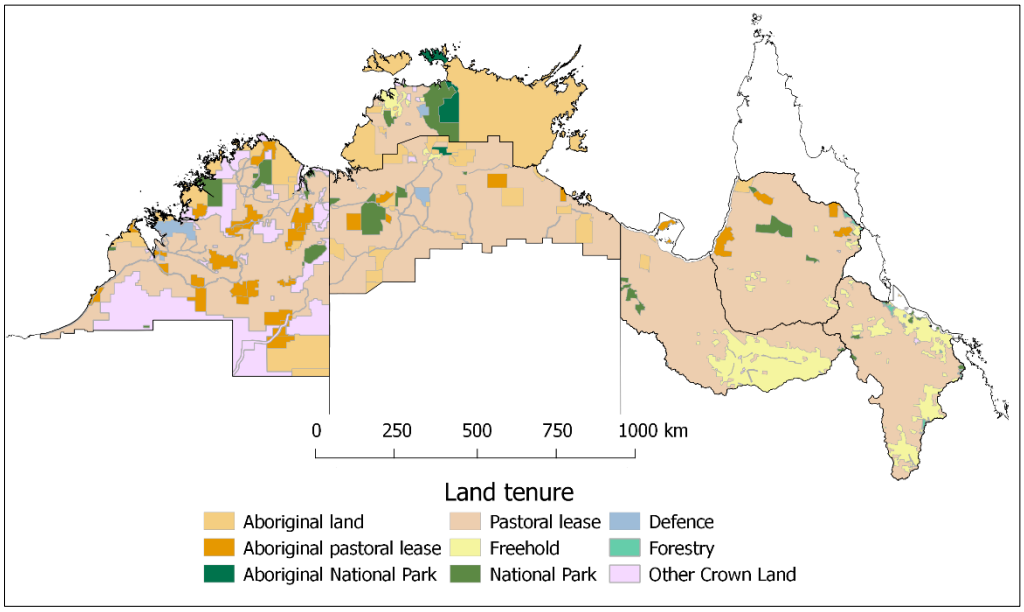


Figure 5. Land tenure across the Monsoonal North

Source of data: Geoscience Australia (2004)[23]

NB: Tenure changes that have occurred since 1993 may not appear on this map.

Table 1. Land tenure across the Monsoonal North

Source of data: Geoscience Australia (2004)[23]

NB: May not include tenure changes that have occurred since 1993.

	WA	NT			Qld		
	Kimberley	Top End	Gulf Savanna	Southern Gulf	Northern Gulf	Burdekin Dry Tropics	Monsoonal North
Area (km^2)	420,000	176,500	311,000	195,200	194,000	146,000	1,442,700
Aboriginal land	**22.7**	**73.1**	**15.2**	**1.5**	**5.6**	**-**	**19.6**
Freehold	-	68.3	12.0	0.9	1.2	-	11.0
Leasehold	10.5	-	2.8	0.6	4.4	-	4.3
Reserve	12.2	-	-	-	-	-	3.6
National Park	-	4.8	0.3	-	-	-	0.6
Non-Aboriginal land						**100.0**	
Leasehold	43.7	14.1	78.9	73.1	88.9	75.4	61.1
Freehold	-	3.0	0.4	23.4	2.2	21.9	6.2
Nature conservation	3.5	8.3	3.4	1.4	3.0	1.2	3.5
Defence	1.4	0.7	0.7	-	-	0.1	0.7
Forestry	-	-	-	-	0.4	1.1	0.2
Other Crown Land	28.7	0.8	1.4	0.5	-	0.3	8.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Population

Even though the Monsoonal North covers 19% of Australia's land mass, less than 2.5% of Australia's population lives there (Table 2, Figure 6). Just over half of this population lives in the major cities of Darwin, Townsville and Mount Isa. Outside these cities population density averages one person per six square kilometres. Population density is greatest in the Burdekin Dry Tropics and Top End and lowest in the Southern and Northern Gulf.

Table 2. Population statistics for the Monsoonal North

Source of data: Australian Bureau of Statistics (2014)[24]

	Kimberley	Top End	Gulf Savanna	Southern Gulf	Northern Gulf	Burdekin Dry Tropics	Total
Number of people	39,890	166,375	26,011	26,182	8,969	283,718	551,145
Percentage of Australian population	0.17	0.72	0.11	0.11	0.04	1.23	2.38
Number of people outside major cities	39,890	51,075	26,011	10,536	8,969	100,111	261,383
Population density outside major cities (people/km^2)	0.09	0.29	0.08	0.05	0.05	0.69	0.17

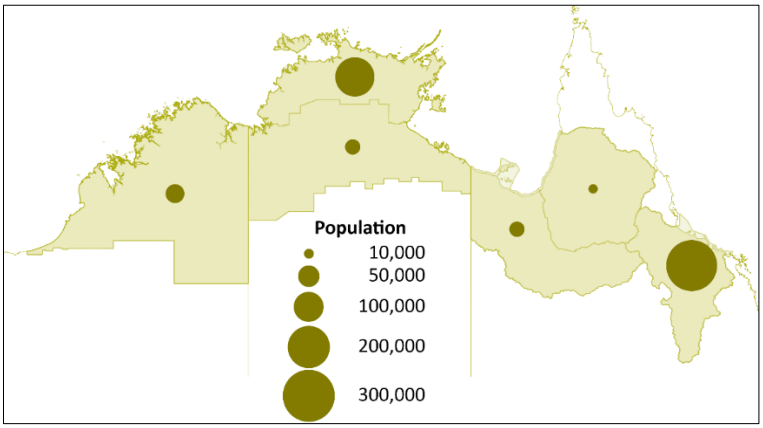


Figure 6. Population of the Monsoonal North

Source of data: Australian Bureau of Statistics (2014)[24]

The region has a high Indigenous population. Representation of Indigenous people increases from east to west (Table 3) and with remoteness. Across Australia, Indigenous people make up 1% of the population in major cities, 3% in inner regional areas, 6% in outer regional areas, 15% in remote areas and 49% in very remote areas[25].

Table 3. Population estimates for Indigenous people living in northern Australia

Source of data: Australian Bureau of Statistics (2013)[26]

Indigenous statistical region	Total population	Indigenous population	
	(no.)	(no.)	(%)
Western Australia			
Broome	15,737	5,481	34.8
West Kimberley	8,955	4,930	55.1
Kununurra	12,099	6,611	54.6
Northern Territory			
Darwin	131,619	14,660	11.1
Jabiru - Tiwi	15,586	12,151	78.0
Katherine	19,602	10,543	53.8
Nhulunbuy	16,899	10,896	64.5
Queensland			
Mount Isa	34,026	9,358	27.5
Townsville - Mackay	385,525	27,607	7.2

The northern beef industry

The northern cattle herd

An assessment of the northern beef industry based on numbers alone reveals a success story. Two-thirds of the Monsoonal North is currently used for cattle grazing (Table 4), accounting for approximately one-fifth of Australia's cattle herd and more than one-third of the cattle in northern Australia[27].

Table 4. Numbers of cattle in the Monsoonal North

State/ Territory	Region	Land area	Pastoral enterprises		Cattle	Sources
		(km^2)	(no.)	(% of region)	(no.)	
WA	Kimberley	422,000	94	53	750,000	28,29
NT	Top End/Savanna Gulf	487,500	148	55	1,000,000	30,31,32
Qld	Southern Gulf	175,000	?	90	1,593,000	33,27
Qld	Northern Gulf	194,000	?	92	933,000	33,27
Qld	Burdekin Dry Tropics	141,000	977	85	1,432,000	27,34
Total		**1,419,500**	**1,219**	**66**	**5,708,000**	

After the industry rapidly spread across the region in the late 19th century, its growth was initially aided by low wages paid to Aboriginal stockmen until the late 1960s; progressive introduction of drought-hardy and tick-resistant Brahman stock (*Bos indicus*) from the 1940s; and the shift away from sheep from the 1960s[35-37]. While affected by a major market slump in the 1970s, stock numbers doubled across Queensland, the Northern Territory and Western Australia between 1965 and 2014

(Figure 7). Subsequent growth has been facilitated by eradication of brucellosis and tuberculosis in the 1980s[a]; infrastructure development and management changes, including the introduction of pasture species; supplementary feeding; hormone growth promotants; and improvements in herd management.

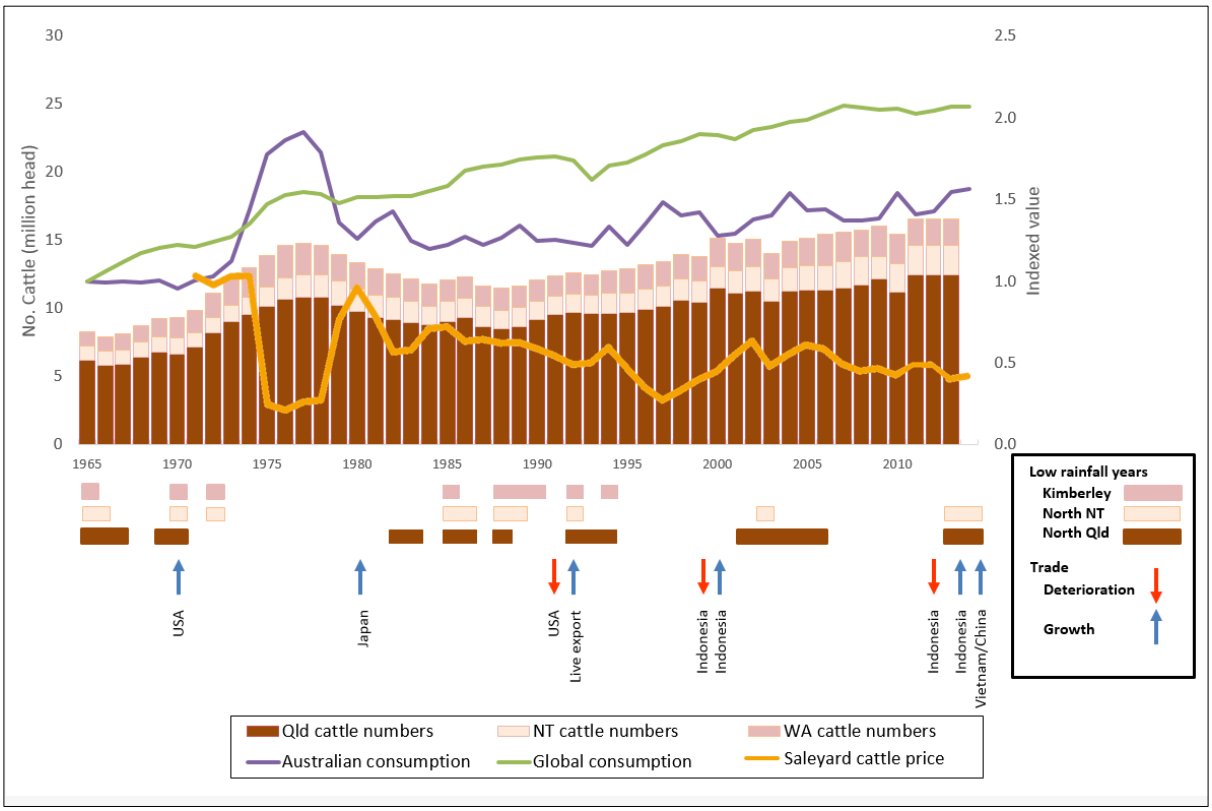


Figure 7. Growth of the northern cattle herd in relation to consumption, demand and rainfall

Source of data: Cattle numbers: Australian Bureau of Statistics (2013)[38]; Beef consumption: United States Department of Agriculture (2015)[39]; Saleyard prices: Mathews and Ryan (2015)[40]; Rainfall: Australian Bureau of Meteorology (2015)[2]

Growth in cattle numbers since 1965 has also been subject to fluctuations in domestic and global demand, prices and trade restrictions. Resultant changes in stocking rates have had temporal implications for grazing pressure and land condition. While beef consumption and stock numbers have generally increased (with some variations) saleyard prices have decreased in real terms affecting industry profitability (see Profitability).

Demand for beef was stimulated by global economic growth in the early 1970s[41]. Herd-building to take advantage of the high prices followed both in Australia and overseas, and stocking rates in the north began to exceed carrying capacity. In the least resilient land systems, intensification of the northern

[a] With replacement herds further increasing the proportion of Brahman stock

grazing lands was accompanied by degradation, with negative impacts on production, biodiversity and water quality[35,42,43]. Over-supply saw the price of beef collapse in late 1973[41]. Cattle numbers then further increased as several of Australia's trading partners imposed trade restrictions, and favourable climatic conditions allowed stock to be retained rather than sold at low prices. Stocking rates escalated. Improvement in prices at the end of the 70s saw an increase in cattle sales, only briefly interrupting the northern herd's growth. At that stage, the north was only exporting chilled boxed beef.

A cattle glut in the United States of America in the 1990s lowered demand and prices for Australian boxed beef. At the same time feedlots were being established in south-east Asia to service a growing demand for freshly-slaughtered beef[44]. Northern Australia was well placed to supply the Brahman cattle demanded by the Asian market, and further adapted to this market by reducing the age at which animals were turned off breeding properties[45]. This growth of the live-export market coincided with drought, and there was only moderate growth in cattle numbers[37].

A rising Australian dollar through the early 2000s, combined with high domestic prices, saw Australian beef exports fall[45]. In 2010, aiming to have a self-sufficient beef industry, Indonesia imposed import quotas on Australian beef and a weight limit of 350 kg[37]. In 2011, exports of live cattle to Indonesia were suspended for two months over welfare concerns[46] and only recommenced after the Australian Government was satisfied that a system[47] was in place to safeguard animal welfare[48], and the Indonesian Government was prepared to resume issuing permits. When trade recommenced, Indonesia reduced import quotas, issuing permits on a quarterly basis. The Australian herd reached record numbers in 2013[49]. Prices once again slumped[50]. Concerns about overstocking led some producers to shoot cattle, rather than let them starve[50].

By the end of 2014, following successful implementation of the Exporter Supply Chain Assurance Scheme, exports to Indonesia had almost returned to pre-2011 levels with 730,000 head exported to this market. New markets opened and exports reached record levels. This growth was only possible through investment in specialised infrastructure, such as holding yards at ports and specially fitted-out ships[37]. Initially, not all producers benefited from this live-export market. Most cattle came from properties that were close to export facilities and had all-season access, especially when demand weakened[45]. Unfortunately, once the Indonesian market reopened, many of the cattle that had originally been destined for this market now exceeded the 350 kg weight limit[51]. Producers left with these "out-of-specification" cattle had difficulty selling stock because of a lack of market appeal and high cost of transport to alternative markets, leading to overstocking[51]. Average incomes of northern

beef producers suffered a 43% decline between 2011-12 and 2013-14, 36% of producers recording negative farm cash incomes and 12% of producers were in a position where they are unable to service further debt[52].

Drought conditions persisted in western Queensland through 2014, causing further stress on enterprises, and forcing producers to offload stock[a]. Stock numbers were so low that some saleyards suspended trading[b].

By the start of 2015, ongoing drought and record exports had reduced the size of the cattle herd[49], with the expectation that it would take years to recover to peak levels[c]. Reduced numbers of cattle available for slaughter and export, increased global demand and the opening of some new markets[49] drove prices higher and forced northern exporters to source cattle from southern states[d]. By October 2015, prices were higher than they had been in decades and were expected to remain high[53]. Sustained price increases returned optimism to the industry[e]. However, drought-affected producers with few stock were unable to take advantage of these prices, which made the cost of restocking after the drought breaks prohibitive[f].

Industry-wide, continued growth in demand, a reduced Australian dollar and high global prices, are expected to maintain improved incomes for Australian beef producers in the short-term[54]. In the longer term, Australian beef production is expected to continue to grow, and be 80% greater in 2050 than it was in 2007[55]. Whether this is achieved will depend on a number of factors. These include global supply and demand dynamics; trade agreements and market access; policies and programs of government, industry and financial institutions; adequacy of infrastructure (roads, ports, saleyards, abattoirs); the pastoral industry's capacity to weather current and emerging stresses (including climate change) and to adopt business models and management practices necessary to support intensification; and the capacity of the land and water resources to support increased stock production.

[a] http://www.abc.net.au/news/5982842
[b] http://www.abc.net.au/6466804
[c] http://www.abc.net.au/6847786
[d] http://www.abc.net.au/news/6017028
[e] http://www.abc.net.au/6158822
[f] http://www.abc.net.au/news/6814294

Markets

In 2003, 62% of Australian beef was exported[49]. With stagnating domestic and growing global demand (see Domestic and global demand), this figure had grown to 74% by 2015. While exports are expected to hover around 70% in the short-term[49], growth is expected to continue as a result of increased production, with exports projected to more than double by 2050[55]. Since 2000, the majority of beef exported from northern Australia has been sold to Indonesia[37,56]. Exports to Indonesia peaked at 720,000 head in 2009-10, but steadily declined over the next three years, reaching a low of 270,000 in 2012-13 as a combined result of the live-export ban and subsequent trade restrictions by the Indonesian government (see Profitability). In 2014, sales to the Indonesian market had nearly recovered to peak levels, with 700,000 head exported and a total of 1.2 million head to all destinations[49]. Other destinations for northern cattle were unaffected by the ban, and exports to many destinations increased over this period. In particular, China and Vietnam have become significant destinations for northern cattle in the last five years, and now receive 8 and 12% of Australia's total live beef exports respectively[56]. Live exports to China have increased sixfold since 2008-09, and Vietnam has risen from an almost non-existent base to being the second most important destination for Australian cattle in 2013-14. Most of the cattle to both these destinations have been sourced from northern Australia. In the first three quarters of 2015, live exports to Indonesia were 22% lower than in 2014, and income generated from these exports 12% lower. This has been offset by increases in exports to Vietnam[57]. Volatility in the live export sector (which averaged 21.5% of total volume of beef exports between 1998 and 2010, and fell to 16.2% in 2011) affects availability and price in the rest of the market. Prices slumped following the live export ban and have escalated with recovery of this market. This may change as more processing facilities are built in the north, which will improve the capacity of northern producers to export chilled beef (see Supply chain). In contrast to the volatile live export numbers, Australian packed beef has been exported at fairly consistent levels in recent years (Figure 8).

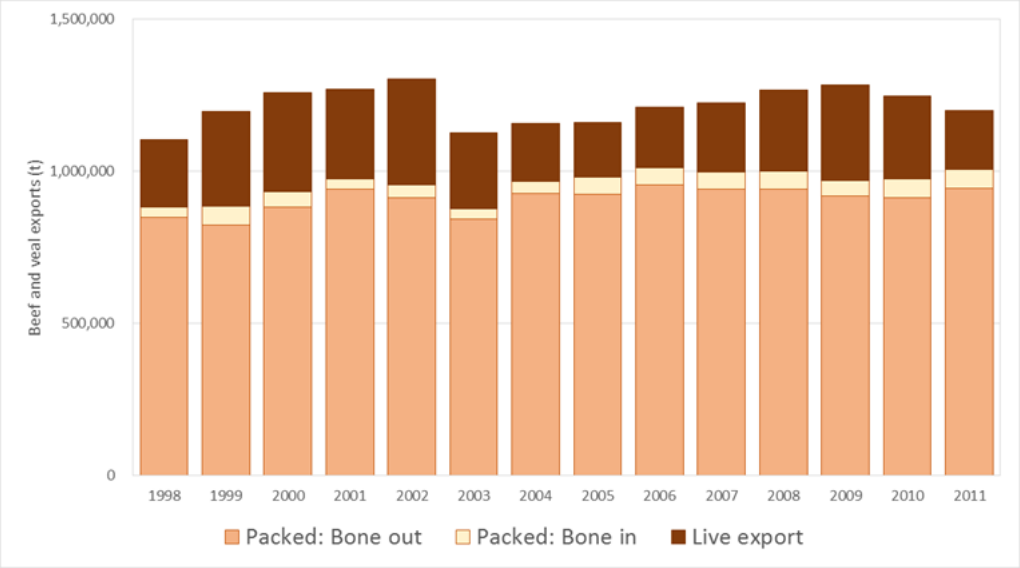


Figure 8. Australian beef and veal exports

Source: Australian Bureau of Statistics (2015)[58]

Cattle enterprises

The cattle industry in the Monsoonal North is based on extensive grazing of native pastures with low stocking rates[30,59,60]. Introduced pasture species are used to a limited extent on most properties. Although the region supports a range of production systems (Table 5), poor productivity means most enterprises breed animals for the low-value live export trade or for fattening and finishing elsewhere. Calving generally occurs at the end of the dry season and cattle are mostly sold at the start of the dry season, when weaner steers or store steers are turned off for the southern market, live-export or finishing[61]. Most fattening occurs outside the region on coastal pastures or in feedlots (Figure 9). Within the region, fattening and finishing is limited to areas of fertile native pastures (such as Mitchell Grass *Astrebla* spp.), on introduced pastures or in feedlots.

Table 5. Beef cattle enterprises found in the Monsoonal North

Source: Ausvet Animal Health Services (2006)[62]

Enterprise focus	Activities	Kimberley	Top End	Katherine	Southern Gulf	Northern Gulf	Burdekin Dry Tropics
Breeding	Breed cattle destined for sale at weaning	+	+	+	+	+	+
Breeding & growing	Breed cattle for sale as store yearling cattle to be finished at a feedlot or specialist finisher	+	+	+	+	+	+
Breeding & finishing	Breed and finish cattle for sale for slaughter, generally for the domestic market				+	+	+
Growing & backgrounding	Acquire weaner or yearling steers for growing-out to weights required by specialised finishers or lot-feeders	+	+	+			

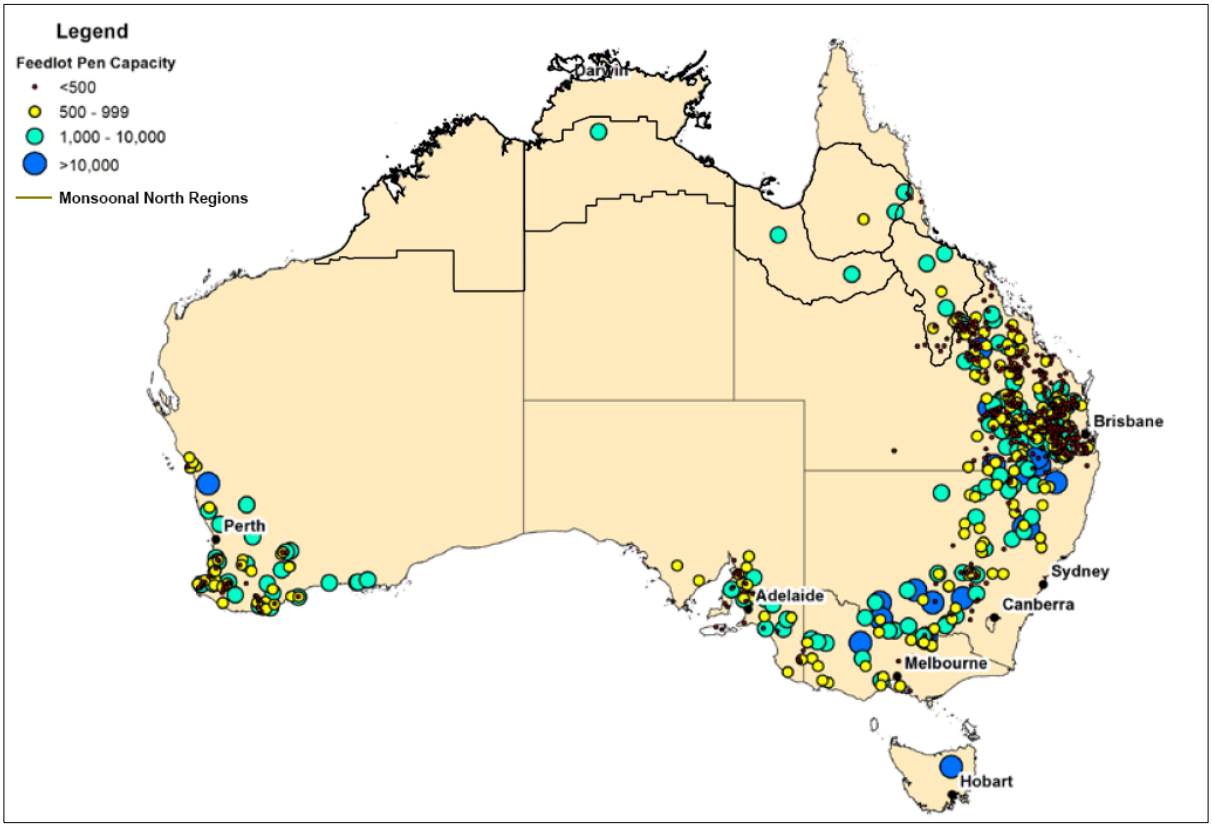


Figure 9. Location of feedlots in relation to the Monsoonal North

Source: Adapted from Australian Lot Feeders' Association

Indigenous pastoralism

Indigenous people have a long association with the northern beef industry, with many Aboriginal stockmen providing cheap labour on cattle stations until the equal pay decision of 1967[63,64]. Indigenous pastoralism is a significant and growing part of the northern beef industry. Efforts to develop Indigenous pastoralism have adopted a vertical integration approach spanning resource development; education and training; cattle breeding, fattening, processing and live-export, with the addition of pastoral tourism[65-67]. Along with increasing the number of properties in Indigenous hands and employment opportunities for Indigenous people, Indigenous-owned lands offer the opportunity to increase the size of the northern Australian cattle herd. Herd-building on Indigenous land in the last decade or so has increased cattle numbers in the Northern Territory by around 100,000 head, and there are plans to double the herd on Indigenous land in the Kimberley through improving land condition and investing in watering points, fencing, access roads and stock handling facilities[37,59,68]. However, there is some question as to whether these properties can sustainably support viable herds[69].

Development of Indigenous pastoralism in the Monsoonal North is supported by government agencies and the Indigenous Land Corporation (ILC)[a]. The ILC operates 14 pastoral operations across Australia and runs approximately 90,000 head of cattle[67]. Six of these properties are in the Monsoonal North. In 2013-14, ILC employed 137 Indigenous people and hosted an additional 148 Indigenous trainees. ILC operates breeding and fattening enterprises, runs a small abattoir and butcher shop in the Top End (which supplies Indigenous communities and niche outlets), and has an export depot outside Broome.

The Western Australian Government is investing in Indigenous pastoralism in the Kimberley region, by underwriting irrigation infrastructure needed for pasture crops[70]. It aims to increase the size of the cattle herd on the Aboriginal-owned cattle station, Mowanjum from 1,500 to 10–15,000 head by building a centre-pivot irrigation system that draws on local groundwater to provide dry season feed for a fattening operation. It will also provide a training facility for Derby TAFE's Pastoral Management Studies program for both Mowanjum and Derby students.

In the Northern Territory, the Indigenous Pastoral Program (IPP) aims to increase Indigenous participation in the pastoral industry and increase cattle numbers on Indigenous land to around 200,000[71]. Initiated in 2003, IPP operates through a partnership between ILC, Northern Land Council (NLC); Central Land Council (CLC) and the Department of Primary Industry and Fisheries, Northern

[a] A government entity established to assist Indigenous people to acquire and manage land to achieve economic, environmental, social and cultural benefits

Territory (DPIF NT); the Northern Territory Cattlemen's Association (NTCA) and the Australian Government. Achievements of the program to 2104 include[72,73]:

- An additional 90-100,000 cattle on Indigenous-owned land
- An additional 24,000 km^2 of land fenced, watered and in pastoral production
- 25 new grazing licenses on Indigenous-owned land covering 34,000 km^2
- 14 natural resource management audits on Indigenous held pastoral enterprises
- Development of 23 business/property management plans.

An Indigenous Pastoral Project[74] was also established within the Rural Industries Research and Development Corporation (RIRDC) as part of the northern Australia Beef Strategy (see Northern Australia Beef Industry Working Group). It aims to help Indigenous pastoral businesses become commercially viable and sustainable. Its main achievement has been the production of a pastoral management manual for the Indigenous pastoral sector[66].

Not all pastoral properties purchased on behalf of Indigenous communities will remain as pastoral operations. Fish River (1,825 km^2) in the Top End and Tallaroo Station (315 km^2) in the Northern Gulf were purchased to establish Indigenous Protected Areas[75], with land management on Fish River being supported through fire abatement projects[76]. Land on Cape York Peninsula transferred to Aboriginal ownership since March 2012 included excision of 3,257 km^2 of two pastoral properties to create new National Parks [77]. However, some of the 6,628 km^2 of new Aboriginal freehold land on Cape York Peninsula is likely to be used for grazing.

Profitability

Up until the start of 2015, profitability of the northern cattle industry had not improved in 30 years, and had declined for the best performing enterprises (Figure 10). This is because costs of cattle production increased thirty-fold from 1950 (i.e. stayed level in real terms), while income had only increased eight-fold (i.e. decreased 60% in real terms)[78]. Indeed, after interest payments are made, most cattle businesses make a loss and so are deemed to be unsustainable[78].

The direct costs of producing a 400 kg steer (labour, supplements and fodder, agistment, animal health and freight and selling) rose by 150% between 2001 and 2008, and total costs of production increased by 54%[79]. These estimates do not account for lost production as a result of Weeds (ca $1,000 million/year industry-wide), Pest animals (ca $36 million/year) and Disease and parasites (ca $390

million) as documented in subsequent sections of this report, or of natural disasters—for which costings are not available. In addition, cattle theft has been estimated to cost the industry between $1.5 and $2 million a year in Queensland alone[a]. Costs would be even higher without current biosecurity efforts, which are estimated to save beef producers an average of $12,927 per enterprise, largely through the through preventing the introduction of Foot and Mouth Disease and the spread of exotic pests, weeds and diseases[80].

While most enterprises have offset cost increases by reducing their labour costs, this is not an option for the top 25% of businesses, which are already operating at a high level of input efficiency. Hence, the gap between the best performing and average businesses is closing. Corporation-run businesses are the least flexible in their cost structure, and can be outperformed by well-run family businesses[78].

While there is marked variation in enterprise performance across the region, the majority of northern beef enterprises are not considered viable in the long term[78,79] (Figure 10). Between 2001-2012, enterprises performing in the top 25% made an average profit of $66 per head of cattle sold compared to an industry average of $6 per head[78]. Performance was found to be related to good management, rather than constrained by environmental factors. Top performance was characterised by reproductive rates that were higher, mortality rates that were lower and sale weights that were better than industry averages. These enterprises, therefore, demonstrate that adoption of management practices to improve herd performance (as outlined in the next section) flows through to improved enterprise profitability. Top performers also had larger herds, high income, low operating expenses, high labour efficiency and low ratios between asset value and herd size. Businesses with fewer than 800 head typically made a loss[78]. Even the best performing businesses in this size class averaged losses of nearly $14 per head.

[a] http://www.abc.net.au/news/6322062

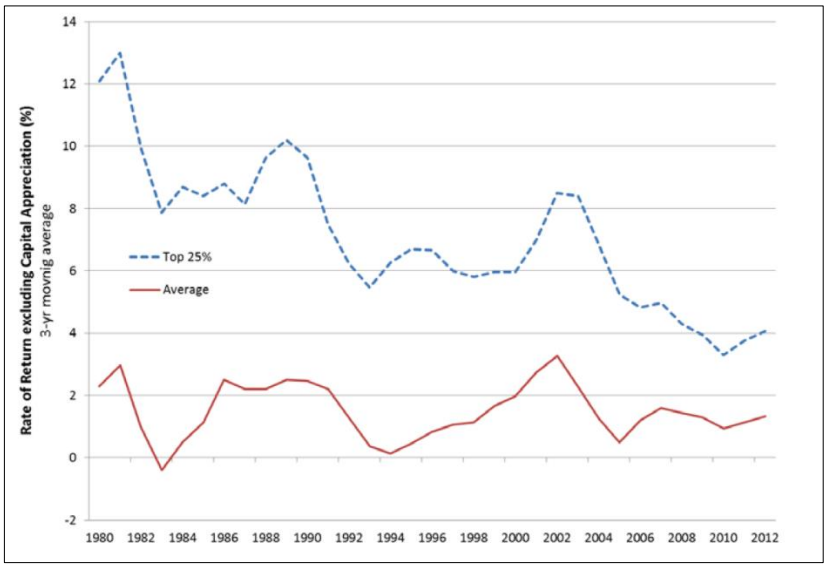


Figure 10. Long term profitability of average and top 25% northern beef businesses

Source: McLean, Holmes, Counsell, Bush AgriBusiness Pty Ltd and Holmes & Co. (2014)[78]
Reproduced courtesy of Meat & Livestock Australia Limited - www.mla.com.au

Note: Includes enterprises in the Monsoonal North, Pilbara, Barkly, Alice Springs and Cape York Peninsula.

The average price paid per head (adult equivalent/AE) declined between 2004 and 2014 from close to $200 to around $160, and cattle prices have rarely been higher than they were in the 1970s[78]. Average income of surveyed northern beef properties in 2013-14 was 43% lower than it was in 2012-13, and 48% below the ten-year average[52]. Northern beef enterprises made an average loss of $63,000 in 2013-14[a], following on losses of $6,100 in the previous year. As a result, off-farm income is particularly important for propping up small enterprises, which receive more income from off-farm activities than they do from cattle production (Figure 11). While off-farm work improves financial capacity for cattle and land management, it also restricts time and physical capacity available for on-farm work[81]. Off-farm work also increases in times of drought, placing considerable stress on family businesses[82].

[a] Income minus expenses

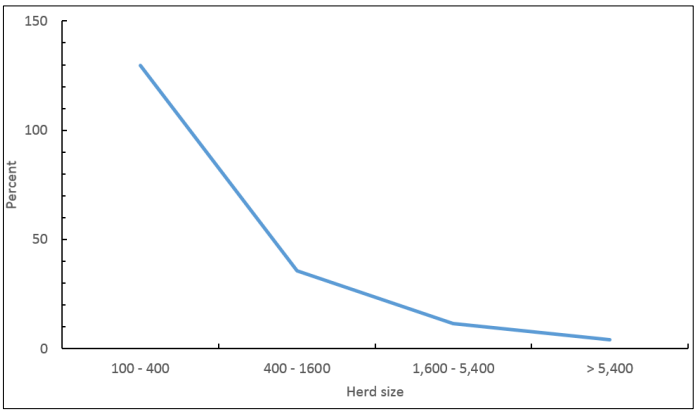


Figure 11. Ratio between off-farm and on-farm income in relation to herd size

Source: Data from Martin, Phillips, Leith and Caboche (2014)[83]

The price of pastoral land rose steeply between 1990 and 2008 (Figure 13), reflecting land speculation rather than productivity, which has increased by less than 1% a year since 1977[52]. At the same time, debt levels across the region increased as pastoralists were encouraged to borrow against their growing asset base. Increased debt has resulted in interest payments reaching 13% of farm income[52]. Cattle producers responding to the Gulf Cattlemen's Association survey suggested bank managers actively encouraged over-extended borrowing during this period[84]. This strategy came unstuck for pastoralists when land prices collapsed in 2008. The same cattlemen reported the value of their properties declined by an average of 28% between 2010 and 2014[84].

Northern Territory and Kimberley properties have increasingly specialised in supplying cattle for the live-export market, while Queensland producers export both live cattle and packed beef (Figure 12)[52,78]. The immediate impact of the ban on cattle enterprises was assessed by surveying pastoralists in the Kimberley and northern half of the Northern Territory[a]. When the live-export trade with Indonesia was suspended in 2011, almost all pastoral enterprises were intending to send cattle to Indonesia. For just over half of the enterprises, at least 50% of the cattle to be sold that year had been intended for the Indonesian market; and three-quarters of enterprises had cattle ready to send when the ban occurred[46]. Queensland pastoralists had lower exposure to the market's suspension. Just over a third of pastoralists surveyed[b] were intending to send cattle to Indonesia, only 6% to sell more than 50% of their turn-off, and only 13% had cattle ready to send.

[a] 55 beef enterprises in the Kimberley, Top End and Gulf Savanna NRM regions
[b] 89 businesses surveyed in the three statistical regions covering the Queensland section of the Monsoonal North

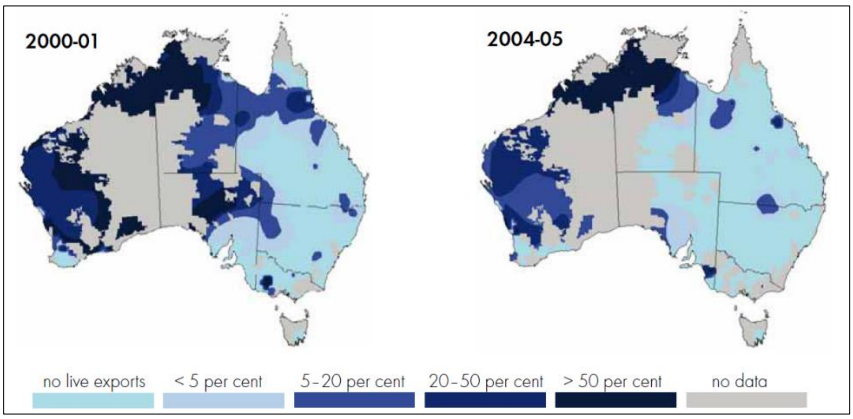


Figure 12. Regional patterns of reliance of the beef industry on the live export trade

Source: Martin, Mellor and Hooper (2007)[45]

Across northern Australia, most pastoralists affected by the live-export ban responded to its suspension through adjusting their business practices (Table 6). Stocking rates were increased on 11% of properties, and 33% of enterprises were of the opinion that land degradation would occur should the suspension extend beyond the end of July 2011[46].

Table 6. Adjustments made to northern cattle businesses in response to the live export suspension or intended with continuation of suspension beyond July 2011

Source: ABARES (2011)[46]

N/A = not applicable

Adjustment	Kimberley/ Pilbara		Northern Territory		North Queensland	
	Made (%)	Intended (%)	Made (%)	Intended (%)	Made (%)	Intended (%)
Defer/reduce expenditure	80	95	37	86	23	51
Seek alternative market	53	94	43	88	18	61
Change mustering plans	76	82	48	89	14	50
Increase/adjust stocking rate	23	81	17	75	25	47
Adjust herd management	n/a	73	n/a	70	n/a	41
Re-muster some areas	n/a	55	n/a	86	n/a	35
Reduce staff	26	54	35	66	2	26
Renegotiate loans/defer payment	56	11	61	3	22	4
Return stock to paddocks	24	n/a	54	n/a	15	n/a

Around 5% of businesses indicated that they would be unlikely to continue to operate beyond a few months if the suspension continued. Combined with a halving of property prices from 2008 (Figure 13) and the Queensland drought, the live-export ban made mortgage repayments increasingly

difficult. In some cases[a], this was exacerbated by increasingly stringent mortgage arrangements, including increased interest rates and overdraft margins[84]. The majority of pastoralists surveyed (59%) considered that such changes to mortgage arrangements had adversely affected their businesses and a further 8% saw these changes being a threat to their long-term viability.

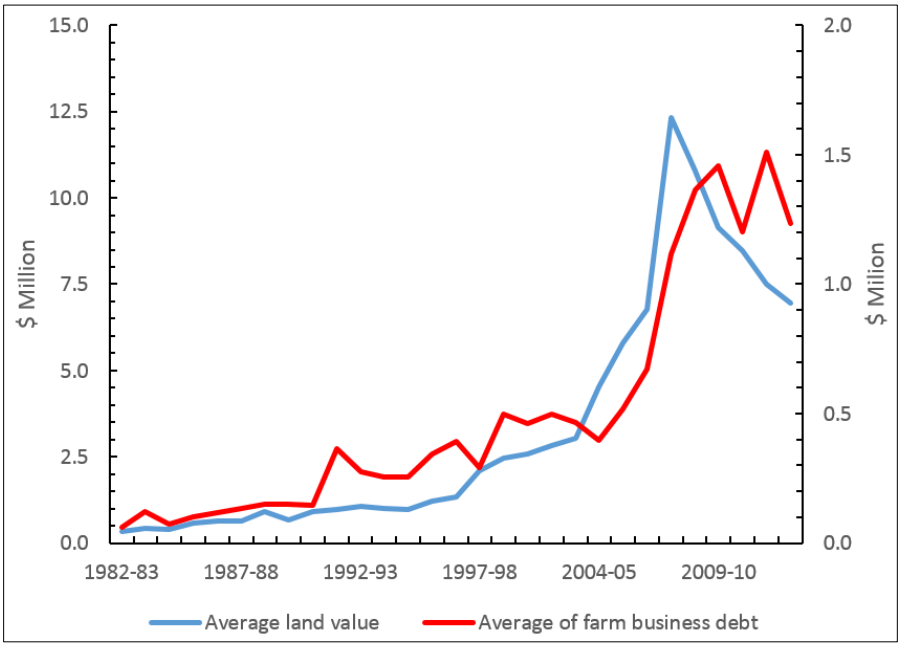


Figure 13. Land prices and debt burden of grazing properties in Monsoonal North

Source of data: Australian Bureau of Agricultural and Resource Economics and Sciences (2012)[86]

The percentage of Queensland beef producers in debt rose by 15% from 5,658 in 2009 to 6,499 in 2011[87]. Over this period, the industry's combined debt increased from $7.8 billion (54.5% of the state's total) to $9.2 billion (54%). In the Queensland gulf, the average debt of pastoralists to financial institutions increased by 22% between 2010 and 2014 and their debt to rural businesses increased by 600%[84]. In mid-2012, 23 Queensland gulf pastoralists were more than 90 days overdue on bank loan repayments (1.9% bank customers)[84]. By mid-2014, this figure has almost doubled. This has led to an increase in forced sales, particularly in Queensland. Although ANZ announced a 12-month moratorium on foreclosures in drought affected parts of Queensland in December 2014[b], other banks did not follow suit. Across the wider pastoral industry, ongoing loss of equity has reduced capacity to provide

[a] 18% of respondents to Gulf Cattlemen's Association survey[85]
[b] http://www.abc.net.au/news/5961490

capital investment for infrastructure and other development[78]. The flow-on effects of reduced capacity to service debt on beef enterprise sustainability (including impacts on the health and well-being of pastoralists) and natural resource condition are dealt with in other sections of this document.

Despite spiralling debt, pastoral businesses in northern Australia still have relatively high equity in their businesses, averaging 89% in 30 June 2013[52]. This may explain why the Queensland Government considers the vast majority of these borrowers to be either viable in the long-term or potentially viable despite current debt-servicing difficulties[87]. This stands in contrast to industry assessments indicating the majority of northern beef enterprises to be unviable in the long term[78,79] and the majority of pastoralists surveyed in the Queensland gulf having no confidence in the industry's future in the region[88].

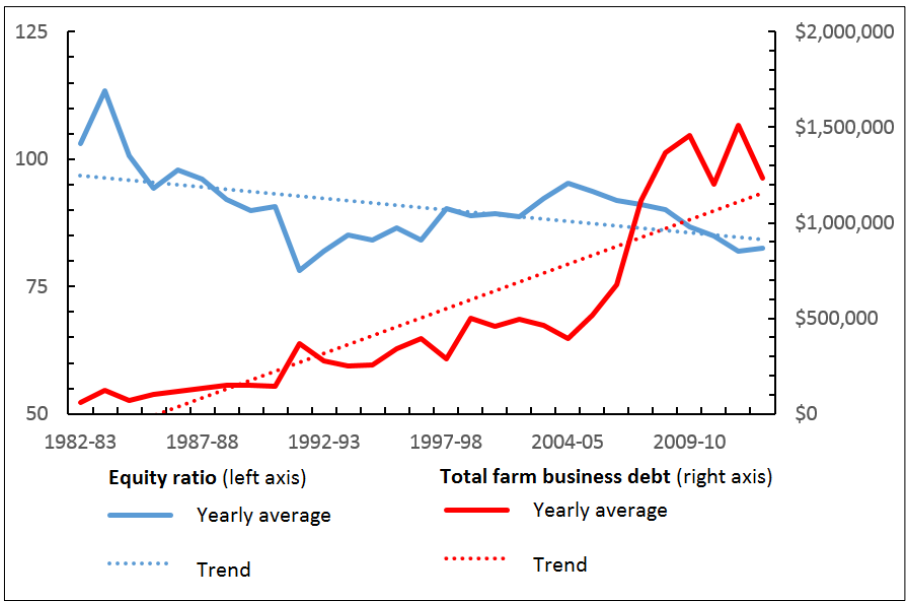


Figure 14. Average equity ratio and business debt of beef enterprises in the Monsoonal North

Source of data: Australian Bureau of Agricultural and Resource Economics and Sciences (2012)[86]

In October 2105, cattle prices were as nearly as good as they have ever been and demand from international and domestic markets is expected to grow [53] [4917]. A new abattoir in the Darwin rural area has provided access to the lucrative Asian packed meat market. However, increased beef cattle turn-off during the drought and in response to high prices has reduced the size of the Australian herd and, as a consequence, the value of cattle inventories[52]. The size of the Australian cattle herd is not expected to recover to 2013 levels in the foreseeable future[53], so many pastoralists may be unable to take advantage of these conditions. However, fortunes of pastoralists not affected by drought have

begun to improve, with Kimberley pastoral enterprises shifting from average losses of $150,000 per station in 2012-13 to profits of $650,000 in 2013-14[a].

Pastoralists' perceptions of issues influencing profitability are consistent with the above summary, with costs of production, market access issues and poor animal performance included in the top-rating issues affecting the profitability of grazing enterprises in the Northern Territory in 2011-12. On the other hand, weeds were the main issue considered to have most impact in environmental sustainability, followed by feral animals; drought and seasonal conditions; and government. These issues will be explored in subsequent sections of this report.

Table 7. Top rating issues affecting profitability of Northern Territory grazing enterprises in 2011-12

Source: Cowley et al. (2013)[30]

Issue	Respondents
	(%)
Cost of production	34
Market access/instability	28
Government regulation/policy	15
Live export ban	13
Poor reproductive performance/fertility	13
Cattle prices	11
Freight/transport costs	11

Table 8. Top rating issues affecting environmental sustainability of Northern Territory grazing enterprises in 2011-12

Source: Cowley et al. (2013)[30]

Issue	Respondents
	(%)
Weeds	30
Feral animals	16
Drought/seasonal conditions	13
Government	12

Governments provide financial support to pastoralists in the times of hardship[89]. Most support is provided only at times of declared droughts or natural disasters. One of the most significant forms of support is in the form of concessional loans for debt restructuring, to cover operating expenses or for drought recovery and preparedness activities.

[a] http://www.abc.net.au/news/6321066

As the vast majority of farmers have historically managed climate variability without government support, there is concern that drought assistance rewards poor management[90]. A Productivity Commission inquiry into government assistance programs concluded that government support should concentrate on assisting farmers to improve their business management skills and build self-reliance through research, development, extension, training and professional advice, and that support provided to farmers should be based on the level of hardship, not its cause[90]. Subsequently, there has been a move away from providing concessional loans to programs to assist producers to increase the capacity, efficiency and sustainability of their operations[91]. In 2013-15, the Australian Government also subsidised pest animal management in drought affected areas. In a move away from emphasising enterprise viability over providing subsidies, the Queensland Government granted drought-affected pastoralists grazing rights on National Parks in 2013[a].

Herd performance and market access

Indifferent pasture quality, resulting from the harsh climate and infertile and erodible soils, limits cattle growth rates and reproductive success in much of the Monsoonal North. Except on the Mitchell Grass country in the Southern Gulf, breeding performance is typically poor; with low pregnancy rates, high foetal and calf death rates; and high rates of cows "going missing"[60,92]. Low levels of productivity necessitate large properties and limited resources needed for infrastructure development and to minimise handling[78]. Lack of fattening and finishing options means that most enterprises are supplying the less profitable end of the market[59].

There is a great deal of variation across northern pastoral enterprises on all herd performance criteria. Some enterprises may be lucky and have exceptionally good soils, financial resources and staff, so achieve outstanding performance that cannot be emulated by all producers. However, on any country type or in any given region, it has been argued that anyone should be able to do as well as the pastoral enterprise that is ranked 25 percentage places from the top[60]. An example of this concept is provided (Figure 15) using the mature cows pregnancy rate. The median rate was 17%, meaning that, on half the enterprises, 17% or fewer cows were pregnant by the fourth month after calving. The top 25% of enterprises achieved a mature cow pregnancy rate of 31%, or more. This is called the 75th percentile rate, and is considered to be achievable by all enterprises. Using this approach, significant

[a] http://www.abc.net.au/news/5076268

improvements in all herd performance criteria are considered achievable on pastoral properties across the Monsoonal North (Table 9).

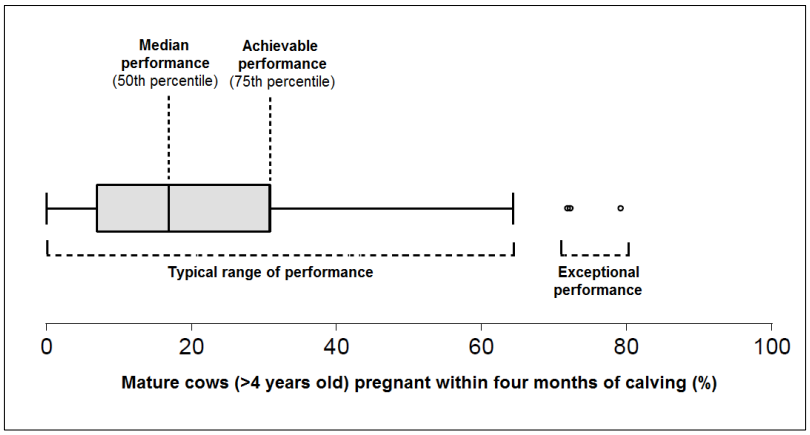


Figure 15. Example of a box plot explaining the concepts of median and achievable performance

Source: Adapted from McGowan et al. (2014)[60]

Table 9. Achievable herd performance targets for the Mitchell Grass and the remainders of the Monsoonal North

Source: McGowan et al. (2014)[60]

NB: In McGowan et al. (2014), Mitchell Grass is called Northern Downs and the rest of Monsoonal North is called Northern Forest

		Direction	Mitchell Grass		Monsoonal North	
		Desired improvement	Median	Achievable	Median	Achievable
Pregnant within four months of calving	(%)	increase	66	75	15	25
Annual pregnancy rate	(%)	increase	80	90	66	73
Foetal/calf loss	(%)	increase	10	4.7	12.9	9.6
Contributed a weaner	(%)	increase	72	78	53	62
Cow mortality (missing animals)	(%)	decrease	6.6	3.8	10.6	5.8
Annual liveweight production per cow	(kg)	increase	141.2	188.8	88.8	122.4
Liveweight gained/weight cattle in paddock	(kg/kg)	increase	0.23	0.29	0.14	0.20
Weaner production	(kg/cow)	increase	163	182.6	93.3	112.4

The best beef quality is produced by cattle that grow quickly (i.e. have high liveweight gain). Fast-grown beef has access to the most lucrative end of the market and attracts the best prices (Figure 16). Cattle grown on unimproved pastures and using substandard herd management have low liveweight

gain, and so can only access the lower end of the market. Outside the Mitchell Grass country, cattle in the Monsoonal North typically have low growth rates[60], so may only be suitable for the live-export market and the lower end of the domestic market. Improvement to herd performance should improve access to more lucrative sections of the market and improve the prices gained.

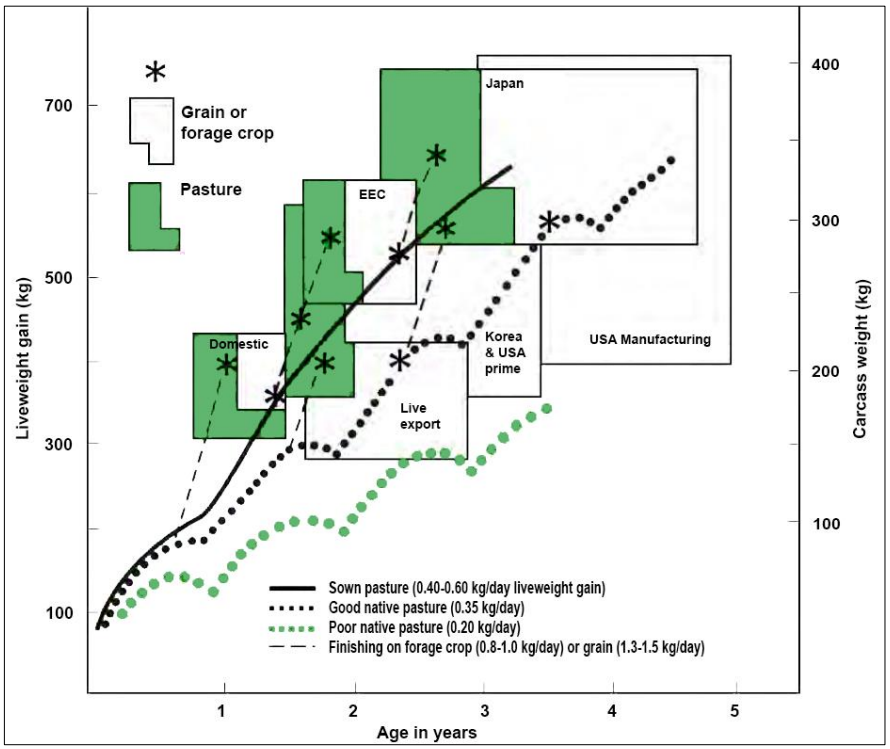


Figure 16. Market suitability of northern Australian cattle grown on different feed regimes

Source: Redrawn from Grice, Watson and Stone (2013)[59] based on Gramshaw and Lloyd (1993)[93] © The State of Queensland (through the Department of Agriculture and Fisheries)[2013])

Health and well-being

The average age of owners/managers of cattle properties in the Monsoonal North is close to 50 years old and there has been very little change in this statistic over the last 30 years[94]. Farmers have higher rates of injury, disease, accident and suicide than do their metropolitan counterparts[95]. Indeed, while suicide rates have decreased in metropolitan and regional areas, they have increased in remote areas[96]. As described above, pastoralists in northern Australia are currently under significant financial and emotional stress. Of pastoralists who participated in the Gulf Cattlemen's Association survey in 2014, 71% expressed the need for financial planning advice; 45% for Department of Human Services assistance; and 54% for counselling for depression and mental health issues[85]. Some financial counselling services are available[97], and have recently survived the threat of being closed down.

However, many pastoralists feel shamed by the failure of their businesses and are afraid to ask for assistance[a].

Farming is a stressful occupation that often involves financial insecurity and isolation, both of which are exacerbated by extreme climatic events, such as drought[98]. Dealing with mining proposals (and the likely impact on the financial viability of the property) also adds to stress experienced by pastoralists (see Mining). The worst outcome of this stress can be suicide. In Queensland, agricultural workers have one of the highest suicide rates of any occupational grouping[99]. Suicides of males in rural Queensland are most frequent within 12 months of a work- or income-related stress (such as a business failure or income reduction), when a mental health illness has been diagnosed, or when moral support from family and friends is lacking[100]. While statistical evidence for drought or natural disasters causing an increase in suicide rates is lacking[96], pastoralists report drought as causing significant financial and emotional stresses (Table 10). The financial difficulties facing the pastoral industry described above (see Profitability), and the need to make substantial changes to their businesses (which are likely to be beyond their financial capacity) just to stay afloat, are additional stresses that are likely to see increasing number of pastoralists needing support for mental health issues.

Table 10. Flow-on-impacts of drought on pastoral families

Source: Paton (2014)[82]

Financial issues
Financial difficulties, possibly leading to poverty and/or bankruptcy
Postponing capital expenditure, sometimes with consequences for farm safety
Drawing down superannuation
Succession issues
Delayed retirement
Inability to keep farm in the family
Employment issues
Increased dependence on off-farm income and employment, which may be difficult to attain
Women and children taking on additional on-farm work
Social issues
Increased stress and other negative health impacts from financial pressures and seeing stock suffer
Forced separation, as one partner moves to take up employment elsewhere
Intergenerational or marital conflict
Social isolation, especially where animals need daily feeding and watering
Difficulty in affording education for children

[a] http://www.abc.net.au/news/5969748

Supply and demand

This section describes the growing global demand for beef, changes in consumer preferences related to health and environmental concerns, and the influence of production by other global beef exporters on demand for Australian beef.

Domestic and global demand

Australia's total meat consumption has increased since 1980, with greatest increase in chicken and pork (Figure 17a). Beef consumption has plateaued and lamb and mutton declined. Per capita meat consumption has decreased (Figure 17b), with lamb, mutton and beef consumption declining and chicken and pork consumption growing. Weekly red meat consumption in 2014 was 0.97 kg and beef consumption was 414 g per week[101]. These figures indicate that domestic demand for beef has not increased significantly in at least 35 years despite the population growing by 60% over the same period[102]. The fall in per capita beef consumption is expected to continue, with no increase in total domestic consumption. Therefore, growth in the industry will be dependent on international demand.

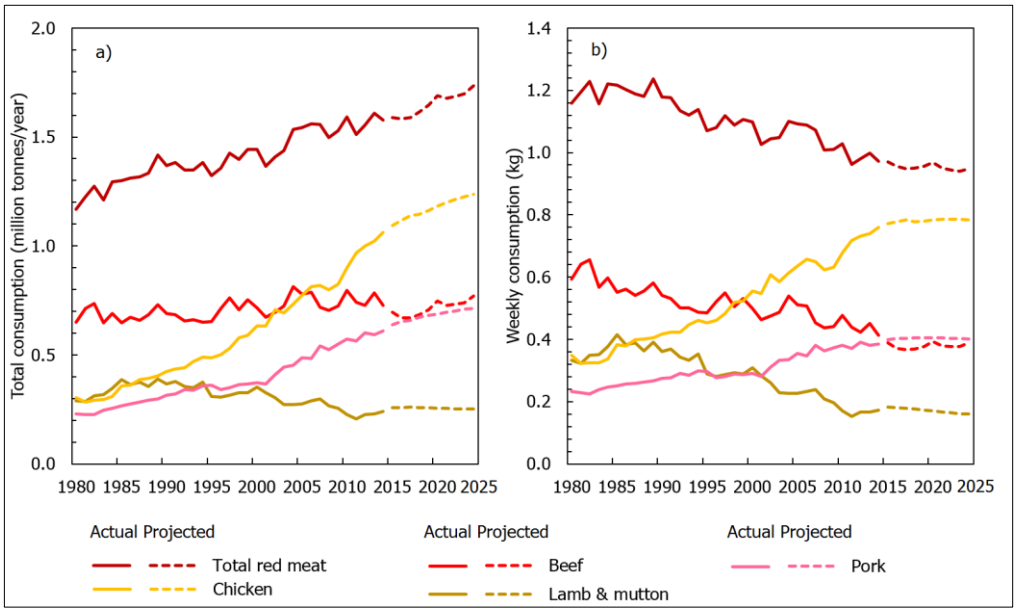


Figure 17. Australian meat consumption: (a) total and (b) per capita

Source: Data from Organisation for Economic Co-operation and Development (2015)[101]

Global consumption of beef has increased with population growth and economic development. Worldwide, beef consumption increased 40% in the last 40 years (Figure 18). Growth and economic

development has been greatest in Asia, with both beef production and beef consumption increasing nine-fold since 1975.

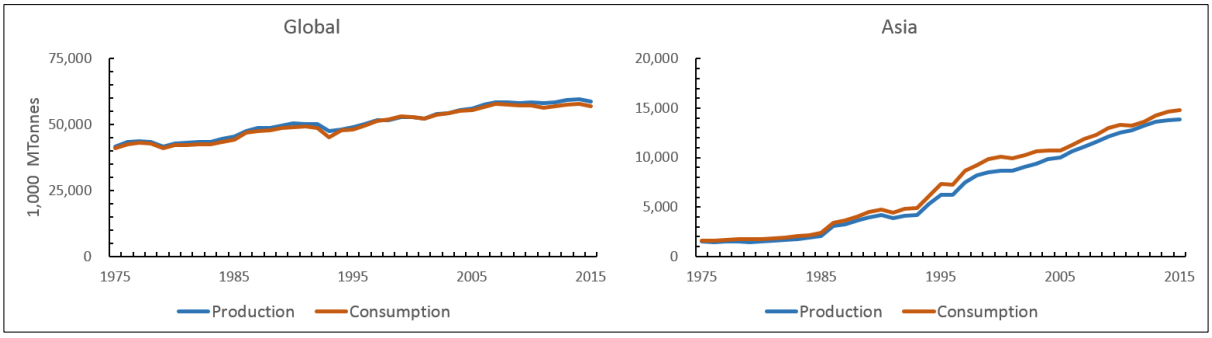


Figure 18. Global and Asian beef production and consumption

Source of data: United States Department of Agriculture (2015)[39]

Global demand for beef is expected to continue to grow. By 2050, an annual population growth of 0.8%, combined with a 2.7% growth in real world income, is expected to result in a 70% increase in food demand and a 300% increase in beef consumption[a,55]. Food consumption is expected to double in Asia over the same period, with the value of food imports increasing five-fold[55]. Beef imports into Asia are expected to increase astronomically, with most of the demand coming from China (Figure 19). These projections were made before China relaxed its population policy to allow all couples to have two children instead of one. This change is likely to accelerate growth in the demand for Australian beef[b].

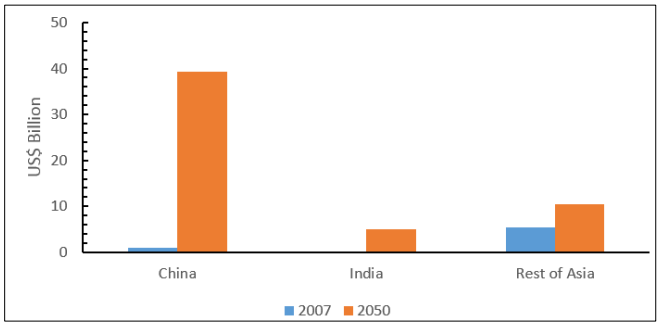


Figure 19. Projected increase in Asian beef imports

Source: Adapted from Linehan, Thorpe, Andrews, Kim and Beaini (2012)[55]

[a] Using 2007 as a base level

[b] http://www.smh.com.au/business/the-economy/will-chinas-twochild-policy-affect-australias-economy-20151030-gkmtxt.html

While growth in demand appears assured in the long-term, short-term changes in demand are more difficult to predict. In early 2014, a levelling of live exports to Indonesia was projected, along with year-on-year doubling of live exports to Vietnam, steady growth in demand from China, further decline in exports to Malaysia and the Philippines[103]. In February 2015, came the realisation that reduced availability of cattle for sale will limit growth in all these markets, and possibly a decline in exports to Indonesia[49].

Competing producers

Global beef production has increased in response to demand, and overtook consumption in 2003 (see Figure 18 in previous section). Australia was the world's top beef exporter between 1960 and 2003 (Figure 20). Brazil exceeded Australia's export of beef in most years since 2004 and India since 2012. These nations, along with Argentina, are strong competitors in the south-east Asian market, although disease concerns prevent them supplying some of Australia's other important export markets, such as the United States (see below). United States, Canada and New Zealand are also considered key competitors to Australia. Production in these countries drives price and has the potential to limit Australian access to markets[37].

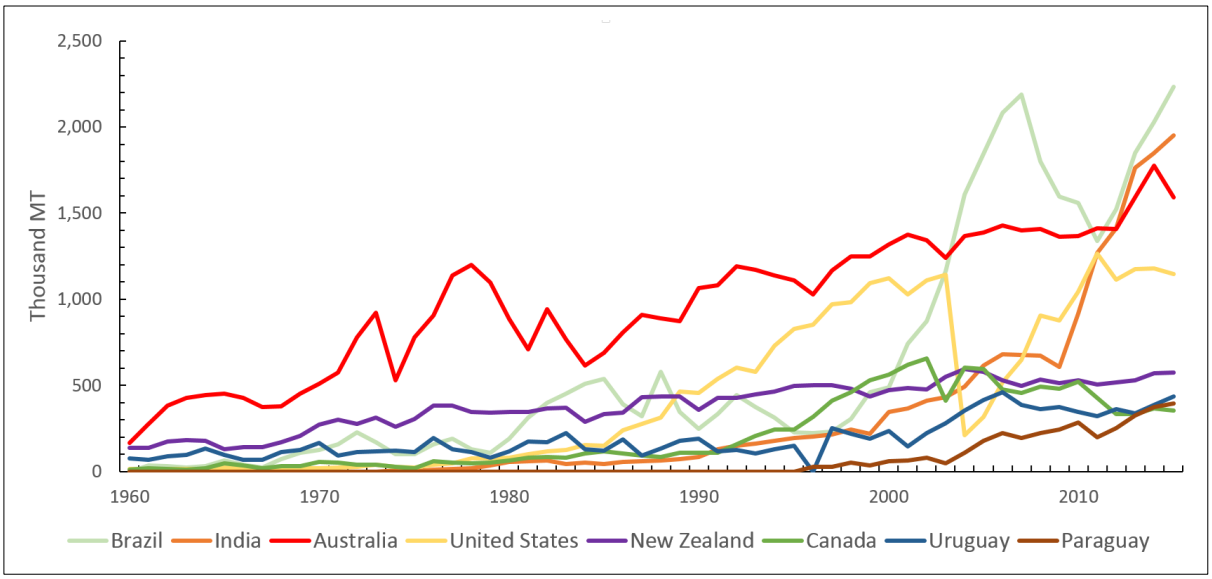


Figure 20. Beef exports by the current five highest ranking exporter nations

Source of data: United States Department of Agriculture (2015)[39]

International trade

Historically, trade in beef, along with most agricultural products has been subject to protectionist barriers, including subsidies, quotas and tariffs, or prohibited altogether[104]. Subsidies are provided by governments of exporting countries, so that beef can be sold at a lower price and have a competitive advantage. Quotas and bans restrict market access. Tariffs increase the cost of beef in the importing country and are often imposed to protect local production or to give preferential treatment to preferred trading partners. The Australian Government has a free-trade policy, as it believes Australian agriculture has a natural competitive advantage and is disadvantaged by protectionism[105].

Since the 1970s, Australia has, therefore, increasingly moved to a "level playing field" approach to agriculture in which the price of goods exported reflects cost of production. Assistance to Australian agriculture through statutory marketing arrangements, tariffs, adjustment assistance, research and development support, drought relief and tax concessions were reduced in real terms from around 25% in 1970-71 to less than 5% in 2003-04[106]. Removal of these subsidies disadvantaged Australian producers competing with countries where high subsidies remain in place. In 1986, continuation of subsidies to Australia's agricultural competitors was estimated to cost Australian farmers $30,000 per farm[107]. To offset trade disadvantages, Australia first pursued global trade agreements, and then after these failed to bear fruit, preferential bilateral and multilateral trade agreements (Table 11)[108]. While these agreements have not been beyond criticism, they have resulted in the opening of new markets and reduction of barriers to the export of Australian beef. Australia now has trade agreements with most of its major trading partners, including the growing Chinese and Korean markets.

Australian beef will be most attractive to overseas markets when both the Australian sale price and the exchange rate are low relative to those of other beef-exporting countries[45]. Australian beef became less competitive through the early 2000s as the exchange rate and domestic price increased[37]. As a result, India and Brazil increased their share of the south-east Asian beef market at Australia's expense[45]. Depreciation of the Australian dollar in 2014 and continued weakening through 2015 reduced the price of Australian beef overseas, once again favouring Australian exports[49,53]. Domestic prices at the end of 2015 were nearly twice what they were at the start of 2013[53] and the price of export meat increased by 30% after adjusting to US dollars (Figure 21). While this made Australian beef less competitive against beef from southern America, it remains cheaper than beef from either the United States or Canada.

Table 11. Timeline of recent significant events affecting northern beef exports

Date	Event	Source
1970-	Progressive withdrawal of subsidies to Australian agriculture	106
1983	Australian dollar floated	109
1987	Australia first exports live and slaughter cattle to the Philippines	37
1990	Australia's first live export to Indonesia	37
1998–9	Asian financial crisis	37
	Live export to Philippines peaked	37
2000-	High exchange rate reduced competitiveness of Australian beef	37
2000-5	Australian beef exports to Philippines fell	37
2003	Singapore-Australia Free Trade Agreement came into force • All tariffs for Australian imports into Singapore eliminated	110
2005	Thailand-Australia Free Trade Agreement came into force • Thailand reduced the tariff on Australian beef imports from 51% to 40% (to 0% by 2020)	110
2005	Australia-United States Free Trade Agreement revised • US to increase Australian beef imports to 70,000 tonnes by 2021, with free access from 2023 • Immediate elimination of in-quota tariffs for beef imports into USA, and phasing out of over-quota duties between years 2012 and 2021	110
2010	Indonesia imposed weight limits and quotas on live cattle imports, aiming to achieve beef self-sufficiency by 2014	37,111
2011	Australia suspended export of live cattle to Indonesia in Jun 2011, mandating the Exporter Supply Chain Assurance System	48
	Australia lifted ban on export of live cattle to Indonesia in Jul 2011, but Indonesia delayed issuing import permits till August	37,48
	Live export trade to Indonesia resumed in Aug 2011	37,48
2012	Indonesia imposed further export restrictions on Australian live cattle imports	
2013	Malaysia-Australia Free Trade Agreement comes into force • Tariff-free treatment for the vast majority of Australian agricultural products imported into Malaysia	110
2014	Korea-Australia Free Trade Agreement came into force • Progressive elimination of 40% tariff on Australian beef imports into Korea by 2028	110
2014	Agreement Establishing the ASEAN-Australia-New Zealand Free Trade Area – First protocol signed • Elimination of agricultural export subsidies for trade between partner countries	110
2014	China-Australia Free Trade Agreement negotiations concluded • Elimination of tariffs on Australia beef over nine years	110
2014	Depreciation of Australian dollar increased competitiveness of Australian produce	49
2015	Japan-Australia Economic Partnership Agreement comes into force • Tariff on frozen beef reduced from 38.5% to 30.5%, dropping to 19.5% by 2033 • Tariff on fresh beef reduced from 38.5% to 32.5%, dropping to 23.5% by 2030 • Replacement of "global snapback" to 50% tariff in the event of escalating imports, to discretionary tariff rise to 38.5% if the import volume exceeds Australia-specific triggers within a given year (14.5% above 2013 exports for frozen beef and 12% above 2013 exports for fresh beef), rising each year for ten years before being reviewed	110
	Trans Pacific Partnership agreement signed in Oct 2015, but yet to be ratified • Japanese beef tariffs to be reduced to 9% within 15 years • United States price-based safeguard under the Australia-United States Free Trade Agreement to be eliminated • Canadian, Peruvian and Mexican beef tariffs to eliminated within 10 years	110

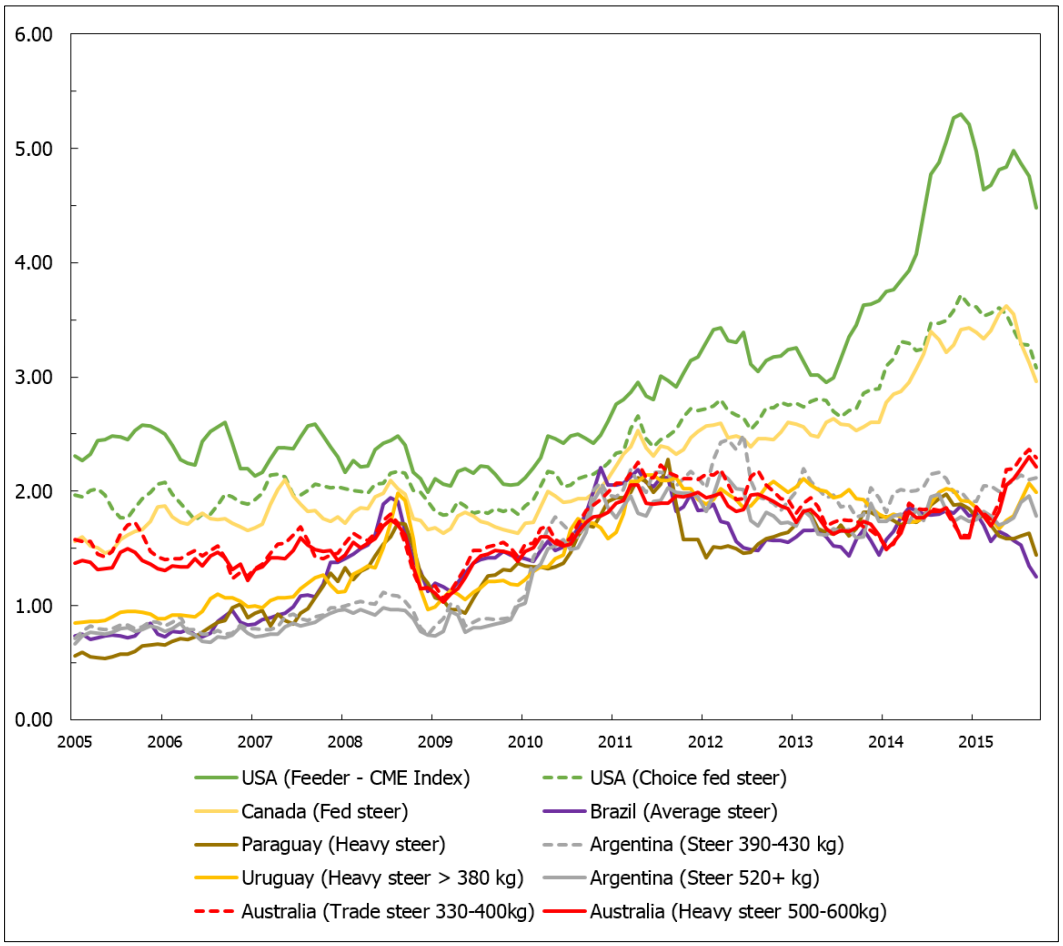


Figure 21. Comparative global beef prices 2005-2015 ($US/kg liveweight)

Source of data: MLA Statistical database[112]

Reproduced courtesy of Meat & Livestock Australia Limited - www.mla.com.au[112]

Recent dependence of the northern beef industry on the Indonesian market made it highly vulnerable[a]. Financial hardship and environmental degradation followed when this market was suspended for two months in 2011 in the peak export season. The fall-out of this was economically disastrous for many northern producers (see Profitability). Maintaining good relations with the Indonesian Government was then seen as essential to providing economic certainty for the northern beef industry[37]. Subsequently, the industry has benefited from access to an increased range of export destinations and northern meat processing facilities. Current expansion into Vietnamese and Chinese

[a] http://www.abc.net.au/news/6348020

markets for both live cattle and packed meat should improve resilience in the northern beef industry[a], and, along with Indonesian market restrictions, have contributed to increased beef prices[b].

Therefore, while global demand, favourable exchange rates and trade agreements that recognise Australia's disease free status drive beef production in northern Australia, they may be offset by increased production by competitors and anti-competitive behaviour, such as trade restrictions imposed by importing nations and trade subsidies by exporting countries.

Market requirements

Some markets demand beef meet specific requirements (Table 12). Demand by premium markets for heavy, quickly-grown cattle has already been discussed (Figure 16). For access to the most lucrative markets, animals must reach 300 kg in twelve months and 500 kg within two years (Figure 22). These growth rates are hard to achieve in northern Australia. Animals sold to the Indonesian live-export market must be under 350 kg[37], with no age restriction. This forced heavier cattle back on to the Australian market from 2010, making them harder to sell[c]. Also, selling cattle under 350 kg in weight may not be financially viable in the long term[d].

Table 12. Requirements for beef to access quality markets

Source: Meat and Livestock Australia (2015)[113] Reproduced courtesy of Meat & Livestock Australia Limited - www.mla.com.au

Characteristic		Japanese market	European market	Meat Standards Australia
HSCW	(kg)	300–420	320–420	160–220
Dentition	(adult teeth)	0–6	0–4	0
P8 fat depth	(mm)	7–22	6–22	3–10
Butt/muscle shape score		A–C	A–C	A–C
Bruising		Nil	Nil	–
Sex		Steer and female	Steer and female	Steer and female
Ossification score		–	–	< 180
Marbling score		–	–	> 0.5
Fat colour score		0–3	0–3	0
Meat colour grade		–	1b–3	1a–2
Eye muscle area	(cm^2)	–	> 85	70
Ultimate muscle pH		–	–	< 5.71
Loin temperature	(°C)	–	–	< 9
Retail meat yield	(%)	–	–	70
Hormone growth promotants		–	Free	Yes
Acceptable compliance	(%)	-	90	85

[a] http://www.abc.net.au/news/6636880
[b] http://www.abc.net.au/news/6273314
[c] http://www.abc.net.au/site-archive/rural/news/content/201008/s2978525.htm
[d] http://www.abc.net.au/news/6339788

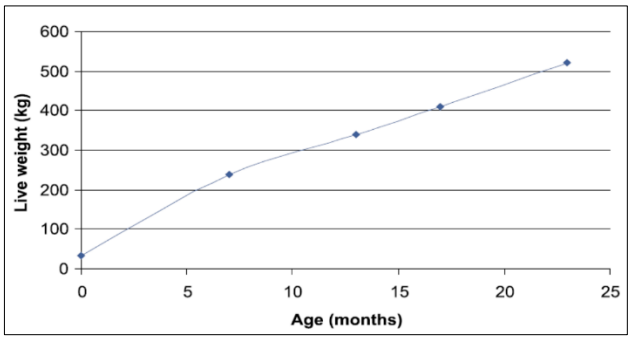


Figure 22. Minimum weight for age to meet most prime beef markets

Source: Reproduced courtesy of Meat & Livestock Australia Limited - www.mla.com.au

Many countries will also only import beef and cattle from countries that are free of bovine spongiform encephalopathy (BSE) or foot and mouth disease (FMD)[37,114]. In addition, only countries that are free of brucellosis and tuberculosis can export beef to Indonesia[45,115]. Australian beef meets these requirements, and so is able to export to a range of countries that cannot be accessed by South American countries. Australia could lose some export advantage if Indonesia goes ahead with plans to relax restrictions on importing beef from countries that have foot and mouth disease[a].

Most Asian feedlot markets prefer Brahman cattle, as these animals tolerate the hot and humid conditions[45,115,116]. Lack of refrigeration in many non-urban areas in Indonesia means live export is required to supply the fresh meat trade[117]. Local slaughter gives the Moslem population confidence that slaughter has been undertaken according to Halal requirements[118], particularly during religious festivals[115]. The weight restriction of 350 kg is aimed at supplying the feeder market[119].

In summary, while required growth rates for premium markets are hard to achieve in northern Australia, the region's cattle has the advantage of meeting requirement of the Asian market, such as disease-free status and Brahman stock.

[a] http://www.abc.net.au/news/6676404

Consumer preferences and concerns

Australian dietary patterns are changing, with a shift from a protein intake dominated by beef and lamb to one dominated by chicken and pork[120] (Figure 17). This shift can be largely explained by changes in relative prices and expenditure[120,121]. Advertising by Meat and Livestock Australia has been successful at increasing beef consumption in the short term[122], but the trend continues.

Consumer demand for beef is also affected by ethical, health and environmental concerns. Consumers are increasingly concerned about the ethics of the red meat production and transport. Preventing animal cruelty was the most frequently stated reasons for choosing to become vegetarian (64% of 843 respondents to an online survey)[123]. Concerns over animal welfare closed down the Australian live-export trade in 2011.

The second most cited reason was health concerns (46%)[123]. Health concerns are likely to have a negative impact on demand for beef. A review sponsored by Meat and Livestock Australia published in May 2015, concluded that red meat consumption was associated with an increased risk of colorectal cancer of 11%[a] based on 27 independent studies[124]. When processed meat was excluded, leaving 17 studies, the increased risk was reduced to 5%[b]. When intake rates were analysed separately, consumption of less than 100 g per day was found to have no identifiable cancer risk[c]; but an average consumption of 100 g per day was associated with 20% risk increase[d]. It is not clear if this last assessment included processed meats as well as unprocessed red meat.

Publication of this review was followed in October 2015 by a much publicised assessment by the World Health Organization's International Agency for Research on Cancer (IARC), which came to much the same conclusion[125]. It reported on an analysis of 10 studies of red meat consumption (excluding processed meat)[126], which found that colorectal cancer risk increased by 17%[e] with a daily consumption of 100 g per day. The same analysis also found consumption of processed meat further increased this risk: daily processed meat consumption of only 50 g per day was associated with an increased risk of 18%[f].

[a] with 95% confidence that the actual increase was between 3 to 19%, which is expressed as:
All meat consumption: 1.11, 95% CI: 1.03–1.19, 27 studies
[b] Red meat consumption (separated from processed meat): 1.05, 95% CI: 1.02-1.12, 17 studies
[c] Red meat consumption >40 g/day: (1.02, 95% CI: 0.98–1.07, 9 studies); 40-70 g/day (1.00, 95% CI: 0.96–1.04, 12 studies); 70-100 g/day (1.03, 95% CI: 0.89–1.18, 8 studies)
[d] >100 g/day (1.20, 95% CI: 1.11–1.29, 6 studies)
[e] Red meat alone consumption of >100 g/day (1.17, 95% CI: 1.05–1.31, 10 studies)
[f] Processed meat consumption of >50 g/day (1.18, 95% CI: 1.10–1.28, 10 studies)

What is interesting is not the differences in the findings—which are not great—but the differences in the way they were reported. The first study does not appear to have been reported at all in the mainstream media following its release, but was interpreted in the blogosphere as acquitting red meat of causing cancer[a]. The second study was released with much hoorah, when an online search revealed 3,200 news articles within 48 hours of the paper's release[b]. Most articles reported the findings as indicating red meat intake was carcinogenic, and a few quoted vociferous refutations of this claim. Meat and Livestock Australia released a statement reaffirming their recommendations of a weekly intake of 455 g of red meat[127], which is well within the no-significant-impact level, and consistent with Australian Dietary Guidelines[128]. Estimated average weekly Australian red meat consumption based on carcass sales of 971 g[101] is twice recommended in these guidelines. Self-reporting of meat consumption levels are considerably lower; 685 g for men and 445 g for women, but are considered to be under-estimates[129]. Both sets of figures indicate that average red meat consumption exceeds Australian Dietary Guidelines, so that increased efforts to meet these guidelines could mean a substantial reduction in domestic meat consumption.

Consumers are also increasingly concerned about the sustainability of the red meat production. However, Australians have little awareness of the impact of meat production on the environment, and it barely influences their dietary choices[130]. Only 12% of vegetarians surveyed cited environmental reasons for their dietary choice[123]. Nevertheless, demand for ecologically-produced food is growing domestically[131], as well as in China and India[132,133]. The perception that Australian beef is sustainably produced may have given it a market advantage in the past, but consumers increasingly expect such claims to be backed up by certification[134]. Meat branded as sustainably-produced does have a domestic market advantage[131], but complex supply chain arrangements make it hard to trace product from paddock to plate[135].

Industry challenges

Constraints identified as affecting profitability of the northern cattle industry include lack of property infrastructure; land use regulation and lease conditions; lack of processing facilities; transport costs and access to skilled labour[37,52,60,78,83,92,136,137]. These challenges are examined in detail below, along with efforts to overcome them.

[a] http://suppversity.blogspot.com.au/2015/05/fresh-red-meat-acquitted.html
[b] http://news.google.com/

Supply chain

Cattle from the Monsoonal North are either sold into the domestic or international market, but rarely does the producer have direct contact with the buyer at the end of the supply chain (Figure 23). If cattle are not finished on the property or sold to another grazing enterprise, they will need to be transported to a saleyard, port or feedlot. Lack of such facilities across much of the north raises freight costs and reduces market access options[138]. As described earlier, although some cattle are fattened and finished on limited areas of fertile native pastures or introduced pastures in the area, most cattle fattening occurs outside the region (see Cattle enterprises), and so must be transported long distances.

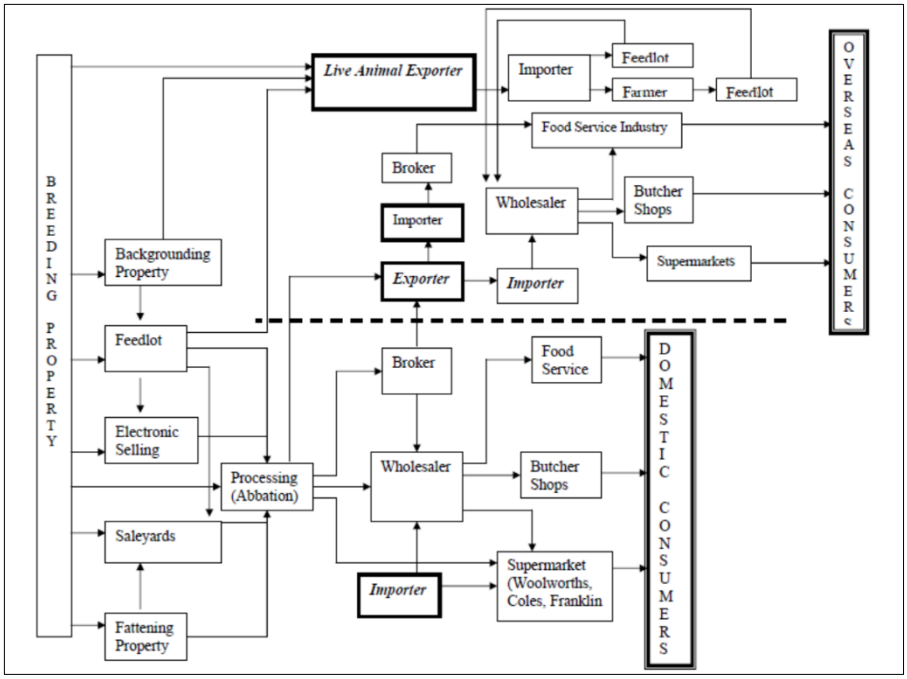


Figure 23. Australian beef supply chain

Source: Jie, Parton and Cox (2007)[139]

Spelling at yards is required if cattle are transported more than a certain distance or to allow for tick inspection when a load of cattle crosses from a tick zone to a tick-free zone. Other than for tick clearing stations in Queensland[140], information on the location of spelling yards is difficult to obtain. However, it has been estimated that an additional 17 to 32 spelling yards are required in Western Australia and the Northern Territory to facilitate cattle movement between cattle properties and abattoirs in Darwin and Broome[141].

Hence along with lack of developed, fertile country for fattening, limited numbers of spelling yards, feedlots and meatworks eat into the profits of northern cattle businesses by necessitating cattle be transported long distances at each section of the supply chain[142,143].

Saleyards

The number of saleyards in Australia has been declining as a result of increasing costs, urban encroachment into industrial areas and the burden of complying with occupational health and safety and animal welfare regulations[144]. This has led to closure of most small council-run saleyards and concentration of larger processing facilities close to end markets. There are few saleyards in the north, and none in north-western Western Australia (Figure 24) where *virtual auctions* have been successfully trialled using online selling [145,146]. There currently appear to be no plans to build new saleyards in northern Australia.

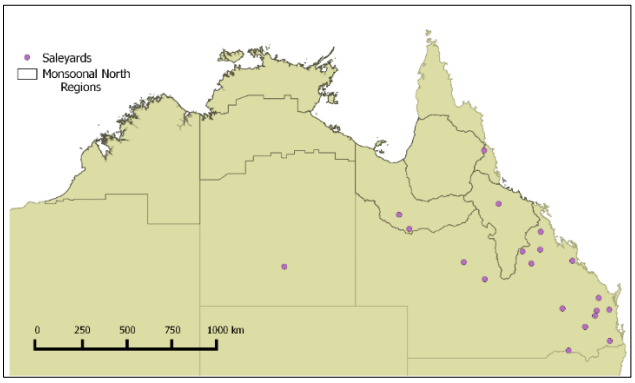


Figure 24. Location of saleyards in relation to the Monsoonal North

Source of data: Australian Livestock Markets Association (2015)[147]

Meatworks

Abattoirs are required for the processing of packed meat and their location can have an impact on transport costs. There are few meatworks in the north, with several having closed in the second half of last century (Figure 25)[148]. Poor financial viability; company mergers; increased hygiene requirements; and increased competition from feedlots and live exporters all contributed to these closures[37]. For many years the only operational export abattoir in the Monsoonal North was in Townsville. In October 2014, an abattoir capable of processing 1,000 animals a day opened at Livingstone, just south of Darwin[149,a]. An abattoir is also well into the construction phase outside

[a] http://www.abc.net.au/news/6176206

Broome[a]. A few small-scale meatworks also operate across the north , and mainly service Indigenous communities as well domestic specialty meat markets[66].

There has been much discussion about the need for additional meatworks in northern Australia. The proposed location at Cloncurry, on the tick line, makes it the most economically viable place to construct an abattoir in north-western Queensland, as this would allow cattle to be transported to it from any direction without incurring tick inspection costs[142]. An additional meatworks has also been proposed south of Townsville[b] and there have been calls for one to be built at Emerald[c]. As additional meatworks come on stream, transport costs to producers should be significantly reduced[143].

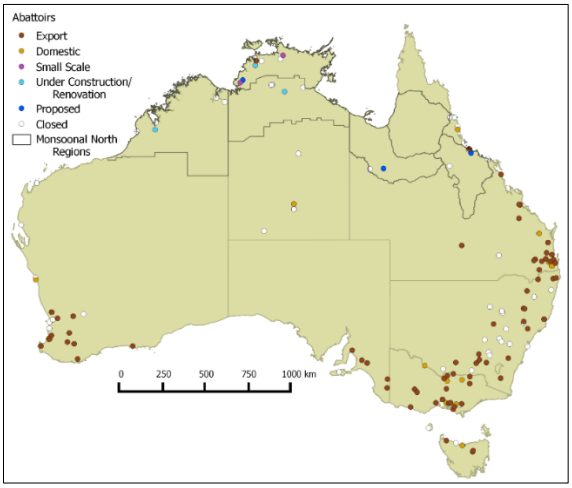


Figure 25. Location of meatworks in relation to the Monsoonal North

Source: Locations from Bloomfield (2015)[150] and McClelland Rural Services Pty Ltd (2014)[66]

Lack of competition in the meatworks sector is probably disadvantaging beef producers[d]. A senate inquiry was conducted into the *Effect of market consolidation on the red meat processing sector*[151]. The terms of reference included:

- Any misuse of market power through buyer collusion and impact on producers
- Impact of consolidation on market competition, regional monopolies and farm gate prices
- Existing selling structures and processes at saleyards, and current relevance
- Regulatory environment covering livestock, livestock agents, buyers and meat processors.

[a] http://www.abc.net.au/news/6324912
[b] http://www.abc.net.au/news/5877062
[c] http://www.abc.net.au/news/6035246
[d] http://www.abc.net.au/news/6313956

The report for this inquiry is yet to be released.

Freight

As noted above, most cattle raised in the Monsoonal North need to be transported large distances[143]. They are generally transported by road through a dispersed road network using local or regional carriers; very few are transported by rail[144]. Half the cattle produced in the Northern Territory are transported over 1,000 km to processing or export facilities with the transport cost exceeding A$150/head[143] and distances of more than 2,500 km may be required for transport to southern markets[141]. Most cattle raised in north-western Queensland are transported between 500 and 1,000 km[142]. Freight costs are, therefore, a significant component of input costs, being approximately 7% of the total costs of northern cattle operations[52] and accounting for up to 35% of the market price[143].

As well as distance to processing facilities, freight costs and logistics are influenced by the condition of road networks; availability of holding paddocks on freight routes; and the necessity to interrupt transport for tick inspection[138,142,143,152]. Prohibition of road trains on some Queensland roads necessitate diversions to longer routes or the separation of loads[143]. Seasonal road closures also interrupt supply and, where diversions are possible, increase transport costs[143]. In order to maintain market share in the wet season, the meatworks at Gunbalanya has resorted to flying up to three tonnes of meat a week to Jabiru, from whence it can be transported to Darwin by road[a]. This increases the cost of production by about $0.50 per kilogram of meat, but maintains faith with regular customers. An improved road network would reduce costs, but this is impeded by responsibility for the road network being spread amongst about 700 local, state and territory road agencies[144].

The Australia Government's White Paper on developing northern Australia committed $100 million to improving beef roads in the region and $600 million to strategic road projects [153]. A Northern Australia Beef Roads Programme roundtable was held in Rockhampton in October 2015 to discuss the best allocation of this funding[b]. Most of the issues raised at this meeting concerned upgrades needed to roads outside the Monsoonal North[c]. Further roundtable meetings will be held in Western Australia and the Northern Territory[154]. The promised $100 million would cover the cost of sealing between 220

[a] http://www.abc.net.au/news/6025382
[b] http://www.abc.net.au/news/6822820
[c] Access through Rockhampton to abattoirs; access to the Roma saleyards; Clermont to Roma road; Peninsula Development Rd.

and 454 km of dirt highways (based on estimates of the cost of upgrading the Outback Way in Western Australia)[a] or of a single bypass[155].

Linking northern Australia to the national rail network should also assist in reducing freight costs. The Northern Territory and Australian Governments have commissioned feasibility studies into a Mount Isa to Tennant Creek rail link[b] and a Katherine to Kununurra rail link[c].

The opening of the Livingstone abattoir outside Darwin reduced transport distances and costs for many pastoralists in the Northern Territory, increasing earnings before interest and tax by $14.56 per head[156]. The abattoir also addressed poor wet season access by trucking in cattle in the dry season to nearby stations that have access to all-weather roads[d]. Completion of the Broome abattoir and construction of other proposed abattoirs in the north should further reduce transport costs to the industry.

Additional costs are incurred when cattle are transported between the tick-free and tick-affected areas. Tick inspection stops are estimated to constitute about 19% to the cost of transporting cattle on the route between Clermont and Roma[143]. The economic benefit to producers of building an abattoir at Cloncurry was, therefore, estimated at $41.10 per head of cattle, $2.55 better than of building one at nearby Mount Isa, which is several kilometres inside the tick-free zone. Another option for reducing costs that has been suggested is to waive compulsory tick inspection of cattle crossing the tick line when they are being transported directly to an abattoir[143].

Ports

The majority of cattle exported from Australia are sent through northern ports[45], particularly when they are destined for Asian markets. Numbers have fluctuated from year to year, depending on market demand (Figure 26). To enable export of cattle, ports must have yarding facilities[144]. Despite having such facilities, ports at Weipa, Mourilyan and Mackay have not exported cattle for several years. Based on their maximum throughput, the eight ports between Port Hedland and Mackay have the capacity to export just over one million cattle. This maximum was nearly reached in 2014, when 940,000 head were exported. However, unlike in 2009, when all ports were operating and all parts of the region were able to supply the live export market, export was restricted to five ports, dominated by Darwin (Figure 27). Recent lease of the Port of Darwin to Chinese interests has been welcomed by the

[a] http://www.abc.net.au/news/5735650
[b] http://www.abc.net.au/news/6424552; http://www.abc.net.au/news/6603782
[c] http://www.abc.net.au/news/6893958
[d] http://www.abc.net.au/5528780

industry, as this should ensure the live-export facilities are maintained[a]. However, as beef producers and exporters have access to a limited number of ports, there is the potential for lack of competition to lead to price manipulation.

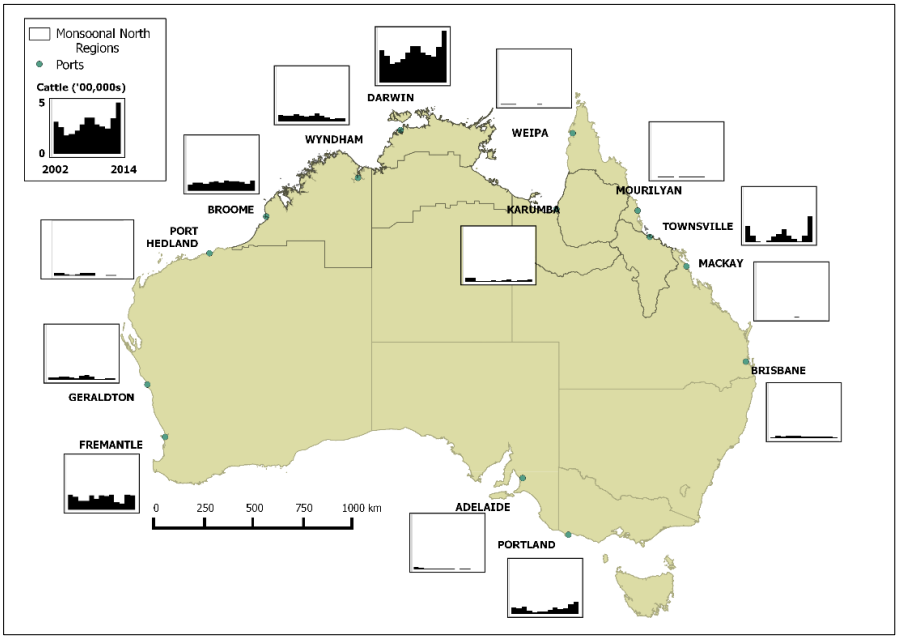


Figure 26. Number of cattle exported from Australian ports from 2002 to 2014

Source of data: Norris and Norman (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)[157-167], MLA (2014)[168]

[a] http://www.abc.net.au/6851430

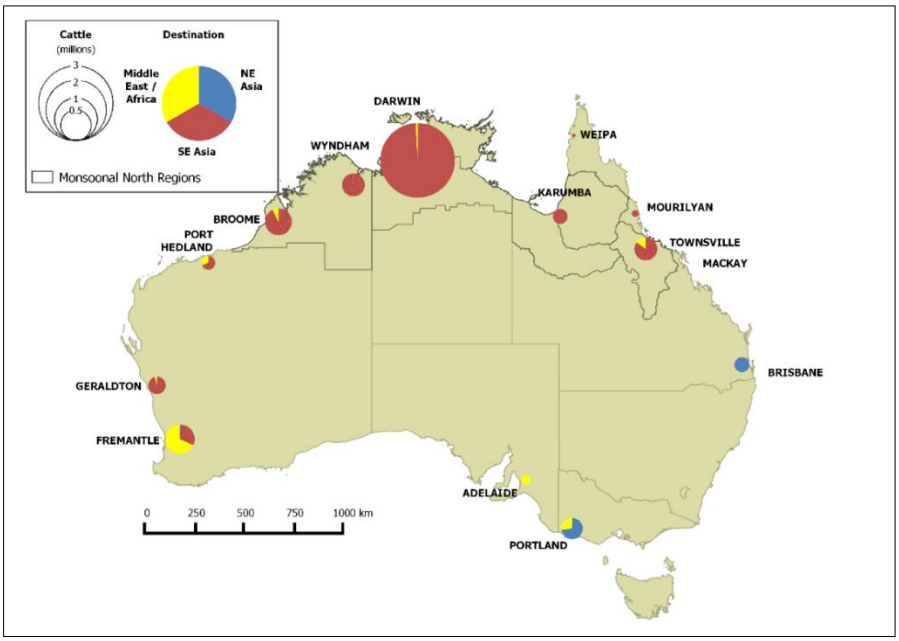


Figure 27. Relative importance of cattle export ports and destinations from 2002 to 2012

Source of data: Norris and Norman (2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)[157-167]

Resources

Water

Livestock and pastoral operations require water. Beef cattle in northern Australia require between 43 and 66 litres per head per day, with lowest requirements in the coolest part of the year and greatest requirements in the late dry season, when it is both hot and dry (Figure 28). Water used by cattle must also meet certain water quality conditions[169]. Poor drinking water quality and diets with high mineral concentrations will increase water needs[170]. Most cattle grazing occurs within 3-4 km of water, so a distance between water points of about 5.6 km is recommended for effective use of grazing lands[171]. To increase the area that can be grazed, many properties across the Monsoonal North are, therefore, installing new water points (see Paddocks and water points). Water is also needed to irrigate pasture crops to provide feed needed to finish cattle on property and sell them at profitable prices (see Forage crops). It is considered that most properties across the Monsoonal North have access to enough water to support small-scale irrigation of this kind[59].

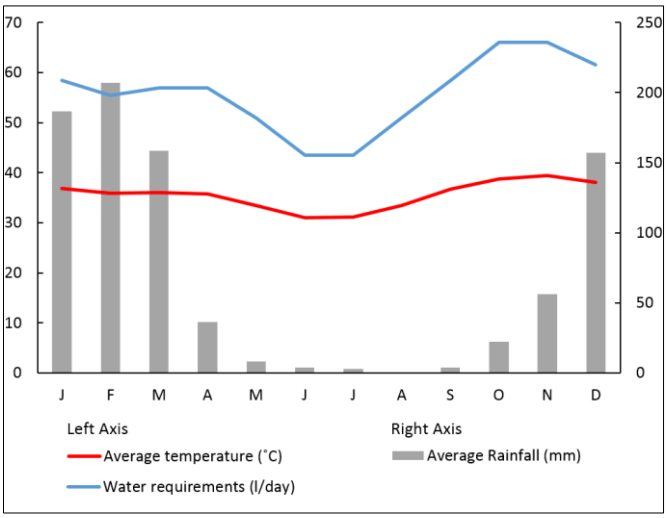


Figure 28. Water requirements of beef cattle at Wyndham in relation to climatic conditions

Source of data: Water requirement calculations based on Luke (1987)[170]; Climatic data: Australian Bureau of Meteorology (2015)[2]

Water for cattle operations can come from natural surface or groundwater storage, or artificial tanks and dams capturing overland flow, stream flow or groundwater. The extraction, storage and use of water is regulated through a complex systems of laws (see Legal and regulatory environment).

The Monsoonal North's highly seasonal rainfall means that most streams are also highly seasonal, with about 90% of flow occurring between December and March[18,19]. High flow rates followed by rapid drainage and high evaporative losses make water capture and storage difficult in the region[172]. Streams with a steady wet season flow contract to isolated waterholes (Figure 29). Farm dams may be breached during the rainy season, and go dry before the end of the dry season when water requirements are at their highest. Water shortage is exacerbated in periods of prolonged drought. Even without any significant change in rainfall, projected increases in temperature and evaporation rates[1] will increase the period stock are exposed to heat stress and reduce the distances they can travel to water[173].

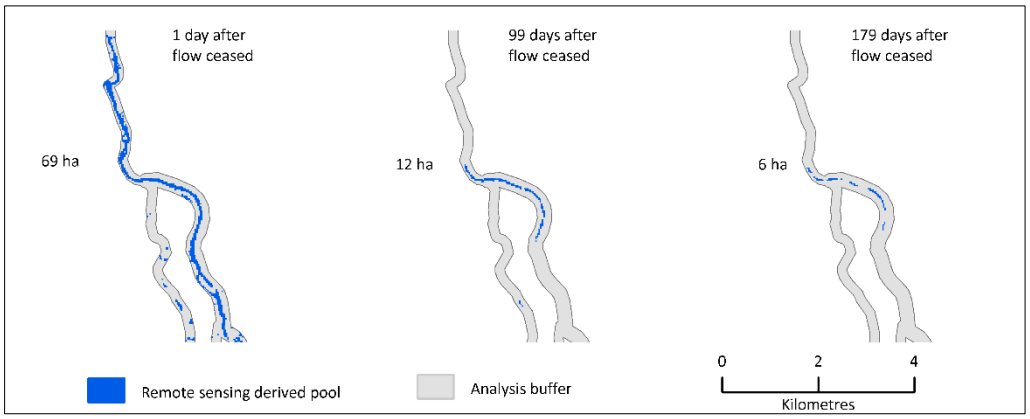


Figure 29. Progressive drying of a section of the Cloncurry River

Source: McJannet, Marvanek, Henderson, Petheram and Jim (2013)[174]

Groundwater is also responsive to rainfall[175]. The water table is generally highest at the end of the wet season. For example, water level in the Howard River catchment in the Northern Territory fluctuates annually from 0-1 m below ground level at the end of the wet season to 12-15 m below ground level at the close of the dry[176]. Year to year variation in rainfall is also important. Braithwaite and Muller[177] found that 80% of the variation in groundwater level in the Top End of the Northern Territory could be explained by rainfall over the previous eight years. Levels peaked at the end of the 1970s after nearly a decade of wet years. Long periods of low rainfall can impact on the vegetation, and even cause tree death[178]. Some basins are highly responsive to rainfall and refill each year and can sustain regular water extraction. The Great Artesian Basin, which extends into the Southern Gulf region and holds vast stores of fossil water, recharges very slowly and thus takes a long time to recover from water extraction[179].

Water tables on pastoral properties may be lowered by extraction by other users[175]. Extraction can affect both the depth to the groundwater (so the effectiveness of bores) and the discharge of water into surface streams. Lowering of water tables is especially significant for pastoral operations when it reduces the period of stream flow through the dry season. Water extraction can also increase levels of soluble salts in the groundwater. Therefore, both mining and agricultural expansion have potential to adversely impact the availability and quality of water for stock, with mining being a particular concern in the Desert Uplands region of Queensland (see Mining).

Land

As grazing is the dominant land use in the Monsoonal North, expansion of any other land-use is likely to reduce the area available for grazing. While carbon farming is most likely to occur on land that is marginal for grazing[180,181], irrigated agriculture is likely to capture the most productive and well-watered areas for cropping[182-184]. In addition, urban development is likely to impinge on pastoral land close to towns and settlements[185,186]. On the other hand, the land surface available for grazing is expanding with the development of Indigenous-held lands (see Indigenous pastoralism) and, within properties, with increased fencing and water points (see

Paddocks and water points).

Mining

Substantial areas of the Monsoonal North are under mining exploration permits, the status of which can be ascertained from separate online mapping sites for Western Australia[187], Northern Territory[188] and Queensland[189]. Mining of coal and gas reserves are driven by growth in both domestic and global demand for energy resources, with a move to cleaner fuels expected to increase the demand for gas over coal[190]. Within the Monsoonal North, coal and coal seam gas (CSG)[a] is present in economic reserves in the Bowen and Galilee Basins in North Queensland. There are also deposits that are not currently considered viable in the Canning Basin of Western Australia (Figure 30)[191]. In 2008, the Bowen Basin was estimated to contain 21% of Australia's coal resources and the Galilee Basin 5%[191]. More than one-third of the Burdekin Dry Tropics is under coal mining and exploration leases (Figure 31, Table 13), including 11 mines for which a mining permit has been granted, and three under application.

[a] Methane held within coal seams

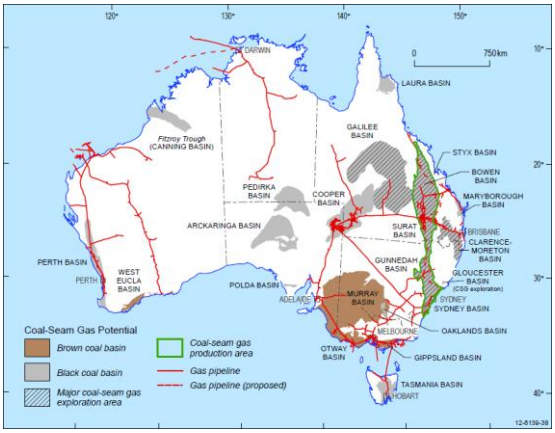


Figure 30. Coal basins and major coal seam gas deposits

Source: Bradshaw, Hall, Copeland and Hitchins (2012)[192]

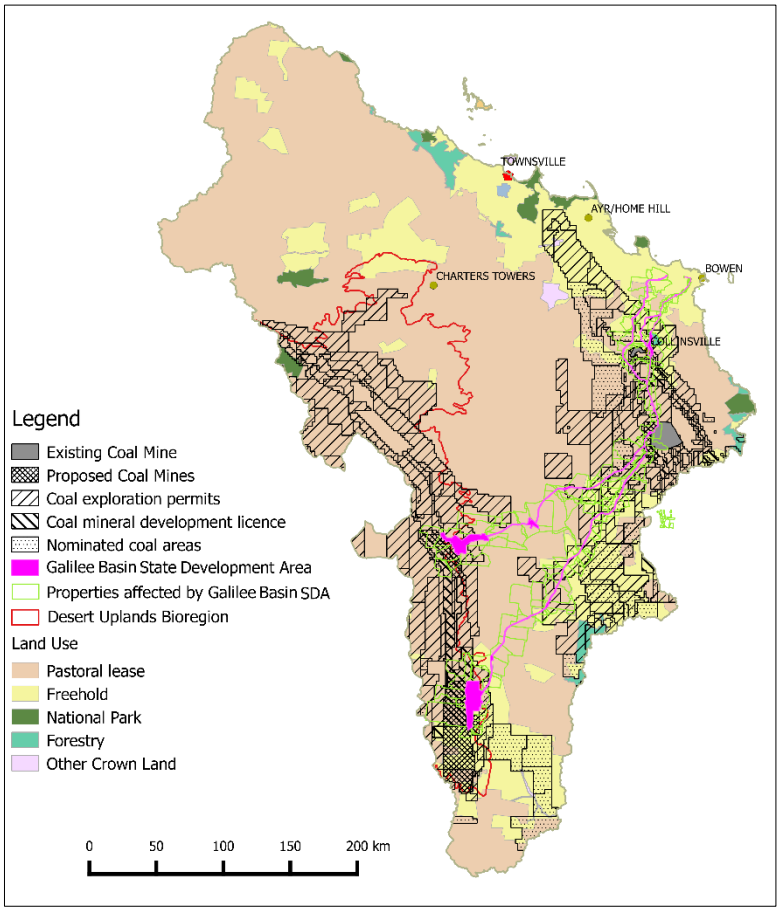


Figure 31. Coal mines, exploration permits, nominated areas and proposed infrastructure in the Burdekin Dry Tropic

Source of data: Galilee Basin SDA: Department of State Development (2015)[193]; Mining tenure details: Department of Natural Resources and Mines (2015)[189]; Land Tenure: Geoscience Australia (2004)[23]

Table 13. Coal mines, exploration permits and nominated areas in the Burdekin Dry Tropic

Source: Queensland MinesOnlineMaps[189]

Category/name	Status	Area	
		(km^2)	(%)
Existing coal mines			
Newlands/ Eastern Creek	Operational	405	0.28
Collinsville	Operational	43	0.03
Subtotal		448	0.31
Mineral development licences			
Alpha Coal Mine	Granted	340	0.24
Byerwen	Granted	174	0.12
China Stone	Granted	21	0.01
Carmichael	Granted	447	0.31
Diamond Creek	Granted	84	0.06
Drake East	Granted	0	0.00
Exevale	Granted	106	0.07
Galilee South	Granted	77	0.05
Gattonvale	Granted	29	0.02
Hillalong	Granted	32	0.02
Kevin's Corner	Granted	318	0.22
West Pentland	Granted	27	0.02
Subtotal		1,209	0.84
Pocky Creek	Application	38	0.03
Laglan	Application	1,020	0.71
Sarum 2	Application	171	0.12
Subtotal		1,676	1.16
Coal exploration permits			
153 areas		40,858	28.40
Nominated coal areas			
24 areas		9,426	6.55
Total		**53,618**	**37.27**

Economically viable deposits of other minerals occur across the Monsoonal North, mainly in rocks that are more than 500 million years old in the east Kimberley, western Top End, Mount Isa Inlier and the Northern Goldfields of Queensland[194] (Table 14). Significant mining and processing operations in the region include the McArthur River zinc, lead and silver mine in the Gulf Savanna and Glencore's copper and lead mining and smelting operations in the Mount Isa region.

Table 14. Economically viable mineral deposits in the Monsoonal North

Source: Geoscience Australia (2004)[194] and Bradshaw et al. (2012)[190]

Commodity	Kimberley	Top End	Gulf Savanna	Southern Gulf	Northern Gulf	Burdekin Dry Tropics
Bauxite	+					
Coal						+
Coal seam gas						+
Cobalt	+	+				
Copper	+	+		+		+
Diamond	+		+			
Gold	+	+	+	+	+	+
Iron	+	+				
Lead	+	+	+	+	+	
Magnesite		+				
Manganese		+				
Molybdenum						+
Nickel	+	+				+
Niobium	+					
Phosphate			+	+		
Platinum group elements	+					
Rare earths	+					
Silver	+	+		+	+	
Tantalum	+	+				
Tin		+			+	
Tungsten						
Uranium		+		+		+
Zinc	+	+	+	+	+	
Zirconium	+					

Environmental impacts

Mining can affect pastoral operations by polluting the land, air and water. Extensive coal mines in the Galilee Basin will mean loss of grazing land. Graziers in this region are concerned about loss of grazing land; loss of access; loss of remnant woodlands from open cut coal mining; impact of rail infrastructure; impact on ground water quality and availability; disturbance to rural lifestyles; inadequate consultation; and impact of the port development on the Great Barrier Reef[195,196,a].

In Mount Isa, contaminants from smelter operations have polluted the atmosphere, soil and water, contributing to health issues in the community[197,198]. Lead pollution from the McArthur River has

[a] http://www.abc.net.au/4966276; http://www.abc.net.au/news/6749244

contaminated fish[a] and appears to be responsible for contamination of 400 cattle that then had to be destroyed[b]. Water produced as a by-product of CSG contains elevated sodium, bicarbonate, chloride, boron and zinc[199]. Other potential impacts of CSG operations include lowering of water tables, and hydraulic fracturing (fraccing[c]) causing ground water contamination, subsurface subsidence and changes to groundwater flow[199,201-203]. Other issues with mining include loss of grazing land, unfettered access rights and disruption of pastoral operations[204-206].

Infrastructure impacts

Mine operation is dependent on infrastructure for transporting minerals extracted to processing facilities or ports. Rail corridors have, therefore, been designated between the proposed mines in the Galilee Basin and the coal terminal at Abbot Point (Figure 31). These infrastructure corridors impact pastoral operations by reducing grazing areas and dissecting pastoral properties[d] and can have serious environmental impacts[207] (as can associated ports[208,209]). The Queensland Government has declared a Galilee Basin State Development Area (SDA) comprising two multi-use rail corridors to service up to six mines[210] (Figure 31). The compulsory land acquisition corridor intersects approximately 74 landholdings, many being pastoral properties, and land acquisition will be required.

Social impacts

Mining is one of the most contentious issues in sections of the Queensland pastoral industry, and is a source of conflict elsewhere in the north[e], though it was not mentioned as a concern of pastoralists in the Northern Territory or Western Australia surveys[28,30]. Queenslanders who own farms have negative views of the CSG industry than are held by the rest of the community, as well as a more dismal outlook of what the future holds for them[211]. In southern Queensland, mental health issues have been identified amongst landholders coping with coal mining and CSG extraction[212]. Elsewhere in Australia repeated mine expansions and contractions or multiple mine developments led to cumulative adverse impacts on access to affordable accommodation; increases in traffic and fatigue-related road accidents; increased pressure on services including medical, dental and emergency services; and increases in criminal and other anti-social behaviour[213,214].

[a] http://www.abc.net.au/news/6724746
[b] http://www.abc.net.au/news/6716346
[c] pumping a fluid (water, sand and chemical lubricants) under pressure into the coal seam to fracture the coal and release gas ([200])
[d] http://www.abc.net.au/news/5526540
[e] http://www.abc.net.au/news/6339416

Mining also affects community structure, especially where mines are operated by Fly-In, Fly-Out (FIFO) staff, who are flown in and out on rosters of one or more weeks at a time[212]. The high wages offered by the mining industry also makes it difficult for pastoralists to attract and retain capable staff[212,213].

Mining can also bring positive benefits to the broader community, especially through infrastructure development[214]. Mining built the great towns of Ballarat, Bendigo, Bathurst and Charters Towers, along with their banks, hotels, hospitals and schools[215]. Even up until the 1970s, mining companies built towns such as Greenvale, in Queensland[216], and Newman and Goldsworthy, in Western Australia, and contributed to the development of larger centres, such as Port Hedland[217]. Hajkowicz et al (2011) found that as the value of mining production in regional areas increases, so do incomes, housing affordability, communication access, education and employment[218]. However, there is an increasing trend for infrastructure provided for mining towns to be temporary (e.g. portable accommodation)[219], as FIFO workers do not require more permanent services. Even the rail line to the Greenvale Nickel mine, built in 1974, was dismantled in 1993[220]. Therefore, the impacts on loss of pastoral land and livelihood, and the preferential treatment the mining industry receives regarding access to land and water resources (see Legal and regulatory environment) can far outweigh the few perceived benefits.

Pests and diseases

Weeds

In 2011-12, Northern Territory pastoralists identified weeds as the most significant issue affecting the environmental sustainability of their properties, with feral animals coming in second at nearly half the level of concern (Table 8). Woody weeds of concern vary between regions (Table 15), and less is known about the distribution of non-woody weeds. Parthenium, the non-woody weed with perhaps the greatest potential, is presently restricted to the eastern seaboard[221]. While Hyptis (Hyptis suaveolens) and Sida (Sida acuta) proliferate in over-grazed or sacrifice areas, such around waters and yards, their impact is less in well maintained pastures[222].

Table 15. Woody weeds with a significant impact on grazing operations

NB: Numbers show source references

Common name	Botanical name	Kimberley	Top End	Savanna Gulf	Queensland Gulf /Mitchell Grass	North Queensland
Weeds of National Significance						
Bellyache Bush	*Jatropha gossypiifolia*	28	223	223-225	223	223,226
Lantana	*Lantana camara*			225	223	223,226
Mesquite	*Prosopis* spp.	223		225	223	
Mimosa	*Mimosa pigra*		30,223,227	223		
Parkinsonia	*Parkinsonia aculeata*	28,223	223,227	30,223,224,228,229	223	223,226
Prickly Acacia	*Vachellia nilotica*		30,223	223-225,228	223	223,226
Rubber Vine	*Cryptostegia grandiflora*				223,230	223,226
Other exotic weeds						
Chinee Apple	*Ziziphus mauritiana*		223	223-225	223	223,226
Crotalaria	*Crotalaria* spp.	28		30		
Devil's Claw	*Martynia annua*			30		
Lion's Tail	*Leonotis nepetifola*			30		
Mimosa Bush	*Vachellia farnesiana*	28	223	223,228	223	223
Rubber Bush	*Calotropis procera*	28	30,227	30,224		
Senna/ Sicklepod	*Senna* spp./ *Senna obtusifolia*		30			
Blackwood	*Acacia argyrodendron*					226
Bread Fruit	*Gardenia vilhelmii*				230	
Problem native species						
Currant Bush	*Carissa* spp.		223	223,231,232	223	223,226
Cooktown Ironwood	*Erythrophleum chlorostachys*				230	
Eucalypt regrowth	*Eucalyptus* & *Corymbia* spp.	223	223	223,228,231-233	223,234	223,226,234,235
False Sandalwood	*Eremophila mitchellii*				223	223
Gidgee	*Acacia cambagei*				223	223
Gutta Percha	*Excoecaria parvifolia*				230	
Hakea	*Hakea arborescens*			231,233		
Lancewood	*Acacia shirleyi*					226
Rosewood	*Terminalia volucris*			231,233		
Sandalwood	*Santalum lanceloatum*					226
Tea Tree	*Melaleuca* spp.				230	
Wattle	*Acacia* spp.	223	223	223,228,229	223,230	223,226
Whitewood	*Atalaya hemiglauca*					226
Yellowwood	*Terminalia* spp.				230	226

Weeds reduce pastoral production by reducing pasture quality and extent, with some woody weeds promoting erosion by reducing ground cover [236]. They can also increase mustering costs. Some weeds are poisonous to stock, so can cause stock losses. In 2004, weed invasions were estimated to reduce the value of Australian beef production by just over $1,000 million a year, and control efforts cost the industry between $38 and $41 million[237]. In 2006, three of the largest pastoral companies in Australia reported spending a total of $1.3 million a year in weed control[238]. There are few weeds for which economic assessments have been undertaken. In 1991, Parthenium was estimated to cost the

Queensland beef industry between $14.5 and 16.5 million dollars[239]. Most of the cost was caused by reductions in turn-off and liveweight, but costs for weed control and reseeding pastures were also significant[240]. The impact of weeds on beef production and control costs increase with the density of the weed (Table 16), with heavy infestations of Rubber Vine estimated to reduce beef production by 80% and heavy infestations of Mesquite costing around $24/ha to control.

Table 16. Impact of Rubber Vine, Prickly Acacia and Mesquite on pastoral enterprises

Source: Adamson and Lynch (2000)[241]

Weed	Infestation	Reduced production	Increased mustering costs	Weed control costs
		(%)	($/ha)	($/ha)
Prickly Acacia	Light	0	0.00	2
	Medium	0	0.15	10
	Heavy	35	0.30	20
Rubber Vine	Light	4	0.00	1
	Medium	25	0.36	10
	Heavy	80	0.72	7
Mesquite	Light	0	0.00	2
	Medium	8	0.18	10
	Heavy	40	0.36	24

Across Queensland, Prickly Acacia, Rubber Vine and Mesquite have a substantial impact on the industry. In 2000, beef production losses were estimated to be $3.17 million, a cost that would have been doubled had it not been for the Queensland Government's $15.5 million Strategic Weed Eradication and Education Program (SWEEP), which operated between 1995 and 2003 (Table 17)[238]. If all three weeds were to fill their potential areas of distribution, their impact on the industry could increase to over $8 million per year by 2044. Had SWEEP continued, it was on track to eradicate Mesquite and Prickly Acacia from Queensland grazing lands in this period. While there are ongoing efforts to control these weeds on a lesser scale, notably the 5-year, $1.88 million War on Western Weeds program[242], stop-start funding of weed programs are a huge impediment to meeting such targets[238].

Table 17. Estimated cost of three weeds on the Queensland beef industry with and without the SWEEP control program

Source: Adamson and Lynch (2000)[241]

Weed	Year	Beef industry losses	
		Without SWEEP	With SWEEP
		($ m)	($ m)
Prickly Acacia	2000	1.43	1.38
	2044	2.30	0.00
Rubber Vine	2000	4.69	1.75
	2044	4.69	1.62
Mesquite	2000	0.44	0.04
	2044	1.32	0.00

Many weeds are expected to flourish under climate change. For example, Prickly Acacia currently occupies a fraction of its potential range in northern Australia (Figure 32). The entire Monsoonal North currently falls within the suitable range for this species, and only small portions, mostly in the Burdekin Dry Tropics are deemed to be highly suitable. The area that is highly-suitable for the weed is expected to increase with climate change, and, under the most severe scenarios, may expand to cover most of the region. Under such conditions, the cost of Parthenium to the beef industry has been project to increase seven-fold[221].

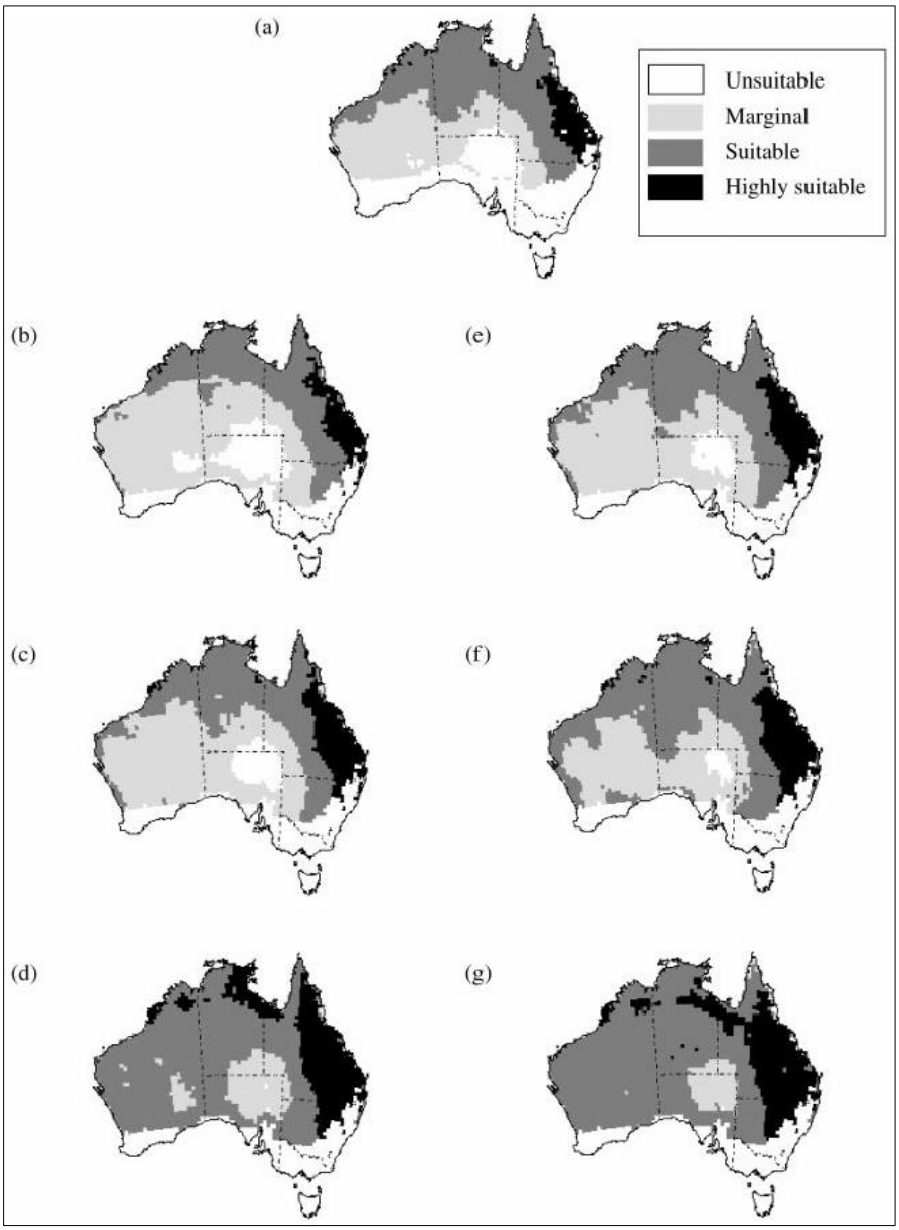


Figure 32. Current and potential distributions of Prickly Acacia based on CLIMEX modelling (a) and projected potential distributions based on various climate change scenarios (b-g)

Source: Adapted from Kriticos, Sutherst, Brown, Adkins and Maywald (2003)[243] [© 2003 British Ecological Society]

Pest animals

Wild dogs and dingos have significant financial impacts on the Australia beef industry, with annual losses estimated at $26.6 million in 2007-8[244]. By comparison, feral pig impacts are relatively small. However, the impacts of wild dogs and dingoes are widely debated, with some arguing that the benefits of macropod control outweigh the cost of calf losses[245,246] as densities of kangaroos are lower

outside the dingo fence[247]. Moreover, by controlling feral cats (and red foxes, where these occur), dingoes are important for maintaining biodiversity[248].

Kangaroos and wallabies contribute significantly to total grazing pressure across the rangelands[249], particularly around water points[250]. Kangaroo and wallaby grazing was estimated to cost the Australian cattle industry $8.1 million in lost cattle production[251]. It is unclear whether climate change will influence the pest impacts of either dingoes or kangaroos and wallabies.

Locusts cause considerable damage to grazing lands in the Monsoonal North. Locusts eat pasture and crop plants, stripping them to bare earth when in large numbers[252]. The most significant species in the tropics is the Spur-throated Locust (*Austracris guttulosa*), which proliferates following drought-breaking rains[253]. Locust plagues are thought to occur under these conditions because, while both numbers of both locusts and their predators are reduced during drought, once rain falls, predators take longer to recover than the locusts do[254]. Such an outbreak followed drought-breaking rain in western Queensland early in 2015[a]. Under climate change, locust outbreaks are expected to increase because of intensifying dry and wet cycles[254].

Disease and parasites

The Australian beef herd is relatively free of significant diseases. Tuberculosis and brucellosis were effectively eradicated in the 1992[255] and Australia is free from both FMD and BSE[256]. This gives Australian cattle a significant trade advantage (see Market requirements). Rigorous quarantine restrictions are in place to reduce the risk of these diseases entering Australia[257,258]. Australia's dominance of the live export trade to Indonesia also helps provide a disease free buffer to its north[37]. Indonesia's plans to relax restrictions on importing meat from FMD-free areas of India and Brazil is, therefore, of concern[b]. The impact of either FMD or BSE entering Australia would be immense, with a widespread outbreak shifting the value of the beef industry to the Australian economy from a surplus of $57 million to a deficit of $1.7 billion[259] potentially amounting to cost of over $50 billion over a 10 year period[260].

The cattle industry already bears heavy disease- and parasite-related costs, particularly from tick-related diseases, bluetongue, buffalo fly and ephemeral fever (Table 18).

[a] http://www.abc.net.au/news/6263414
[b] http://www.abc.net.au/news/5811476

Table 18. Cost of endemic diseases to the northern Australian beef industry

Source: Sackett, Holmes, Abbott, Jephcott and Barber (2006)[261]

NB: - indicates no data available

Disease	Cost per head ($)	Cost to industry ($ m)
High impact		
Tick control	15.62	140.1
Nutritional deficiency	27.58	117.5
Buffalo fly - no treatment	9.32	58.5
Tick fever - unvaccinated	3.43	18.4
Bovine ephemeral fever	6.69	17.9
Buffalo fly - treatment	6.14	16.5
Tick fever - vaccinated	1.83	6.6
Botulism	-	-
Reproductive wastage	-	-
Medium impact		
Pinkeye - treatment	1.29	6.7
Pinkeye - no treatment	1.11	5.8
Clostridial diseases	-	-
Internal parasites	-	-
Pestivirus	-	-
Low impact		
Akabane	-	-
Blue tongue	-	-
Cancer eye	-	-
Blue tongue	-	-
Leptospirosis	-	-
Lice	-	-
Transit tetany	-	-
Weaner stress syndrome	-	-
Unknown impact		
Emerging diseases	-	-
Genetic diseases	-	-
Myositis/stearitis	-	-
Neospora	-	-
Neurological disease	-	-
Plant toxins	-	-
Sporadic bovine encephalitis	-	-

Ticks impose the greatest burden on the cattle industry. Not only are there costs associated with treatment and production losses, but animals must be yarded and inspected at recognised facilities when animals move from tick infested or tick-protected areas into tick-free areas[261]. In addition, further costs arise from the need to prevent and treat tick fever. These costs are dealt with in the following section.

The impact that a disease outbreak can have on the cattle industry was illustrated in a recent outbreak of bovine johne's disease (BJD). Western Australia is in the BJD-free zone and Northern Territory and Queensland are in the Protected Zone, where there is an emphasis on early detection and rapid response to prevent spread[262]. There have been 24 recorded instances of cattle in Queensland being

infected with BJD, mostly in introduced animals[263]. In October 2012, a BJD outbreak occurred on a stud property near Rockhampton, which had transported animals to up to 170 properties across Queensland, Northern Territory, Western Australia and New South Wales before the disease was detected. Interventions included restriction on stock movement and consigning potentially affected animals to feedlot or slaughter to reduce the risk of disease spread. Animals were traced using the National Livestock Identification System (NLIS)[256], but this was hampered by poor compliance and record access, and recommendations have been made for improvements[263].

The cost of controlling this outbreak was estimated to be about $6-7 million, partly borne by the industry and the rest by government[264]. Had the outbreak expanded to a second location, the cost of the response would have been in the order of $23-25 million. Destocking of infected properties was estimated to cost an average of $1.5 million, and the cost of managing the disease on stud properties substantially higher. Compensation paid by the Queensland Government was capped at $100,000. Had Queensland's BJD status been revised from *Protected* to *Management* the costs would have included both production losses and impacts on market access and prices. Disease control measures are, therefore, important, not just at ports, but on-property and when stock changes hands.

Climate change is expected to increase the risk of significant diseases and parasites (such as crew worm) entering Australia from neighbouring countries, as well as favouring many of those already present in the country, such as ticks, bluetongue, leptospirosis, buffalo fly and bovine ephemeral fever[265-267].

Fire

Fire frequency and extent varies across the Monsoonal North. Most of the Mitchell Grass country in the Southern Gulf is rarely burnt, and much of the north Kimberley, western Top End, Northern Territory Gulf country and western Cape York Peninsula is burnt at least every second year (Figure 33). Most fires occur in the second half of the year (Figure 34). These fires tend to be wildfires, and have a significant impact on grazing production. In 2010, pastoralists in the Kimberley identified wildfire as the most significant constraint to environmental sustainability[268].

Fire frequency and extent is related to development and grazing pressure, with highest frequencies occurring on the least intensively managed country, and lowest frequencies in areas with high stocking rates[269]. In areas where wildfires are extensive, the combined costs of fighting fires and feeding or moving cattle exceed those of lighting fires and sacrificing small areas of pasture by burning firebreaks

early in the year[270,271]. Therefore, in areas of high wildfire risk, strategic use of early dry season burning to prevent wildfires is economically viable, especially when combined with carbon abatement (see Environmental service delivery). Lack of fire can also be an issue in the northern rangelands, leading to vegetation thickening and loss of pasture production[272-275].

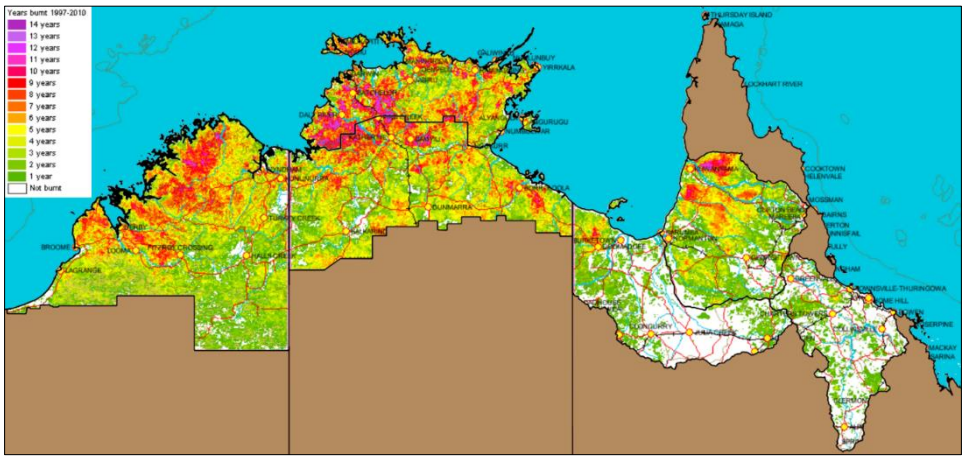


Figure 33. Frequency of fires in the Monsoonal North between 1997 and 2010

Source: NAFI (2015)[276]

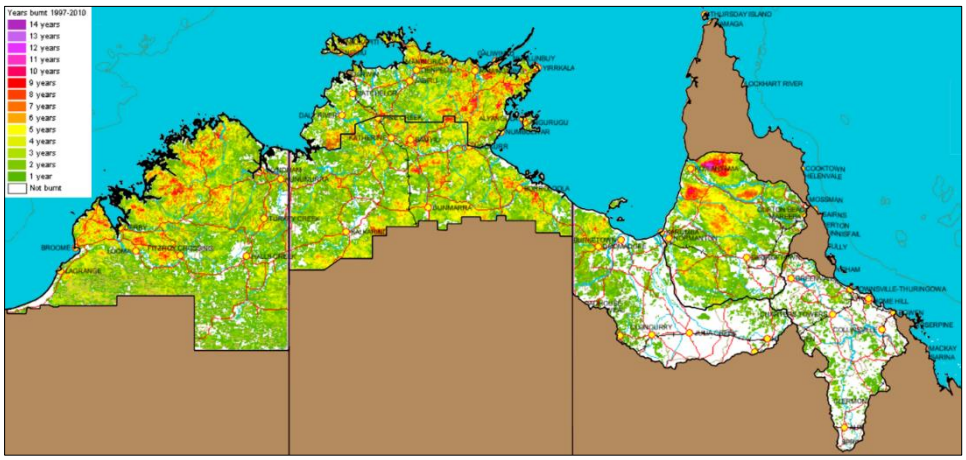


Figure 34. Frequency of late dry season fires in the Monsoonal North between 1997 and 2010

Source: NAFI (2015)[276]

Climate

Variability and seasonal conditions

Beef production is highly dependent on seasonal conditions, with droughts leading to loss of forage and years of good rainfall assisting pasture recovery, improving land condition and temporarily increasing carrying capacity[69,265,277]. Pastoralists respond to severe droughts by destocking to avoid pasture degradation and cattle death, and use good years to rebuild the herd. However, extended periods of elevated rainfall can lead to unrealistic expectations of long-term carrying capacity[278].

The northern cattle herd was reduced in size, or its growth retarded, by extended or severe periods of drought in 1965-66, through much of the 1980s and the early 2000s (Figure 7). Following exceptionally good rainfall years in 2011-12, drought conditions set in in 2013 in the Southern Gulf and large parts of the Northern Gulf and Burdekin Dry Tropics and properties began to destock[279]. Cattle and calf slaughter in Queensland rose 7% in 2012-13 and a further 12% in 2013-14. With sales at near-record highs[54], cattle prices fell, but the volume sold meant business incomes were only marginally reduced[137]. Severe drought conditions persisted to the end of the 2015 dry season, and sales dried up through western Queensland. Prices recovered as the number of stock for sale fell again, with increasing competition between the various market sectors[49]. Hence, adjusting stock numbers in response to seasonal conditions is important for maintaining pasture condition and profitability[280], but also places financial stress on beef enterprises when the whole country is trying to destock or restock at the same time.

Climate change

Climate change poses one of the greatest challenges to natural resource management in Australia. Climate change is being caused by an increase in atmospheric carbon dioxide[a]. In the Monsoonal North, temperature rises of between 0.9 and 1.0˚C have occurred since 1910, and increases of a further 1.3 to 5.1˚C are expected by the end of the century[1], with CO_2 concentrations reaching somewhere between 540 and 940 ppm (depending on efforts to reduce anthropogenic CO_2 emissions)[285].

[a] Atmospheric carbon dioxide has increased from around 280 ppm before the industrial revolution[281] to current levels of around 400 ppm[282].Over the same period, global temperatures have risen by about 1.0˚C[283]. Up until the start of the 20th century, CO_2 influence on global temperature was difficult to separate from that of other factors such as solar radiance and volcanic eruptions[284]. However, the steady temperature rise of about 0.5˚C through the 20th century[283] has been strongly linked to anthropogenic CO_2 emissions[284], and temperature is increasing at an accelerated rate. Both CO_2 and temperatures have continued to increase through the 21st century, and 2014 was the hottest year on record[285,286].

The Monsoonal North is already experiencing climate change, with every year of the 21st century so far being one of the hottest 15 years on record[287]. Droughts, cyclones, wildfires and flooding rains are likely to intensify over the next few decades (Table 19), and continue intensifying until at least the end of the century[1]. These changes will have enormous impacts on the condition of land and seas of northern Australia, including their productive potential and our ability to manage them.

Despite some potential benefits to date, climate change poses many new stresses to the northern beef industry. Since 1900, rainfall has increased by 20 mm per decade in the Kimberley and Northern Territory sections of the Monsoonal North and by 10 mm per decade in the Queensland section[1]. These changes have resulted in increased forage and animal production in the Kimberley and adjoining areas of the Northern Territory[288]; with a further 20% increase in rainfall would be likely to further increase pasture growth by 9% and safe stocking rates by 11%[289]. However, rainfall in the Kimberley is neither predicted to increase nor decrease with any certainty[1]. Rather, large variations in rainfall from year to year are likely to intensify, accompanied by increases in temperature and evaporation. These changes are expected to increase the frequency of heatwave conditions and reduce surface water availability, especially in the late dry season[290]. While not expected to increase fire frequency, dry hot conditions will mean that fires that do occur are expected to be more severe and spread faster than fires do now[1]. This would both reduce forage availability and create challenges for pastoralists diversifying into carbon abatement projects.

Table 19. Climate change projections across the Monsoonal North to 2030

Climate variable	Projection	Confidence	Sources
Atmospheric CO_2	Continue to rise (reaching 425-450 ppm)	Not stated	291,292
Solar radiation	Little change	High	1
Evapotranspiration	Increases of ca. 2-6% in autumn, winter & spring Increases of ca. 1-5% in summer	Medium	1
Relative humidity	Little change	Medium	1
Temperature	Continued substantial warming for mean, maximum and minimum temperature (increases of 0.5-1.3°C)	High	1
Heatwaves	Substantial increase in the temperature of hottest days and duration of warm spells	Very high	1
Days per year over 35˚C	Broome: 72 to 111; Darwin: 25-74; Cairns 4-8 (Currently: Broome: 56; Darwin: 11; Cairns 3)	Very high	1
Days per year over 40˚C	Broome: 6-9; Darwin: 0; Cairns <1 (Currently: Broome: 4; Darwin: 0; Cairns 0)	Very high	1
Rainfall	Continues to be driven by natural climate variability	High	1
Rainfall intensity	Increased intensity of heavy rainfall extremes	High	1
Droughts	No clear indication on time spent in drought	-	1
Soil moisture	Decreases in soil moisture, with largest decreases in autumn	Medium	1
Run-off	No projection - dependent on rainfall & rainfall intensity	-	1
Cyclones	Less frequent but more intense	Medium	1
Fire frequency	Top End & Kimberley: No change	High	1
	Rest of cluster: no change	Medium	1
Fire behaviour	More extreme	Medium-High	1
Average wind speeds	Little change	High	1
Sea level	Continued increase in sea levels requiring raising of sea walls by 11-14 cm	High	1
Groundwater recharge	No projections - Dependent on rainfall, but also sensitive to temperature, rainfall intensity solar radiation and CO2	-	293,294
Groundwater quality	No projections - Dependent on groundwater recharge and sea level rise	-	294
Ocean temperature	Increases of 0.6-0.9˚C in coastal water	Very high	1
Ocean salinity	Variable, but little change	Low	1
Ocean acidity	Increase – pH decreases of 0.07 in coastal waters	Very high	1
Oceanic calcium availability	Aragonite saturation decreases of 0.30-0.42	Not stated	1

Carbon dioxide enrichment alone may also have positive and negative effects on forage production. Increasing growth rates and improving water-use efficiency are expected to contribute a 26% increase in production by the end of the century[288]. However, this increase is likely to be offset by woody thickening as woody plants (with a C3 photosynthetic pathway[a]) respond more vigorously to CO_2 enrichment than do tropical C4 grasses[288]. Moreover, CO_2 enrichment is likely to reduce forage quality[296] and, with it, animal growth rates, enterprise production and profitability[173,290].

[a] Most plants use only the standard Calvin photosynthetic pathway to produce carbohydrates from CO_2, and are known as C3 plants. C4 plants, mostly tropical grasses and sedges, enhance carbohydrate production through a second pathway C4 pathway[295]. Increasing atmospheric CO_2 levels increase vegetative growth in C3 plants, but growth in C4 plants is unaffected.

In most climate change scenarios, whether rainfall remains roughly the same or decreases, pasture growth and safe stocking rates in the Monsoonal North are expected to decrease, with the worst scenarios predicting decreases in pasture growth and safe stocking rates of between 50% and 60%[289].

Climate change impacts on the production environment will filter through the supply chain to affect enterprise and industry viability (Table 20). But each level of the supply chain will also be individually affected. Likely impacts extend from increasingly stressful operating conditions to damage caused by floods and cyclones. The impact of Cyclone Marcia in February 2015 is illustrative of the type of damage that is likely to become more prevalent with climate change. This cyclone not only cut communications in the Rockhampton region[a], but also closed the Rockhampton abattoir for at least six weeks because of power disruption and damage to buildings[b]. This closure affected cattle sales and prices throughout north Queensland[297,298,c]. Similarly, in March 2015, Gunbalanya Meatworks had to stop killing and freeze packed meat when Cyclone Nathan delayed transportation for a week[d].

[a] http://www.abc.net.au/news/6217420
[b] http://www.abc.net.au/news/6285738; http://www.themorningbulletin.com.au/news/meatworks-to-open-in-four-weeks/2566697/
[c] http://www.abc.net.au/news/6268850
[d] http://www.abc.net.au/news/6345286

Table 20. Cascading climate change impacts on beef production in northern Australia

NB: This tables only considers climate change scenarios projected with medium to very high confidence.

Variable	Positive drivers	Negative drivers	Projected overall outcome	Sources
Environmental factors				
Surface water		Increased temperatures	Reduced water availability	173
Soil stability		Increased rainfall intensity Increased cyclone intensity	Increased soil erosion	173,290
Ground cover	CO_2 fertilisation Increased temperatures	Increased heatwave conditions Increased wildfire extent Increased soil erosion	Reduced ground cover	290
Soil carbon		Increased temperatures	Reduced soil carbon	173
Cattle ticks		Increased temperatures	Increased numbers and expanded distribution	173,289
Weed spread and water use		Increased temperatures Increased cyclonic disturbance	Increase weed burden	290,243,299
Pasture and feed production				
Woody thickening	More severe wildfires	CO_2 fertilisation	Uncertain	173
Forage production	CO_2 fertilisation Longer growing season Decreased woody thickening	Reduced ground cover Shorter wet season Increased temperatures Increased evaporation Increased woody thickening	Reduced forage production	288,173,290,289
Forage quality		CO_2 fertilisation	Reduced forage quality	173
Grain for feed		Increased competition for agricultural land Increased demand for grain for biofuel	Reduced availability and increased cost	173
Animal production				
Animal heat stress and water requirements		Increased temperatures Increased evaporation Increased heatwave incidence	Increased heat stress and water requirements	173
Animal liveweight gain		Increased cattle tick abundance Reduced forage production and quality Increased heat stress	Reduced liveweight gain	173
Reproductive rates		Reduced forage production and quality More heat stress	Reduced reproductive rates	173
Animal mortality		Reduced forage production and quality Increased incidence and severity of heat stress Reduced water availability Increased wildfires	Increased mortality rates	173,290
Animal production		Reduced liveweight gain Reduced reproduction	Reduced animal production	173
Enterprise viability				
On property - infrastructure		Increased heat stress Increase water needs Reduced water availability Increased cyclonic severity Increased wildfires	Increased need for shade, cooling sprays and watering points and replacement of damaged infrastructure	173

…/continued

Table 20. continued

Variable	Positive drivers	Negative drivers	Projected overall outcome	Sources
Profitability		Reduced animal production Increased infrastructure and pest and weed management costs Increased cost of grain	Reduced income, gross margins and hence profitability	173,290
Social outcomes				
Emotional stress		Reduced income, gross margins and profitability		300,301
Infrastructure				
Water storage and distribution		Accelerated degradation	Interruptions to supply Increased maintenance costs	302
Road transport		Temporary or permanent road closure necessitating re-routing (where possible) Increased road maintenance costs Increased risk from road damage	Reduced access to properties Reduced ability to get cattle to market Increased transport costs Increased insurance costs Potential increased cattle mortality	302
Rail transport		Temporary closure from submergence or buckling of tracks Damage to signals and electrical systems Damage to rail foundations	Reduced ability to get cattle to market Increased transport costs Increased insurance costs Potential increased cattle mortality	302
Ports		Increased corrosion Storm damage Inundation	Increased frequency and duration of port closures Shipping delays Increased transport costs Increased insurance costs Potential increased cattle mortality	302
Power generation		Increased power disruption Accelerated degradation	Potential interruptions to operation of meatworks	302,303
Communications		Increased frequency and duration of network outages	Disruption of communication services	302,303
Buildings		Significant damage to, and accelerated deterioration of buildings	Disruption of lives and business operations	302

Policy environment

North Australian beef production is influenced by the policies and programs of numerous government agencies and industry bodies at national, state and territory and regional levels (Figure 35). Influence is also exerted directly by peak industry bodies, service providers (e.g. banks and extension providers), and by lobby groups and the media. The policies and programs of organisations that have most influence on the beef industry are examined in detail below.

Government agricultural policies and programs aim to drive development in the north. Traditional forms of government support to agriculture, such as trade protection and vast extension programs, have declined over the past half century[106,304]. Recent government support for the beef industry is currently focused on:

- Increasing access to international markets (see International trade)
- Building more conducive business and financial environments
- Identifying infrastructure needed to provide a reliable supply chain and attract investment in priority infrastructure
- Identifying practice improvement required for industry resilience and growth.

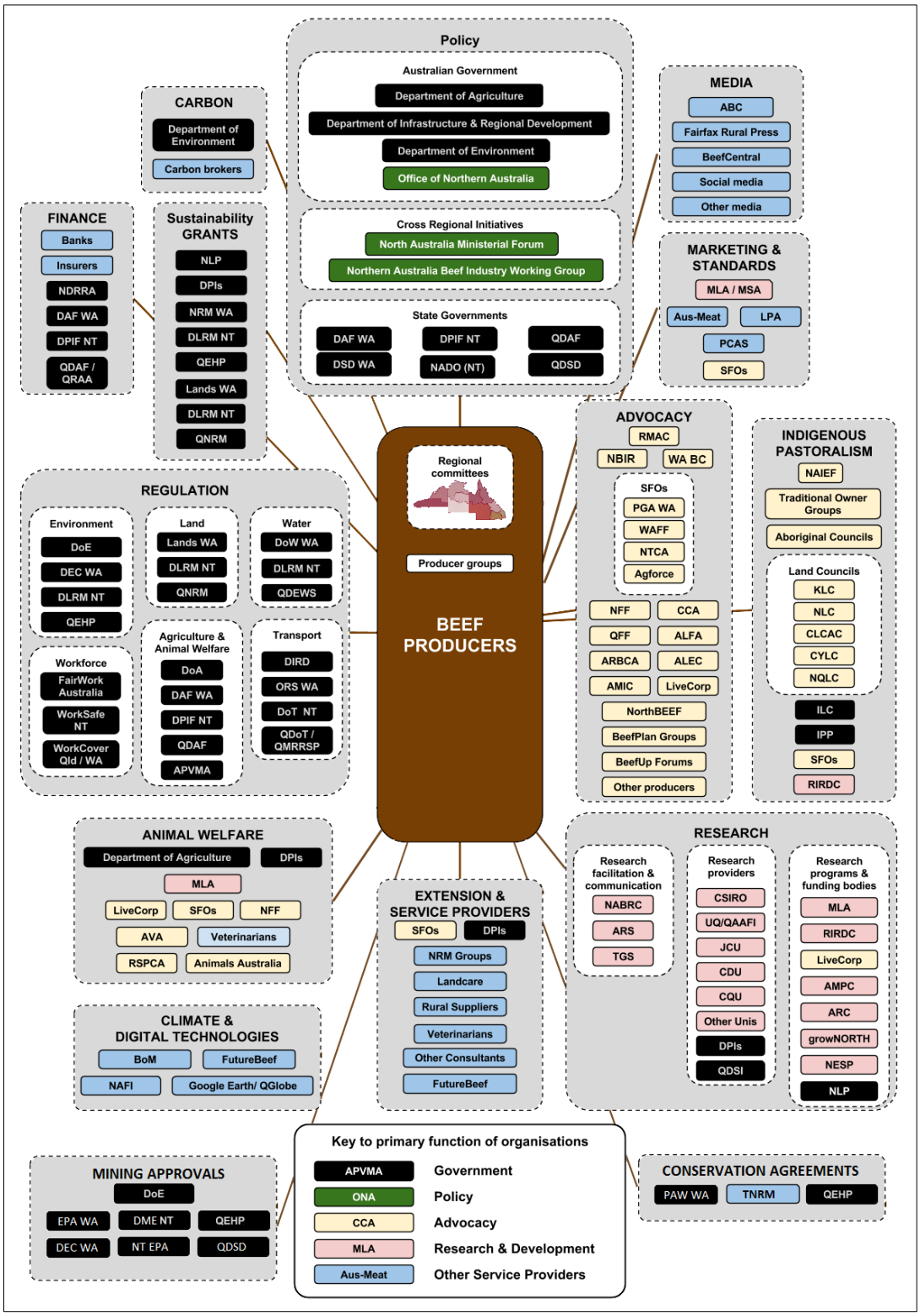


Figure 35. Organisations that influence the northern Australian beef industry

See Table 21 for explanation of abbreviations and acronyms.

Table 21. Organisations influencing the northern Australian beef industry shown in Figure 35

Abbreviation	Organisation
ALEC	Australian Livestock Exporters' Council
ALFA	Australian Lot Feeders' Association
AMIC	Australian Meat Industry Council
AMPC	Australian Meat Processor Corporation
APVMA	Australian Pesticides & Veterinary Medicines Authority
ARC	Australian Research Council
ARCBA	Australian Registers Cattle Breeders Association
ARS	Australian Rangelands Society
AVA	Australian Veterinary Association
BoM	Australian Bureau of Meteorology
CCA	Cattle Council of Australia
CDU	Charles Darwin University
CLCAC	Carpentaria Land Council Aboriginal Corporation
CQU	Central Qld University
CYLA	Cape York Land Council
DAF WA	Department of Agriculture & Food, WA
DCM NT	Department of Chief Minister, NT
DEC WA	Department of Environment and Conservation, NT
DIRD	Department of Infrastructure & Regional Development
DLRM NT	Department of Land Resource Management, NT
DME NT	Department of Mines and Energy, NT
DoA	Department of Agriculture (Cth)
DoE	Department of Environment (Cth)
DoT NT	Department of Transport, NT
DPIF NT	Department of Primary Industry & Fisheries, NT
DPIs	Primary Industries Departments (DAF WA, DPIF NT, QDAFF)
DME NT	Department of Mines and Energy, NT
DSD WA	Department of State Development, WA
EPA WA	Environmental Protection Authority, WA
ILC	Indigenous Land Corporation
IPP	Indigenous Pastoral Program
JCU	James Cook University
KLC	Kimberley Land Council
Lands WA	Department of Lands, WA
LiveCorp	Australian Livestock Export Corporation
LPA	Livestock Production Assurance
MLA	Meat & Livestock Australia
NABRC	North Australia Beef Research Council
NADO (NT)	Northern Australia Development Office, NT
NAFI	North Australia Fire Information website
NAIEF	Northern Australian Indigenous Experts Forum on Sustainable Economic Development
NBIR	Northern Beef Industry Roundtable
NDRRA	National Disaster Relief & Recovery Arrangements
NFF	National Farmers Federation
NLC	Northern Land Council
NQLC	North Qld Land Council
NRM WA	State NRM Office, WA
NT EPA	NT Environment Protection Authority
NTCA	NT Cattlemen's Association
ORS WA	Office of Road Safety, WA
PAW WA	Parks and Wildlife, WA
PCAS	Pasturefed Cattle Assurance System
PGA WA	Pastoralists & Graziers Association of WA
QAAFI	Qld Alliance for Agriculture & Food Innovation
QDAF	Qld Department of Agriculture & Fisheries
QDEWS	Qld Department of Energy & Water Supply

.../continued Table 21

Table 21. continued

Abbreviation	Organisation
QDoT	Qld Department of Transport
QDSD	Qld Department of State Development
QDSI	Qld Department of Science & Innovation
QEHP	Qld Department of Environment & Heritage Protection
QFF	Queensland Farmers' Federation
QMRRSP	Qld Department of Main Roads, Road Safety & Ports
QNRM	Qld Department of Natural Resources & Mines
QRAA	Qld Rural Adjustment Authority
RIRDC	Rural Industries Research & Development Corporation
RMAC	Red Meat Advisory Council
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SFOs	State Farming Organisations (AgForce, NTCA, PAG WA, WFF)
TGS	Tropical Grasslands Society of Australia
TNRM	Territory NRM
UQ	University of Queensland
WA BC	WA Beef Council
WAFarmers	WA Farmers Federation

Australian Government white papers and parliamentary inquiries

Two national white papers released in 2015 have implications for the northern beef industry: the *North Australian White Paper*[305] and the *Agricultural Competitiveness White Paper*[153]. Both were informed by the recommendations of The *Joint Select Committee into the Development of Northern Australia*[306]. The North Australia White Paper committed the Australian Government ($600 m/5 years) to a number of infrastructure-related projects, including:

- Upgrading priority roads
- Great Northern and Arnhem Highways, Northern Territory
- Flinders and Hann Highways, Queensland
- The Outback Way, between Laverton, Western Australia and Winton, Queensland
- Tanami Road, between Halls Creek, Western Australia and Alice Springs, Northern Territory
- Barkly Highway between Tennant Creek, Northern Territory and Cloncurry, Queensland
- Targeted investment to improve transport of cattle through the Northern Australia Beef Roads Fund ($100 m)
- Assessment of investment options for railways particularly between Mount Isa and Tennant Creek
- Establishment of the Northern Australia Infrastructure Facility to support investment in key northern Australia infrastructure projects ($5,000 m) and a portal providing information on potential infrastructure investment opportunities
- Extension of the Regional Aviation Access Programme to remote airstrips.

As part of the white paper process, Infrastructure Australia undertook an audit to identify infrastructure needed to develop northern Australia[307]. This audit characterised the issues facing the north and identified the processes needed to ensure future investment is well directed. It did not make any recommendations.

The *Agricultural Competitiveness White Paper* outlined $4,000 m of new and existing investments to improve profitability, resilience and sustainability of the agricultural sector, and to facilitate access to growing international markets, through improvements to food safety, environmental management, modern technology and workforce skills. The paper's five priority areas cover the business environment, infrastructure, risk management, practice improvement and market access. New initiatives to improve the business environment of primary producers included:

- Oversight of fair-trading and competition in agricultural supply chains by the Australian Competition and Consumer Commission, with a dedicated Agriculture Commissioner ($11.4 m/5 years) to reduce producer vulnerabilities to monopolies in the processing, transport and product purchase
- A pilot programme to help producers establish alternative business models (including cooperatives), manage contract negotiations and attract investors ($13.8 m/2 years)
- A streamlined approval process for agricultural and veterinary chemicals ($20.4 m)
- Productivity Commission reviews to investigate options for reducing the regulatory burden
- Country-of-origin labelling that identifies where a food product was produced and processed and the proportion of Australian-grown produce
- Changes to taxation arrangements for primary producers, including improvements to:
    - Income tax averaging
    - Expanding the use of Farm Management Deposits (FMDs) allowing farmers to set aside pre-tax income in good years to cover low income years (and pay tax liabilities), and to use these deposits to offset loans and reduce interest rates
    - Depreciation for fencing
- Increasing investor awareness of agricultural investment opportunities
- Increased scrutiny of foreign investment.

The paper also highlighted taxation relief and the accelerated depreciation schedules for small primary producers in the Growing Jobs and Small Business package[308] from 2015; extensive reforms of the regulatory system, including for environmental assessments; the tax reforms being considered in a taxation white paper[309], including negative gearing of primary production expenses; and efforts to

reform land tenure systems across northern Australia to assist development as part of the *Northern Australia White Paper*.

New infrastructure commitments included establishment of a National Water Infrastructure Development Fund to improve farm access to water through strategic planning ($50 m/5 years) and construction ($450 m/5 years). Water infrastructure options in northern Australia will be assessed ($30 m) covering:

- West Kimberley, Western Australia
- Ord Stage 3, Western Australia and the Northern Territory
- Darwin region, Northern Territory
- Mitchell River catchment (Northern Gulf region), Queensland
- Nullinga Dam (Northern Gulf region), Queensland.

Expansion of CSIRO's Transport Network Strategic Investment Tool (TRANSIT) will be supported to ensure future investment in transport infrastructure improves agricultural supply chains.

The paper highlighted existing infrastructure investment of benefit the agricultural sector, i.e. road and rail construction (including upgrades to the Bruce Highway, Queensland and Buntine, Plenty, Victoria and Stuart highways, Northern Territory); improved mobile phone coverage; and the National Broadband Network to upgrade internet access.

New initiatives to improve risk management included:

- Improved seasonal forecasts ($3.3 m/5 years)
- Improved taxation arrangements covering new water facilities and fodder storage assets
- Funding for access to insurance advice and risk assessment ($29.9 m/4 years).

Support for producers and agricultural communities experiencing drought conditions included:

- Extension of the Drought Concessional Loans program for 11 years (up to $250 m a year)
- Increased Farm Household Allowance case management for farmers ($22.8 m/5 years)
- Access to FMDs without taxation penalties
- Funding for infrastructure projects to help drought-affected communities ($35 m/5 years)
- Funding to assist pest animals and weed management in drought-affected areas ($25.8 m/4 years)

- Improved access to financial counselling and community mental health services, and advice from the Australian Taxation Office.

The White Paper aimed to assist on-farm practice improvement by:

- Extension of the Rural R&D for Profit Programme for on-farm and collaborative research ($100 m; 2018–19 to 2021–22)
- Extension of research investment to include export fodder and tea tree oil industries through matching industry levies and contributions ($1.4 m/5 years)
- Research support for small industries not currently covered by the Rural Industries Research and Development Corporation ($1.2 m/5 years)
- Reform of use of levies by industry research and development corporations to:
    - Prioritise research, development and extension (RD&E) to areas that will improve farm gate returns
    - Reduce administration costs
- Improve emergency pest and disease eradication capability ($50 m/ 5 years)
- Develop tools and control methods for pest animal and weeds management $50 m/5 years).

Pre-existing programs to support practice improvement highlighted in the paper included:

- Training through the Industry Skills Fund and Green Army
- Expansion of seasonal and working holiday visas in northern Australia
- Review of occupations eligible for temporary skill visas
- National Landcare Programme.

The White Paper committed the government to the following investment to improve access to international markets:

- Address technical barriers to trade and appoint five new Agriculture Counsellors ($30.8/5 years)
- Improve biosecurity systems, including in northern Australia ($200 m/5 years)
- Modernise traceability systems for Australia's food export ($12.4 m/5 years).

Northern Australia Beef Industry Working Group

The Northern Australia Ministerial Forum (NAMF), which operated between 2010 and 2013 to promote sustainable development of the north, set up the Northern Australia Beef Industry Working Group (NABIWG) in 2012 to facilitate development of the northern beef industry [310]. Members of this working group included industry (NABRC, RMAC; NAIEF) and governments with responsibilities in northern Australia.

The working group identified seven strategic priority areas to support industry viability and growth, along with associated actions:

- Trade relationships and market access
- Investment security through land tenure and water rights
- Transport, logistics and infrastructure
- Research, development, extension, education and training across the supply chain
- Indigenous involvement in the industry
- Compliance costs
- Understanding of the resource base.

Reports addressing most of these priorities have been completed and are widely quoted elsewhere in this report. While the Working Group is no longer in operation, each of the government agencies and industry bodies represented on this working group are pursuing actions addressing these priorities, namely:

- Land tenure reform is underway in all jurisdictions (see Tenure and Native Title)
- Industry groups, land councils and government agencies are supporting the development of Indigenous pastoralism (see Indigenous pastoralism)
- State and territory governments are supporting mosaic irrigation (see Diversification), identification and adoption of improved practices, and investing in regional infrastructure development (see below), and new abattoirs have been constructed, are under construction or have been proposed[a]
- Northern agricultural stakeholders, including state and territory governments, have collaborated to develop the collaborative research and development program, growNORTH.

[a] http://www.abc.net.au/news/5877062

Indigenous Land Corporation

The Indigenous Land Corporation's (ILC) key priority of socio-economic development of Indigenous people is largely delivered through assisting in the purchase and management of northern pastoral properties[311]. This priority is addressed through the following activities:

- Acquiring and granting land to Indigenous organisations to achieve Indigenous training, employment and social outcomes
- Operating agricultural and tourism businesses that train Indigenous people and assist them to transition to secure jobs
- Providing funding assistance to Indigenous landholders for projects that will develop land-based businesses and improve management of their land
- Providing property planning assistance to build the capacity of Indigenous landholders to manage and use their land
- Developing projects in collaboration with other organisations to assist Indigenous landholders engage with emerging enterprise opportunities in offsetting greenhouse gas emissions and delivery of environmental services
- Collaborating with other agencies and industry partners to implement regional projects that provide mentoring, support and advice to assist Indigenous landholders to manage land sustainably.

ILC's activities in the northern beef industry were described earlier in this report (see Indigenous pastoralism).

State and territory governments

Each of the three state and territory governments in northern Australia has had policies to increase herd size (Table 22), which are detailed below. Recent changes in government mean it is not always clear which policies remain current.

Table 22. Government projections for the northern Australian beef industry

Year	Cattle numbers	Increase	Period	Annual growth	Source
Kimberley, Western Australia					
2009	750,000				29
2020	1-1.3 million	33-73%	11 years	2.65-5.13%	
Northern Territory					
2009	1.9 million				312
2014	2.0 million	5%	5 years	1.03%	
2019	2.3 million	21%	10 years	2.84%	
2029	2.8 million	47%	20 years	1.98%	
Queensland					
2014	12.2 million				313
2040	16.8 million	38%	26 years	1.24%	

Western Australian Government

The strategic plan of the Department of Agriculture and Food, Western Australia (DAF WA) focuses on improving the supply chain; transforming businesses; improving biosecurity; and protecting natural resources to build markets, increase productivity, improve profitability and build human capacity[314]. In line with the strategies identified by NBIWC, the Western Australian Government has prioritised the development of the beef industry in the Kimberley and Pilbara, focusing on mosaic irrigated agriculture and Indigenous development. Programs to achieve this include *Northern Beef Futures* and *Water for Food*[315].

Northern Beef Futures

The *Northern Beef Futures* project is part of Western Australia's *Royalties for Regions* program[316]. This $15 million investment aims to improve economic and employment opportunities in the Kimberley and Pilbara by increasing cattle production. It aims to build business resilience by facilitating access to a wider range of markets; and attract business investment by assisting pastoral operations develop innovative business models and management capabilities. The program promises to:

- Deliver extension activities to support skills development and the adoption of improved and innovative practices in production, processing and export
- Facilitate value-adding of beef production and supply chain development to meet the needs of new and existing markets, particularly through enabling cattle to be finished to slaughter-ready weights on irrigated pasture within the region
- Identify infrastructure needed for delivering products to new and existing markets and provide seed capital to encourage investment in priority infrastructure
- Deliver stand-alone clearing-yard facilities in the Kimberley to enable transport of domestic cattle without affecting the quarantine status of export depots

- Work closely with Indigenous pastoral businesses, to facilitate increased production and Indigenous participation in all stages of the beef supply chain.

The project is built on partnerships with northern pastoral industry groups, ILC, WA Beef Council (WABC) and Meat and Livestock Australia (MLA), and has been endorsed by Northern Beef Industry Roundtable (NBIR) and North Australia Beef Research Council (NABRC).

Water for Food

Western Australia's *Water for Food* initiative is also part of the *Royalties for Regions* program. It aims to increase economic growth and regional employment by developing new irrigation areas and extending the size and productivity of existing irrigation areas[70]. This involves developing a new tenure framework to allow diversification of land use on existing pastoral leases. The first stage includes investigation of groundwater resources and three pilot projects to develop Indigenous employment opportunities, including using pivot irrigation to provide forage and silage on the Indigenous-owned pastoral lease, Mowanjum[70,317]. This meshes with the aim of the *Northern Beef Futures* project by providing the means for finishing cattle on northern properties.

Northern Territory Government

The Northern Territory Government's policies to support the beef industry are found in its Primary Industry and Fisheries *Industry Development Plan 2013–2017*[318]. These focus on developing a supportive business environment; market development; practice improvement; biosecurity; Indigenous pastoralism; diversification of land use activities; and facilitating investment in essential infrastructure.

The Northern Territory Government projected that the beef industry would grow from 1.9 million head of cattle in 2009 to 2.0 million head in 2014 and 2.8 million head in 2029, and increase of 47% in 20 years[312]. Initial growth was to be delivered by general intensification; followed by increasing cattle numbers on Indigenous land and intensification in the Barkly and Katherine regions; and between 2019 and 2029 by increasing cattle numbers on Indigenous land, especially in the Daly region, further intensive production in the Douglas-Daly and Katherine regions, and increased intensification in the Barkly region. So far, growth of the Northern Territory herd has exceeded these expectations, reaching 2.2 million in June 2013[319].

Queensland Government

Beef Industry Action Plan 2014-2016

The Queensland Department of Agriculture and Fisheries released a *Draft Beef Industry Action Plan 2014-2016*[313] for public comment in April 2014 [320]. This plan aimed to support Queensland's objective of doubling food production by 2040. It proposed a 38% increase in the state's cattle herd and a 31% increase in carcass weights to be achieved through irrigated forage crops and improved pastures, and a significant increase in grain-feeding (Table 23). The plan concentrated on three areas: infrastructure development; research, development and extension services; and a creating a supportive business environment (Table 24). The action plan was not ratified following the change of government, and the government's current stance on herd building is unclear.

Table 23. Beef production targets in Queensland's Draft Beef Industry Action Plan 2014-2016

Source: Chilcott, Waide and Berglass (2014)[313]

		2012/13 production	2040 target	Increase
				(%)
Cattle herd	(no.)	12,200,000	16,800,000	37.7
Cattle slaughtered	(no.)	3,800,000	5,200,000	36.8
Average carcass weight	(kg)	270	354	31.1
Beef production	(t)	1,100,000	1,800,000	63.6
Beef exports	(t)	635,477	1,000,000	57.4

Table 24. Actions to support development of the beef industry in Queensland's Draft Beef Industry Action Plan 2014-2016

Source: Chilcott, Waide and Berglass (2014)[313]

Resource availability
Attract investment into grazing land
• Promote new opportunities in the regulatory framework for investment to increase production from current grazing areas
Support producers to prepare for drought
• Support beef producers to manage climate risks
Productivity
Invest in new research
• Invest in RD&E to improve cattle production
Promote best practice to producers
• Support increased adoption of existing innovations across the beef supply chain
Support intensification of production
• Support feedlot development, use of forage crops and improved pastures to intensify production
Support processing expansion
• Support long term investments by meat processors
Market Access
Build relationships
• Support building international relationships between Queensland and key beef markets
Advocate for market access
• Support industry to realise market opportunities by advocating for market access for beef
Promote Queensland's standards
• Promote Queensland's excellent food safety and cattle biosecurity standards
Reducing costs
Reduce red tape
• Identify and promote opportunities to reduce regulation compliance costs in the beef supply chain, across portfolios and jurisdictions
Improve transport efficiency
• Work with industry to identify and promote opportunities to reduce cattle transport costs

High-level industry bodies

A hierarchy of organisations to represent the interests of beef and other meat producers has been established through a memorandum of understanding (MOU) under the *Australian Meat and Livestock Industry Act 1997* (Cth). Its purpose is to collect and distribute levies collected from producers and processors for research, development and marketing; and to liaise with government on cross-sectoral and whole-of-industry matters[321]. The overarching body in this arrangement is the Red Meat Advisory Council (RMAC), whose members include six peak industry councils (including the Cattle Council of Australia (CCA), Australian Livestock Exporters' Council (ALEC)) and Australian Lot Feeders' Association (ALFA) and the three research, development and marketing corporations: Meat and Livestock Australia (MLA), Australian Meat Processors Corporation (AMPC) and LiveCorp (Figure 36).

The Cattle Council of Australia represents the interests of producers of grass-fed cattle through state farming organisations (SFOs) as well as through direct membership. Its roles include advocacy; strategic direction and planning; and industry oversight and strategic policy development. Levies

collected from producers and processors fund research, development and marketing undertaken by MLA to assist both grass-fed and grain-fed meat production; by AMPC to assist processing; and by LiveCorp to assist live export. These corporations also collaborate to meet industry-wide strategic objectives.

The work of the corporations is funded by levies on the sale or transfer of grass-fed or grain-fed cattle ($0.90 for animals weighing less than 80 kg and $5 per head for all other cattle)[322]. The levy on grass-fed cattle is distributed to MLA for marketing (73.2%) and research and development (18.4%); the remainder being used for animal health (2.6%) and residue testing (5.8%).

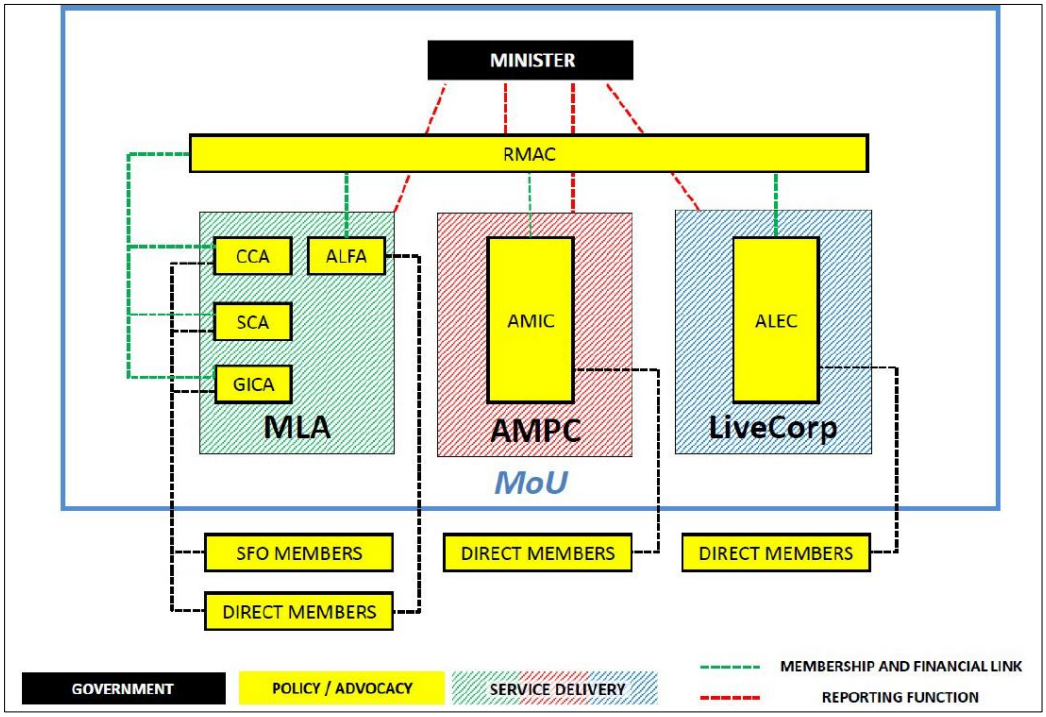


Figure 36. Hierarchy of peak bodies representing the interests of the northern beef industry

Adapted from Rural and Regional Affairs and Transport References Committee (2014)[321]

See Figure 35 for explanation of abbreviations relevant to the northern Beef Industry

In 2013-14, MLA's income from levies amounted to $106 million, of which 58% came from levies on grass-fed cattle and 9% from grain-fed cattle[323]. With additional income from government and private contributions and corporation activities, MLA's income amounted to $188.5 million in 2013-14, and its expenditure to $181.1 million. MLA's investment in marketing and research and development, therefore, has the potential to have significant impact on the direction of the industry.

MLA's areas of activity and achievement fall into four key areas:

- Maintaining and improving market access
- Growing demand
- Increasing productivity across the supply chain
- Supporting industry integrity and sustainability.

For at least the last two decades, MLA's northern Australian operations have included the development of extension programs to improve sustainability of grazing practices and viability of business operations. These include *Grazing Land Management*, *CashCow* and *BreedPlan*. National initiatives of benefit to the northern industry include supporting development of free-trade agreements (e.g. Korea and Japan); promotion of Australia beef at overseas trade shows and domestic marketing campaigns; assisting producers meet ESCAS requirements; and improving disease detection.

In 2014, a Senate Inquiry was held into "Industry structures and systems governing levies on grass-fed cattle"[321]. The inquiry was held in response to discontent in the industry that levies were not delivering benefits to the industry, particularly because their investment failed to address issues that led to the live-export ban.

The inquiry delivered its findings in September 2014, recommending the formation of a producer-owned body (possibly by reforming CCA) to receive and disperse the research and development and marketing components of levies paid by cattle producers and processors and matching government contributions. It also recommended that RMAC be replaced by a new system to manage and disperse earnings from the Red Meat Industry Reserve Fund; and that private contributions to MLA no longer attract matching government contributions. It also recommended transparency and efficiency of levy collection be improved; allocation of voting rights according to levy payments; and consideration be given to legislation to improve transparency in pricing and trade practices.

In a dissenting report[321], Senator Ian MacDonald argued for retention of the current system and organisations, instead arguing for improving the value of the current system to producers of grass-fed cattle by increasing their representation on MLA's board of directors, and allocating a proportion of levies to CCA for strategic development.

State farming organisations

State/territory farming organisations (SFOs) are the recognised peak bodies representing pastoralists' interests. SFOs representing the interests of the northern beef industry are AgForce, Northern Territory Cattlemen's Association, Pastoralists and Graziers Association of Western Australia, and WAFarmers. These organisations advocate on behalf of the northern beef industry to further its economic viability and sustainability in a range of policy areas, including:

- Regulation reform, including more flexible lease and operating conditions
- Trade, market access
- Marketing, labelling, food safety, standards and quality assurance
- Improvements to transport and infrastructure
- Disaster relief
- Animal health and biosecurity
- Technological innovation and identification of improved practices
- Land-use diversification
- Industry leadership and succession
- Targeted RD&E.

SFOs advocate for policy development in these areas by directly lobbying state/territory governments and the Australian Government and through submissions to government inquiries and participation on advisory committees. They also contribute to policy indirectly through their membership of higher-level representative bodies, notably CCA, which reports to the Australian Government through RMAC.

While industry viability is a core interest of SFOs, these organisations do not appear to have a fixed opinion on the size of the industry or the number of cattle required to achieve sustainability in the north. Instead, they actively assist development of best-practice codes and adoption of management practices to improve productivity and profitability.

SFOs also influence the direction of beef industry research and development in the north through their participation in NABRC. Both RMAC and NABRC were members of the Northern Beef Industry Working Group (NBIWC), an advisory body set up by NAMF to "provide coordinated advice on developing the northern Australia beef industry based on the range of initiatives committed, or being advanced, by Australian Government agencies, the northern jurisdictions and the industry"[310]. Hence SFOs are key drivers to the direction of the beef industry in northern Australia. In recent years, they have been particularly active in representing pastoralists' interest in the live-export market; lease renewal

arrangements; vegetation management; and food labelling. In Queensland, AgForce has also been central in supporting the development and delivery of best management practice adoption through the Grazing BMP[324].

Financial institutions

Most producers across the north have mortgages with banks (see Profitability). High debt levels across the industry mean that mortgages must be regularly renegotiated with the banks, with renewal often being conditional on specific practices being undertaken, including stocking regimes. Pastoralists in debt are likely to overstock their properties in an attempt to service their loans[325], and in the Burdekin it has been shown that, on average, as farm debt increases, grass cover decreases[326]. However, there is no evidence that banks insist on unsustainable stocking rates. Rather, the drive to repay loans may be an incentive for pastoralists to overstock in the short-term despite the long-term degradation that will result[327,a]. A high level of dependence on the volatile live-export cattle trade exposed many producers to high debt-servicing costs, with some having to pay interest rates that were up to 2% higher than those paid by neighbouring producers[51].

Banks also have a role in advising investors about the viability of prospective investments. In 2014, ANZ commended the incorporation of irrigated pasture crop into northern beef operations, but was dismissive of the economic viability of developing a new grain and oilseed industry in the north[328]. Such recommendations are likely to affect the capacity of these developments to attract investors.

Research organisations

Numerous organisations undertake, fund, facilitate and communicate research to support the northern beef industry (Figure 35), and can, therefore, have an impact on the direction the industry takes. Key research findings and their adoption by the industry are detailed in earlier sections this report (see Practice improvement). Beef industry research has focused on:

- Improving animal health and performance
- Improving land condition and minimising environmental impacts
- On-property management to improve enterprise viability
- Improving greenhouse gas (GHG) budgets

[a] http://www.abc.net.au/news/5969748

- Supply chain development to reduce costs and improve industry viability
- Diversification options.

MLA is central to the majority of industry-related research, development and extension. Rural Industries Research and Development Corporation (RIRDC) also funds research into expanding pastoralism into non-traditional areas, such the development of Indigenous pastoralism. NABRC helps these organisations define research priorities for northern Australia (Table 25). NABRC holds conferences every few years to showcase northern research. The Australian Rangelands Society (ARS) publishes much of the research that is relevant to the northern cattle industry, and holds a biennial conference at which some of this research is presented.

Through the 1990s and 2000s, cross-regional research supporting the beef industry was facilitated by the Tropical Savannas Cooperative Research Centre (TS-CRC), in which state and territory agencies were active participants. With the closure of CRCs, collaborative research continued, but without a formalised structure to support or bolster cross-regional research capacity. The proposed Cooperative Research Centre for Northern Development may fill this gap. An earlier CRC proposal (growNORTH) included $75 m of Australian Government investment and $316 m from industry, partners and researchers, with an estimated a gross benefit of $1,200 m to the Australian economy[329]. The *Northern Australian White Paper* has now committed $75 m to a revised CRC model, but this funding is to be allocated across agricultural development and tropical medicine.

Table 25. Research, development and extension priorities and goals to enhance development of the northern Australian beef industry

Source: NABRC (2012)[330]

Priority
Reproduction
• Accelerate the dissemination of genetics that will improve the economic performance of beef cattle enterprises in northern Australia
• Reduce losses from pregnancy test to weaning
• Increase producers' capacity to identify the impact of their enterprise's current reproductive performance on profit and implement the reproductive and turnoff strategies that will maximise profit
Grazing land management
• Engage many producers in grazing management through development of a compelling, economic-focussed, value proposition
• Provide tools that guide what should be changed or varied (where and when) to improve grazing management outcomes
• Reduce the impacts of grazing land weeds and feral animals on profitability and resource condition
• Assist producers to better assess and manage the opportunities and risks associated with managing grazing land for beef production
• Assist industry as a whole to better assess and manage the opportunities and risks associated with use of grazing land for beef production
• Optimise current and future income flows for producers including the carbon economy
• Increase resilience of enterprises and regions
Nutrition and growth
• Optimise production from the pasture base
• Identify and develop cattle phenotypes with greater forage conversion efficiency
• Increased profitability of northern beef enterprises through improved supplementation practices
• Optimise lifetime productivity through accelerated growth pathways
• Increase profitability of beef cattle enterprises through optimising rumen function
Human capacity and enabling change
• Facilitate continuous improvement of RD&E and training
• Foster continuity of industry and RD&E capacity through greater recruitment, development and retention of staff
• Greater understanding of producer decision-making and adaptation processes to improve the design of RD&E and accelerate innovation and adoption
Animal welfare
• Improved husbandry practices
• Continual improvement in beef cattle welfare
• Greater adoption of practices to improve on-property animal welfare based on a commonly-agreed understanding of, and assessment method for, beef cattle welfare
Information technology and precision livestock management
• Finer scale management of animals, pastures and landscape
• Timely provision of data, information and knowledge that drives reductions in cost of production and improvements in work safety and natural resource condition with temporal matching of animals with pasture
• Develop, refine and integrate technologies that reduce input costs and/or accelerate cost-effective improvements in productivity

Objectives of the growNORTH CRC proposal were to deliver "high impact research that will lower investment barriers enabling significant capital to flow to agricultural development in the north" through four programs:

- Transformational economic investments
- Sustainable water and land management

- Technologies for agriculture/aquaculture
- Development policies and regional change.

The *Northern Australia White Paper* and associated CRC commitments[305] made no mention of broad landscape planning or economic development. Research programs with an environmental focus are covered elsewhere in this document.

Extension providers

Extension is provided to the northern beef industry by a wide range of organisations (Figure 35), many of whom also have other roles in the industry. State primary industries departments (DPIs), SFOs and NRM groups are all involved in programs to facilitate practice improvement. This includes running land and business management courses and best-practice frameworks, as well as managing devolved grants to support adoption of specific technologies or land management practices.

Digital technology and social media are increasingly important in extension delivery, and have been supported by the FutureBeef platform[331]. Digital technologies being adopted by the industry include stocking rate calculators; pasture monitoring programs (e.g. *Stocktake*); fire mapping (North Australian Fire Information website (NAFI)); and programs to assess the economic impacts of different management regimes (e.g. *BreedCow-Dynama*)[332]. The most effective programs are those that involve the pastoral managers in collecting and assessing data from their own properties, and allowing them to compare their results with regional performance (e.g. *CashCow*)[60].

Climate change

Concerted international efforts to avert climate change began in 1992 in the Rio Earth Summit with the signing of the United Nations Framework Convention on Climate Change[333]. By signing this convention, Australia has committed to setting policies that are climate-change aware and take actions to minimise its contribution to climate change. Under the Kyoto Protocol (which lapsed in 2012), Australia was obliged to limit GHG emissions.

Countries attending Kyoto in 1997 committed to reducing emissions of GHGs (carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) that contribute most to climate change[334]. Under the resultant Kyoto Protocol, developed countries were expected to stabilise their emissions at 1990-levels by 2008-2012. Because of its dependence on coal, Australia was given dispensation to stabilise its emissions at

108% of 1990 levels. This commitment was largely met through bans on land clearing, which resulted in Australia's emissions in 2007 to be calculated at 104%—rather than 125%—of 1990-levels[335,336].

In 2012, the Australian Government pledged:

1. An unconditional 2020 GHG emission reduction target of 5% below 2000-levels
2. A 2020 target of 15-25% below 2000, subject to international action
3. A non-binding 2050 target of 80% below 2000 levels.

The first two commitments had bipartisan support and are now obligations under the 2012 Doha amendment to the Kyoto Protocol[337]. When Australia had an emission trading scheme[a], it appeared likely to reach its unconditional target, but not its conditional one[339,340]. The energy sector lobbied hard against these targets[341]. Carbon pricing has since been abandoned in Australia[b] and the Renewable Energy Target (RET) settled at 33,000 GWh by 2020 (ca. 23.5% by 2020)[342]. However, climate policy is still in a state of flux, and even industry believes that carbon pricing is likely be reinstated[343].

Australian Government legislation relating to climate change includes:

- *National Greenhouse and Energy Reporting Act 2007* (Cth)
  Establishes the framework reporting greenhouse gas emissions, greenhouse gas projects and energy consumption and production by corporations in Australia
- *Clean Energy (Consequential Amendments) Act 2011* (Cth)
  Ensures carbon pricing is integrated with existing regulatory schemes and processes, including the National Greenhouse and Energy Reporting scheme, the Carbon Farming Initiative (CFI), the Australian National Registry of Emissions Units, the regulation of financial services and competition and consumer laws
- A host of Acts that regulate markets for clean energy, greenhouse gasses and ozone
- *Climate Change Authority Act 2011* (Cth)
  Establishes the Climate Change Authority to conduct reviews of the Climate Change laws.

Western Australia has a climate change strategy covering mitigation and adaptation[344], which includes supporting land managers to engage in the carbon economy. The Northern Territory's Climate Change

[a] with a price on carbon and a renewable energy target for electricity generation (RET) of 20% by 2020 [338]
[b] http://www.abc.net.au/news/5604246

Policy[345], introduced by the Henderson government in 2009[a], was discontinued by the current Country Liberal Party Government.

The Queensland Government's climate change initiatives were dismantled by the Newman government and are being revitalised by the Palaszczuk government. Emerging adaptation and mitigation commitments include:

- A Queensland Climate Change Adaptation Strategy
- A Climate Change Coastal Hazard Adaptation Program
- Reinstating world class coastal planning laws
- Reducing GHG emissions and supporting increased use of renewable energy.

One aspect of carbon policy that has so far survived through this period of instability has been an Australian Government commitment to land sector participation in the carbon economy through the Emission Reduction Fund (ERF)[b]. The ERF enable pastoralists to derive income from accredited options for GHG sequestration and abatement (see Greenhouse gas budgets).

Producers have mixed opinions about climate change, but none dispute the impact of on-going climate extremes. However, at least one group of farmers is concerned about climate change and has written an open letter asking for politicians to take action on climate change (Box 1).

[a] Which included support for carbon abatement and capture by land management sector
[b] Which replaced the CFI in 2014 under the *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth) [346]

Box 1. Open letter from farmers on climate change

Aussie farmers are on the front line of rising temperatures and more extreme weather, so global warming is a priority issue for rural, regional and remote Australia.

Hot days have doubled in the last fifty years and heatwaves are longer, hotter and more intense. Climate change is already worsening drought conditions in south-west and south-east Australia and droughts are likely to worsen in many parts of the country without deep and rapid cuts to greenhouse gas emissions. The first five months of 2015 have been the hottest ever recorded.

A strong target to cut carbon pollution, a transition plan away from coal and gas towards renewable energy, and a strong deal at the UN climate talks in Paris this December are all in the interests of Aussie farmers and our families.

We as Aussie farmers call on the Liberal Party conference to reject the motion put by the regional and rural committee of the Liberal Party questioning the basis of climate science, and instead call for post-2020 targets to cut carbon pollution that are in line with scientists' recommendations of at least 40% by 2025, and at least 60% by 2030 over 2000 pollution levels.

Source: http://www.farmerletter.org

Legal and regulatory environment

Legislation and regulations have the potential to drive the direction of the beef industry by mandating adoption of management practices (or affecting the capacity to do so) and imposing compliance costs that affect financial viability. The following section is not a comprehensive review of legislation and regulations, but covers aspects that influence practice improvement and operational costs.

Legislation controlling pastoral lease renewal, operating conditions and vegetation management are key drivers of pastoral management and reflect the agenda of governments of the day. Conditions of leases affect the ability of pastoralists to respond to drivers to develop and diversify their operations to achieve financial sustainability, and are under review. Through the first decade of the 21st century, there was a move towards legislation restricting development, particularly in Queensland. With the election of conservative governments in Queensland 2012 and the Northern Territory in 2013, there

has been a move to self-assessment of activities associated with pastoral purposes, with permits being largely restricted to non-pastoral activities or for high value conservation areas.

Legislation and regulations are imposing increasing obligations on pastoralists with respect to the treatment of livestock and wages and conditions. There is general recognition for the need to maintain standards in these areas, but also of the financial and transactional costs of complying with these regulations. This is reflected in policies labelled "red tape reduction" that aim to assist industry development in the north (see Policy environment).

Tenure and Native Title

Cattle grazing occurs on a number of tenures across northern Australia, including pastoral and perpetual leases, freehold and Indigenous lands. However, the vast majority of grazing in the Monsoonal North occurs on pastoral leases (see Land use and tenure). Security of tenure affects a cattle operation's capacity to obtain finance. This becomes more difficult approaching the end of the lease tenure, and pastoralists may become reluctant to make improvements—and financial institutions to underwrite them[347]. Also, current tenure arrangements discourage diversification into non-pastoral pursuits, at least in Western Australia (see Diversification). Recent recognition of the limited management options on pastoral leases has led to a widespread review of tenure and lease renewal arrangements[347-351].

Properties that are not subject to Native Title can be sold, subleased or used as security for loans or converted to a new tenure type[351]. Most pastoral leases coexist with Native Title[352], which restricts land use diversification whether the land is owned by Indigenous or non-Indigenous people[353]. The *Native Title Act 1993* (Cth) guarantees that a pastoral lease can be renewed without compensation being paid to the Native Title holders[354]. However, it does not guarantee rights to non-pastoral uses on pastoral leases, and the rights of Native Title holders must be met before such permits can be granted. Tenure conversion for the purposes of land use diversification would require the unlikely repeal of the *Racial Discrimination Act 1975* (Cth) to enable Native Title to be extinguished[355], so a negotiated outcome is probably the only option. This is usually achieved through an Indigenous Land Use Agreement (ILUA) to be negotiated. ILUAs cover the use of, and access to, traditional land and waters[356] and have been negotiated over pastoral properties in all three jurisdictions.

Table 26. Rights and responsibilities associated with grazing land tenures in Queensland

Source: Adapted from Holmes (2014)[355] ©2014 Institute of Australian Geographers

* = subject to lease conditions

	Freehold	Grazing Homestead Perpetual lease	Pastoral lease
Landholder rights relevant to use of land and related resources			
Graze livestock	Yes	Yes	Yes
Cultivate land	Yes	No	No
Introduce plant species	Yes	No	No
Clear vegetation	Yes	No	No
Take timber	Yes	No	No
Ownership of water	No	No	No
Ownership of minerals	No	No	No
Ownership of wildlife	No	No	No
Exclusive occupation (Native Title extinguished)	Yes	Yes	No
Use at discretion of titleholder	Yes	No	No
Landholder responsibilities and duties			
Develop and maintain improvements	No	*	*
Be in residence	No	*	No
Maintain stock numbers above a prescribed minimum	No	*	*
Duty of care for the land	No	Yes	Yes
Control stocking levels	No	*	*
Engage in property planning	No	*	*
Tenure security and transferability			
Perpetual title awarded	Yes	Yes	No
Unrestricted transferability	Yes	No	No
Unlimited right to subdivide	Yes	No	No
Unlimited right to aggregate	Yes	No	Yes
Surrender of some land on lease expiry	No	No	Yes
Liability to forfeiture	No	Yes	Yes
Landholder financial and other obligations			
Payment of rent	No	Yes	No
Accountability to QDNRM	No	Yes	Yes

Different approaches to realising diversification ambitions are appropriate under different combinations of lease ownership and Native Title rights. In the North Kimberley and to the west of the Gulf of Carpentaria, where Indigenous landholdings predominate, there is potential to reform land tenure while consolidating Indigenous rights, as has occurred on Cape York Peninsula (Figure 37)[355]. Elsewhere in the Monsoonal North, it is likely that pastoral intensification will take precedence over Indigenous rights, but diversification to other forms of land uses remain uncertain.

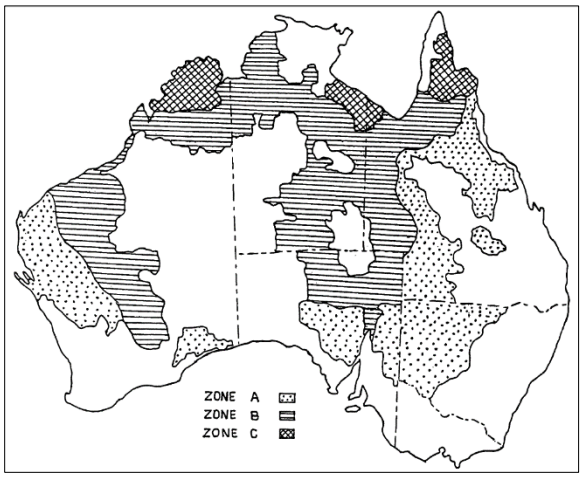


Figure 37. Potential recognition of Native Title on pastoral leases in relation to assumed level of Aboriginal connection to the land

Source: Holmes (2014)[355] ©2014 Institute of Australian Geographers

Zone A: Limited ongoing connection to land; Limited recognition of Native Title rights; Protection of sacred sites with negotiated access. **Zone B:** Extensive ongoing connection to land; Native Title rights recognised but curtailed by ongoing development; Rights of access and traditional use under extensively managed areas. **Zone C:** Widespread, ongoing physical and spiritual connection; Widespread recognition of Native Title rights assured by limited scope for agricultural development; Comprehensive restructuring of land tenure and use through negotiated regional agreements.

Environmental management

As with all industries, beef operations are subject to environmental legislation protecting threatened species and ecosystems and heritage sites at both the national and state/territory level. Environmental matters are most likely to come into play when new developments are proposed. Australia is a signatory to the international *Biodiversity Convention 1992*[357], which aims to ensure conservation and sustainable and equitable use of biological diversity. In signing this convention, Australia has agreed to institute measures to protect biodiversity, including through a protected area estate and management of environmental values outside that estate. Each Australian jurisdiction has a different process by which environmental matters are managed. Relevant legislation includes the *Environment Protection and Biodiversity Conservation Act 1999*, *Wildlife Conservation Act 1950* (WA), *Territory Parks and Wildlife Conservation Act* (NT), and the *Nature Conservation Act 1992* (Qld). Each of these Acts and their associated regulations provide a list of threatened species and ecosystems that are a priority for conservation management, as well as threats that need managing and mechanisms for doing so. Each jurisdiction has a range of environmental policies through which environmental damage can be avoided and addressed.

This hierarchy of laws, regulations and policies has implications for pastoralism, including through promotion or imposition of sustainable management of resources and control of weeds and pest animals, and restriction of vegetation clearance (see Land clearing). Alongside regulation, mechanisms are also provided for payment for environmental services as a means to incorporate biodiversity conservation into commercial enterprises. These shift the emphasis from penalising pastoralists for the presence of threatened species or ecosystems on their land by resuming land or restricting development to rewarding them for good environmental management that protects biodiversity values.

Mechanisms also exist for conservation agreements in each state and territory. These agreements generally involve the landholders voluntarily entering into an agreement to protect sections of the property in return for fencing (see Environmental service delivery). Conservation agreements may be entered into by landholders in return for a development approval, or as a means of delivering an environmental benefit or offset sought by the Australian Government, or a state or territory government. NRM groups may be closely involved in negotiating conservation agreements. However, the relevant pastoral lands Acts (see Tenure and Native Title) currently provide no legislative backing for conservation reserves on pastoral leases, so conservation agreements are subject to the indulgence of the relevant minister[358], and Native Title considerations may come into play where the conservation agreement precludes grazing over significant sections of a pastoral lease. This tension is recognised in the *Kimberley Science and Conservation Strategy*[359], which identifies a number of measures required to support conservation in the region[360].

Pastoral lease conditions

The duration of pastoral leases varies across the three jurisdictions. Under the *Pastoral Land Act* (NT), pastoral leases in the Northern Territory may be extended for a period of up to 25 years and renewed within two years of expiry. In Western Australia, the *Lands Administration Act* 1997 (WA) stipulates that the duration of a new pastoral lease over a property must be no more than that of the pre-existing lease (between 18 and 50 years), with the right to renew specified in the lease[350]. Amendments to the *Queensland Lands Act 1994* in 2007 introduced a stepped renewal process (which came to be known as the Delbessie process) in which all pastoral leases could be renewed for 30 years, with an addition of 10 years where the land was assessed to be in good condition; and a further 10 years where an Indigenous Land Use Agreement (ILUA) and a conservation agreement or covenant were in place. The *Queensland Lands Act 1994* was further amended in 2014 to remove the stepped renewal process and requirements for ILUAs, and conservation and land management agreements. Queensland pastoral

leases can now be extended (rolled over) for a period equivalent to the original term of that lease (but for no more than 50 years), and renewal can be granted once 80% of the lease term has expired. It remains to be seen whether the Palaszczuk government maintains these changes. Significantly, restrictions preventing Aboriginal- and family-owned corporations from owning pastoral leases in Queensland and individuals from holding multiple pastoral holdings were not removed until the Act was amended in 2014[361].

Conditions for the management of pastoral leases are similar under the three jurisdictions, each requiring the lease to be used for pastoral purposes and for the leaseholder to exercise a duty of care. Under the Northern Territory *Pastoral Land Act*, leaseholders are required to prevent land degradation; participate in land condition monitoring; and improve land condition. Duty-of-care provisions introduced in the 2007 amendments to the *Queensland Lands Act 1994*[a] were retained in the 2014 amendments (Section 199).

In 1997, the *Land Act 1933* (WA)—the Act under which pastoral leases in Western Australia were recognised—was repealed. As a result, all pastoral leases in Western Australia (along with their mortgage interests) expired on 30 June 2015 and had to be renewed[362]. The replacement Act, *Lands Administration Act 1997* (WA) stipulates that a pastoral lease must be managed "to its best advantage as a pastoral property" and pastoralists must use "methods of best pastoral and environmental management practice, appropriate to the area where the land is situated, for the management of stock and for the management, conservation and regeneration of pasture for grazing". In preparation for lease renewal, the Western Australian Government issued new lease documents describing these duty-of-care obligations in detail. Pastoralists and their representative bodies objected to these conditions. Most contentious was the strengthening of obligations for the leaseholder to meet, monitor and report on environmental conditions[b]. In responses to these and other concerns, the Department of Lands offered pastoralists the option of new leases on "substantially the same conditions" as the expiring leases. However, this is more form than function, as the conditions of *Lands Administration Act 1997* (WA) apply to all leases, regardless of what is contained in the lease papers.

Land condition monitoring has historically been undertaken by the Western Australian Rangeland Monitoring System (WARMS) in Western Australia[363,c] and the Two Tier Land Monitoring in the

[a] in relation to land salinisation; soil and water resources; riparian vegetation; perennial and productive pastures; woody thickening of grasslands; declared pests; and biodiversity conservation
[b] http://www.abc.net.au/news/5061552
[c] 6th WARMS assessment completed in 2011[364]

Northern Territory[a]. While legal mechanisms for biodiversity protection are theoretically in place, the capacity to assess conservation impact is minimal. There is no formalised monitoring system in Queensland, although condition assessment methods have been developed for both pastoral land condition[366] and biodiversity[367]. Across the region, there has been a move to transfer the responsibility of monitoring pastoral land condition to the pastoral leaseholder, who is unlikely to have the capacity to do so.

Water

All rights to water and its use, flow and control are vested in the relevant state or territory government. In Western Australia, the agency responsible for water is the Department of Water; in Northern Territory, the Department of Land and Resource Management; and in Queensland, the Department of Natural Resources and Mines. In Queensland, water quality and environmental values are the responsibility of the Department of Environment and Heritage Protection. The relevant legislation is the *Rights in Water & Irrigation Act 1914* (WA), *Water Act* (NT), *Water Act 2000* (Qld), and *Environment Protection Act 1994* (Qld). These Acts stipulate the purposes for which water can be taken without a specific authorisation being granted (Table 27); the conditions that must be met for an authorisation to be approved; and the conditions that can be imposed on any authorisation. Where a water allocation is granted, the volume of water is not guaranteed in times of low water availability.

[a] Tier One involves on-ground monitoring and Tier Two uses remote sensing to assess changes in land condition[365]

Table 27 Rights to take for various uses across the Monsoonal North without a permit

Sources: *Rights in Water & Irrigation Act 1914* (WA); *Water Act* (NT); *Water Act 2000* (Qld); *Environment Protection Act 1994* (Qld)

NB: "Yes" indicates that water rights exist to take or interfere with water without a special authorisation being granted. In all other cases, an application for an authorisation (licence, permit or water allocation) is required

Activity	Capture environment	Purpose	Region		
			Kimberley	**Top End/ Gulf Savanna**	**Queensland Gulf/ Burdekin**
Take water	Watercourse	Non-intensive grazing	Yes	Yes	Yes
		Agriculture	-	-	-
		Mining	-	Yes	-
Construct dam	Overland flow – not on a permanent watercourse	Non-intensive grazing	Yes	Yes	Yes
		Agriculture	-	Yes	-
		Mining	-	Yes	-
	In-stream flow – water-course, waterhole, lake or spring	Non-intensive grazing	-	-	-
		Agriculture	-	-	-
		Mining	-	Yes	-
Divert drainage	Watercourse	Non-intensive grazing	-	-	-
		Agriculture	-	-	-
		Mining	-	-	-
Sink bore	Groundwater	Non-intensive grazing	-	Yes	Yes
		Agriculture	-	-	-
		Mining	-	Yes	Yes

Western Australia and Queensland have designated water management areas, which are covered by specific water management plans defining water licencing and allocation arrangements (Canning-Kimberley and Broome Groundwater Management areas; and Ord and Le Grange Surface Water Management Areas in Western Australia; and Burdekin Basin and Gulf Water Management Areas in Queensland).

Across the Monsoonal North, pastoralists can water their stock using water from watercourses on or adjoining their property, or from a dam that traps overland flow on that property without a specific authorisation. In Queensland and the Northern Territory, pastoralists may also extract and use groundwater without a permit. A specific authorisation must be obtained for extracting groundwater in Western Australia, and for constructing a dam on a watercourse in all three jurisdictions.

Water rights for grazing livestock are generally more liberal than are those for agriculture (for which authorisation is required for most uses), but more stringent than are those for mining. In the Northern Territory, miners can capture, use and store water without any specific authorisation. In Queensland, mining, petroleum and gas companies can divert watercourses and take groundwater from a bore sunk by a landholder, subject to make-good arrangements and identification and monitoring of impacts. Under the *Water Act 2000* (Qld), make-good arrangements should ensure that the owners of

bores in the "immediately affected and long-term affected areas" have access to adequate water supplies. These areas (and, therefore, affected landholders) must be identified in an Underground Water Impact Report (UWIR) (see Legal and regulatory environment: Mining). A water management plan must also be prepared explaining the treatment of water generated in CSG production (see Mining). Hence, while the legislation aims to minimise its impact on pastoral agricultural land use, miners can access any water resource on a pastoral property. In a case objecting to the Alpha Coal Mine proceeding in the Galilee Basin included that impacts of the mine on groundwater may not be reliable (particularly in relation to the impacts of multiple mines), and so make-good arrangements were inadequate[a]. The Queensland Land Court agreed with this assessment, and recommended that the mine not be approved until corrections were made to the impact assessment[368].

Land clearing

Pastoral operations rely on productive pastures. The majority of the Monsoonal North is native pasture, but operations are increasingly developing parts of their properties to improve viability (see Diversification). Developments such as mosaic irrigation of pasture crops will require vegetation clearance[59]. Moreover, thinning may be required to restore the productivity of vegetation that has been degraded by woody thickening using fire or other means[272-274,369,370]. Pastoralists may also wish to clear vegetation to establish introduced pasture species to improve productivity. Each jurisdiction has controls on where and how much clearance can occur. Land clearing legislation varies between jurisdictions, and has seen momentous changes over the last decade. In their current form, regulations have converged between the three jurisdictions, with an increasing emphasis on self-assessment and facilitation of clearing for pastoral-related activities.

In Western Australia, land on a pastoral lease may be cleared without a permit for purposes that are consistent with the lease conditions (Table 28) as long clearing is done in accordance with the Best Management Practice guidelines produced by the Pastoral Lands Board[371]. Clearance and other activities consistent with pastoral uses may be permitted as long as they comply with the requirements of environmental legislation, including the *Biosecurity and Agriculture Management Act 2007* (WA); the *Environmental Protection Act 1986* (WA); the *Soil and Land Conservation Act 1945*

[a] http://www.abc.net.au/news/6867330

(WA); and the *Wildlife Conservation Act 1950* (WA). Leaseholders clearing land without correct permissions have recently been prosecuted[a].

Table 28. Conditions for vegetation management for pastoral purposes in Western Australia

Source: Anon. (2007)[371] http://www.lands.wa.gov.au/Pastoral-Leases

Purpose of vegetation clearance
Permit not required
Manage and work the land under the lease to its best advantage as a pastoral property
Pastoral improvements, including fences
Fire suppression or fuel hazard reduction
Permit required
Other purposes
Sowing or cultivation of introduced pasture species
Use of land for crop, fodder, horticultural or other specified kind of agricultural production if the proposed use is reasonably related to the pastoral use of the land
Low-key pastoral-based tourism

In the Northern Territory, the *Pastoral Land Act* stipulates that pastoralists may clear vegetation without a permit for activities required for pastoral operations (Table 29). Permits are required for clearing or vegetation thinning for all other purposes. Applications for permission to clear vegetation must include information on potential impacts of the clearing (and how they intend to mitigate them) in relation to native flora and fauna; soils, surface water and ground water; heritage and Aboriginal sacred sites; and greenhouse gas emissions, paying particular regard to impacts that may cross property boundaries. Applications for non-pastoral uses must comply with the *Native Title Act 1993* (Cth) and Native Title holders having the right to object.

Table 29. Conditions for vegetation management for pastoral purposes in the Northern Territory

Source: http://www.lrm.nt.gov.au/

Purpose of clearance
Permit not required
Vegetation clearance for infrastructure development
Vegetation clearance for cutting of hay from native pasture
Maintaining areas from which vegetation had been cleared under a permit obtained after 1992
Permit required
Vegetation clearance or thinning for other purposes
Use of pastoral lease for non-pastoral purposes (e.g. forestry, horticulture, agriculture, tourism)
Not covered in lease conditions
Sow or cultivate introduced pasture species

[a] http://www.abc.net.au/news/6309098

The *Vegetation Management Act 1999* (Qld) was amended in 2004 with the aim of phasing out broadscale clearing of remnant vegetation by 2006[a]. In 2009, the Act was amended to include protection of high value regrowth (i.e. regrowth not cleared since 31 December 1989) as well as regrowth vegetation adjacent to watercourses in the Burdekin, Mackay-Whitsundays and the Wet Tropics catchments, as these drain to the Great Barrier Reef. From mid-2014, Queensland landholders have been able to clear native vegetation for most pastoral purposes, using self-assessable codes and submitting a notification form (Table 30). Clearing for environmental works can also be conducted under a self-assessable code, enabling the clearing of native vegetation where clearing is necessary to restore the environmental condition of the land or prepare for a natural disaster. However, restrictions are still in place for vegetation with recognised conservation value. The Palaszczuk government came to power promising to re-introduce strict tree clearing laws[b], although such changes face stiff opposition[c].

[a] *Vegetation Management and Other Legislation Amendment Bill 2004* (Qld)
[b] http://www.abc.net.au/news/6032484
[c] http://www.abc.net.au/news/6280876; http://www.abc.net.au/news/6892172

Table 30. Conditions for vegetation clearance for pastoral purposes in Queensland

See https://www.qld.gov.au/environment/land/vegetation/ for details

Purpose of clearance	Classes
Permitted without notification or permit	
Control weeds in recognised grassland regional ecosystems	All
Build or maintain fences, roads or tracks (up to 10m wide)	LC
Build or maintain fire management lines (up to 10m wide)	All
Build or maintain firebreaks to protect infrastructure	All
Reduce fuel hazard	All
Build and source timber for new infrastructure (buildings, fences, roads & water points)	LC
Maintain and source timber for existing infrastructure	All
All other purposes	X
Permitted under self-assessable code with submission of notification	
Control weeds (listed non-endemic native, non-native & declared plants)	B
Restore land condition	B
Selectively clear thickened vegetation to restore regional ecosystem	B
Manage invasion of grassland by native woody species (western bioregions)	B
Manage regrowth state-wide (for grazing; control of weeds, thickening or encroachment; fodder harvesting & infrastructure)	C
Manage regrowth in Burdekin catchment (for control of weeds or thickening; restore land condition or channel formation & infrastructure)	R
Harvest recognised fodder species to feed livestock (western Queensland)	B
Prepare for natural disaster	B
Build or maintain infrastructure (fences, roads, firebreaks, and dams)	B, C & R
Permitted under "Area Management Plan for the control of pest plants in the Dry Tropics region"	
Control weed species listed in plan	B, C, R & X
May be permitted on other vegetation classes subject to approval	
Control weeds	
Harvest fodder	
Thin thickened vegetation	
Clear encroachment	

[a] **LC**, Least Concern regional ecosystems; **A**, Areas subject to compliance notices, offsets and voluntary declarations; **B**, Remnant vegetation; **C**, High-value regrowth vegetation; **R**, Regrowth vegetation within 50m of watercourses in priority reef catchment areas; **X**, Other non-remnant

Carbon

The *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth) established programs to enable landholders to derive income from GHG sequestration and abatement using approved ERF methodologies. These projects generate Australian Carbon Credit Units (ACCUs) that can be used to offset emissions or meet regulatory requirements for carbon abatement and can be sold or traded domestically or internationally. Kyoto-compliant ACCUs can be sold to an entity that has a liability under the *Clean Energy Act 2011* (Cth). To undertake an ERF project, the project must also be approved and audited to determine how many ACCUs have been earned. Accounting and auditing procedures are complex and may mean that only projects liable to generate high numbers of ACCUs are financial viable[372,373].

To participate in (and derive income from) a carbon abatement or sequestration project, the proponent must have a carbon right over the land on which the project occurs. Under the *Carbon Rights Act 2003* (WA) a pastoral leaseholder in Western Australia must obtain permission from the state governments before diversifying into carbon farming. The Act enables a carbon right to be registered on the land title as a separate interest in that land, and allows for a covenant to protect the carbon to be drawn up between the person with the carbon rights and other interested parties.

In Queensland, the situation is far more complex, but a pastoral leaseholder must also gain permission from the relevant minister(s) before entering into a carbon abatement project. The *Forestry Act 1959* (Qld) and the *Nature Conservation Act 1992* (Qld) endow ownership of all forest products on Crown Land and all natural resources (including carbon) in the state, but enable leaseholders to apply for a right to abate carbon on their land and derive income from doing so. Carbon sequestration rights are recognised by the *Waste Reduction and Recycling Act 2011* (Qld). The *Land Act 1994* (Qld) enables carbon abatement interests to be created that enable the rights holder to carry out abatement projects. The *Land Title Act 1994* (Qld) allows carbon sequestration projects to be undertaken on freehold land only.

The Northern Territory has no legislation to clarify carbon rights[372]. On pastoral leases, carbon projects related to pastoral activities (e.g. reducing methane emissions from livestock) should be allowable without specific permission being granted. Non-pastoral activities require permission of the Pastoral Lands Board, which has so far provided no impediment to Savanna Burning projects. A more comprehensive review of the legislation covering carbon rights in all jurisdictions can be found in Dore et al[372].

Reef regulations

Under the *Environmental Protection Act 1994* (Qld) and the *Chemical Usage Act 1988* (Qld), grazing properties larger than 2,000 ha in the Burdekin and other catchments draining to the Great Barrier Reef are required to manage their properties to minimise reef pollution[374]. Under this legislation, which came into force in 2010, Burdekin graziers must prepare environmental risk management plans (ERMPs) explaining how they intend to maintain ground cover and land condition in order to reduce erosion and runoff from their paddocks, and limit the impacts of chemicals (especially Tebuthiuron, which is used for tree clearing). Graziers must also report annually on their ERMP implementation. By July 2011, 319 Burdekin graziers had ERMPs in place and 200 had been granted extensions[375]. Following the change of government in 2012, pastoralists could elect to either continue with the ERMP

process or enter into the *Grazing Best Management Practice* (BMP) program[324]. A taskforce has been set up to determine the direction of reef protection under the Palaszczuk government and advise on whether a regulatory approach should be reintroduced [376].

Pest, weed and disease management

Under state and territory legislation[a], landowners are responsible for managing declared weeds and pest animals on their properties. Obligations vary with the perceived severity of the threat posed, ranging from not to introduce, through keep under control, through to eradicate. Producers are also responsible for detecting and reporting diseases affecting animals in their care[b]. Costs of disease, weeds and pest animals to the beef industry and of their control are covered elsewhere in this document (see Pests and diseases).

National Livestock Identification System

State and territory regulations[c] require pastoralists across northern Australia to microchip their cattle using tags linked to the National Livestock Identification System (NLIS) in order to assist tracing of cattle during disease and food incidents and, more recently, through the live-export chain. NLIS tags cost around $3.50 each, set-up costs amount to between $5,000 and $10,000 and processing costs are minimal[377].

Animal health and welfare

Animal welfare codes covering cattle have been in place at state, territory and federal levels since 1983[378]. Standards and codes of practice govern animal welfare during routine animal management and transportation are policed by state and territory governments[44]. *Australian Animal Welfare*

[a] Western Australia: *Biosecurity and Agriculture Management Act 2007*; Northern Territory: *Weeds Management Act* and *Territory Parks and Wildlife Conservation Act*; Queensland: *Land Protection (Pest and Stock Route Management) Act 2002*
[b] Western Australia: *Biosecurity and Agriculture Management Act 2007*; Northern Territory: *Livestock Act*; Queensland: *Stock Act 1915*
[c] Western Australia: *Biosecurity and Agriculture Management (Identification and Movement of Stock and Apiaries) Regulations 2013* under the *Biosecurity and Agriculture Management Act 2007*; Northern Territory: 2013 amendments to the *Livestock Regulations* under the *Livestock Act*; Queensland: *Stock Identification Regulation 2005* under the *Stock Act 1915*

Standards and Guidelines for Cattle were developed in 2014 and are awaiting endorsement from state, territory and Australian agriculture ministers[379]. These standards cover:

- Feed and water
- Risk management of extreme weather, natural disasters, disease, injury and predation
- Facilities and equipment
- Handling and management
- Castration, dehorning and spaying
- Breeding management
- Feedlots
- Slaughter.

The cost of implementing these standards, which were widely endorsed by the industry, has been estimated at $1.90 per animal[380]. The animal welfare lobby proposed more stringent standards, which were estimated to cost an additional $41.46 per animal, but these were not adopted.

The Primary Industries Ministerial Committee has recently endorsed *Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock*[381]. These standards are now compulsory in Queensland and the Northern Territory, and will be adopted in Western Australia in the near future. These standards cover:

- Stock-handling competency
- Transport vehicles and facilities
- Pre-transport selection of livestock
- Loading, transporting and unloading.

There are additional requirements covering provision of food and water, and treatment of bobby calves[a] and pregnant or lactating cows. While these regulations have industry support, adhering to them adds to the costs of handling cattle, which have been estimated to cost the cattle industry between $10.8 million and $12.1 million a year[382].

Following the suspension of the live-export trade with Indonesia in 2011, the Australian Department of Agriculture introduced the Exporter Supply Chain Assurance System (ESCAS), with the aim of

[a] a calf that has not been weaned

improving animal welfare during transport and allowing animals to be traced through to slaughter in the destination country[47]. This system covers:

- Animal handling and slaughter in the importing country
- Exporter-control of all arrangements for livestock transport, management and slaughter
- Requirement that the exporter is able to trace cattle through the supply chain
- Independent audit of the supply chain in the importing country
- Compliance measures and sanctions, including revocation of export licences and non-approval of future export applications.

In addition, exporters must comply with Australian Standards for the Export of Livestock[383], covering:

- Sourcing and on-farm preparation of livestock
- Land transport of livestock
- Management of livestock in registered premises
- Vessel preparation and loading
- On-board management of livestock
- Air transport of livestock.

By the end of November 2014, 8 million livestock had been processed by ESCAS in 1,139 consignments sent to 18 countries[48], and 866 abattoirs and feedlots in 19 countries were certified as compliant with the World Organisation for Animal Health animal welfare standards[384]. The vast majority of compliant facilities are in Indonesia, Malaysia and Vietnam. From the 1,139 consignments, 59 breaches of ESCAS conditions were identified, 23 of which concerned cattle. These included seven cases of confirmed animal welfare breaches and 16 where movement of cattle to unaccredited facilities meant animal welfare could not be assured. Action was taken to mitigate against further breaches in all cases.

Industry was largely supportive of the tightening of live export procedures, and the program has been successful in improving animal handling[385,386]. However, compliance imposes a significant financial burden, costing the Australian Government $5.7 million to administer in 2013-14 and adding between $8 and $45 per head of cattle to the cost of live export[48]. There was, therefore, industry wide support for the review of ESCAS and identification of opportunities to reduce this impost. Any modifications to the system are yet to be determined.

Workforce management

Under the *Fair Work Act 2009* (Cth), wages and conditions, including training, of pastoral workers in the Northern Territory and Queensland are covered by the *Pastoral Award (2010)*, with oversight by the Fairwork Ombudsman[387]. In Western Australia, pastoral workers employed by corporations are also covered by this award, but non-corporate employees are covered by the Farm Employees' Award 1985[a], with oversight by the Western Australian Industrial Relations Commission.

Occupational health and safety (OH&S) laws cover an employer's duty of care to employees, codes of practice, education, inspection, advice, compliance activities and prosecution[388]. Obligations of the employer[66] include:

- Provide a safe and healthy workplace for all concerned
- Institute work systems designed to prevent injury, illness and disease
- Train employees to work in a safe and competent manner
- Allow access to inspectors to assess compliance, investigate accidents and enforce legislation
- Include employees and their representatives in decisions regarding OH&S matters.

Workplace health and safety laws are being harmonised across Australia, with minor variations in each jurisdiction[389]. Relevant legislation and regulations are the *Work Health and Safety (National Uniform Legislation) Act 2011* and the *Work Health and Safety (National Uniform Legislation) Regulations* in the Northern Territory; and the *Work Health and Safety Act 2011* and the *Work Health and Safety Regulation 2011* in Queensland. In Western Australia, the *Occupational Safety and Health Act 1984* and the *Occupational Safety and Health Regulations 1996* currently apply, but alignment with other jurisdictions was proposed though the *Work Health and Safety Bill 2014*, which was tabled in the Western Australian Parliament in October 2014. National awards and harmonisation of OH&S laws should simplify workplace arrangements for companies operating across borders.

Labour is one of the biggest input costs in pastoral businesses, accounting for about 70% of overhead expenses and 50% of the total expenses[78]. Improving wages and conditions and strengthening of OH&S laws increases costs to pastoral enterprises and have resulted in a steady reduction in the labour

[a] Advice from Department of Commerce Wageline on 3 March 2015: *Pastoral workers in Western Australia employed by Sole Traders or Partnerships are covered by the Farm Employees' Award 1985, even though it expressly excludes "employees who are bound by the award of the Australian Conciliation and Arbitration Commission and known as the Pastoral Industry Award, 1965 as varied or replaced from time". As the Pastoral Industry Award (1965) no longer exists, this exclusion does not apply.*

force on pastoral stations. Before 1967, up to 200 Aboriginal stockmen were employed on the larger cattle stations[255]. When Aboriginal workers were awarded equal pay in 1967, most Aboriginal stockmen lost their jobs[64]. Pastoral enterprises continue to reduce the number of staff they employ, increasingly depending on owner/manager and family to provide the workforce[52]. This is increasingly difficult where there is a reliance on off-farm income, leading to financial stress and associated health issues (see Health and well-being). On the smallest properties (with fewer than 1,000 cattle) employed labour accounts for less than 20% of the workforce[78]. Even on the largest properties (more than 10,000 cattle), this figure only rises to 57%, so pastoral operations have minimal impact on regional employment. However, finding skilled labour remains a challenge[78] and will be increasingly important if new technologies, such as mosaic irrigation are adopted[59]. In summary, employing staff is a significant cost, and lack of capacity to employ skilled staff can be a barrier to innovation.

Mining

Mining is covered by a raft of legislation at national and state/territory levels (Table 31). The salient points for mining impacts on pastoral enterprises are briefly described below. This legislation aims to facilitate the exploitation of mineral and gas and fuel resources while safeguarding other interests, notably environmental matters.

In almost all cases the resources are owned by the government of the state or territory in which they are found; the exception being for uranium and other sources of atomic energy in the Northern Territory, which are owned by the Australian Government. While Native Title extends over much of the land in the north, it does not include rights to mineral resources, gas or fuel. So while negotiation with Traditional Owners is required for mining to proceed where Native Title exists, that negotiation is more about access and impact than about ownership. There are mechanisms for over-riding non-cooperation of Native Title holders, including by extinguishing Native Title where a project is designated of *State Significance* (or a *Major Project* in the Northern Territory) [390]. Similarly, where pastoral lease holders deny access or place unreasonable conditions on access, they can be overruled by the relevant minister or department.

Applications for a mining exploration or extraction permit are advertised in newspapers. In Queensland, notice is given to owners and occupiers when an application is made for mining activity is made over their land or on adjoining land. Landholders may object to a mine's approval. All of the 29 mining and related infrastructure developments considered by the Queensland Coordinator General between 2005 and 2014 were approved with conditions. Objections rarely prevent a mine

proceeding on pastoral land, but result in strict conditions being imposed and/or compensation for losses resulting from mining activity. Once a mining title is granted, requirements to inform or seek consent of landholders vary between jurisdictions. Mining operators give written notice of intent to enter a pastoral property over which they hold mining rights in Queensland and the Northern Territory, but apparently not in Western Australia, although stockyards and gardens are off limits. Exemptions are made in cases where landholders cannot be contacted or on remote sections of Northern Territory properties, where access does not require coming in sight of the homestead. Queensland also has a comprehensive Land Access Code, which includes everything from shutting gates to informing land holders of all completed activities and any potential adverse impacts.

Table 31. Major legislation covering mining activity in northern Australia

NB: This list is not comprehensive

National
Aboriginal Land Rights (Northern Territory) Act 1976
Atomic Energy Act 1953
Environment Protection and Biodiversity Conservation Act 1999
Native Title Act 1993
Northern Territory (Self Government) Act 1978
Western Australia
Aboriginal Affairs Planning Authority Act 1972
Environmental Protection Act 1986
Mining Act 1978
Petroleum and Geothermal Energy Resources Act 1967
Petroleum Pipelines Act 1969
Rights in Water and Irrigation Act 1914
Northern Territory
Energy Pipelines Act
Environmental Assessment Act
Mineral Titles Act 2010
Minerals Acquisition Act 1953
Mining Management 2001
Petroleum Act
Queensland
Environmental Protection Act 1994
Geothermal Energy Act 2010
Mineral And Energy Resources (Common Provisions) Act 2014
Mineral Resources Act 1989
Petroleum Act 1923
Petroleum and Gas (Production and Safety) Act 2004
Regional Planning Interests Act 2014
State Development and Public Works Organisation Act 1971
State Development and Public Works Act 1974
Sustainable Planning Act 2009
Territory Parks and Wildlife Conservation Act 2000
Water Act 2000
Water Supply (Safety and Reliability) Act 2008

The holder of a mineral exploration or mining lease can occupy the lease area (even where this overlies a pastoral lease), and has exclusive rights to explore, mine, evaluate, process, refine, store or remove minerals and store, treat or dispose of waste (as designated in the title, and approved by the minister). They may also conduct operations as are necessary to complete these activities (e.g. operate a processing plant). They also have the right to use existing infrastructure, and develop such

infrastructure as is required for mining activities. In Queensland, the government may declare a State Development Area (SDA) to facilitate the development of mines and associated transport corridors, as has been done in support of the Galilee Basin coal mining projects (see Industry challenges: Mining). Under the *State Development and Public Works Organisation Act 1971* (Qld), the Queensland Coordinator-General may compulsorily acquire land needed for private infrastructure, if agreement cannot be reached with the land owners and/or Native Title holders.

Environmental approvals

Before a mining activity is approved in Australia, it requires an assessment of potential impacts on matters of national environmental significance (e.g. threatened species or communities) and how any such impacts are to be managed. For CSG and large coal mining developments, this includes impact on water resources. The assessment process is undertaken by state and territory governments, but the Australian Minister for the Environment uses the assessment to decide whether to approve the mining activity.

Additional state/territory-level requirements for environmental assessments of mining activities vary between jurisdictions. In Western Australia and Queensland, all mining proposals must include an environmental impact assessment (EIA). In the Northern Territory, the Environment Protection Agency (NT EPA) and Minister for Lands, Planning and Environment decide whether a mining activity requires an EIA.

In Western Australia, the Environmental Protection Authority runs the EIA process and provides advice on the acceptability of the mining proposal to the Minister for the Environment, who then confers with other ministers before deciding whether the project should proceed[391]. In the Northern Territory, the EIA process is run by NT EPA and the decision to approve a mining activity is made by the Minister for Mines and Energy. In Queensland, the EIA process for most mining proposals is handled by the Department of Environment and Heritage Protection, whose minister makes the approval decision. However, for projects involving major infrastructure development, the Coordinator-General in the Department of State Development runs the EIA process, and the Minister for State Development makes the approval decision. This has been the case for all CSG projects in the Galilee Basin, along with their associated infrastructure.

In each case, the responsible minister may impose specific conditions to safeguard environmental values. A financial surety is usually required to cover costs of rehabilitation in the event of the

developer defaulting on these obligations. The Queensland Government monitors compliance and environmental impacts and may impose conditions on operators to address breaches.

Requirements for EIA content and format differ between jurisdictions, but generally cover biodiversity, biosecurity, water, atmosphere, cultural values and social factors. Assessments include a description of values; potential impacts on them; and actions to avoid adverse impacts, and mitigate, rehabilitate or offset unavoidable damage. In Queensland Coordinator-General Projects, both positive and negative impacts must be assessed.

Although a separate assessment of impacts on future gas and petroleum recovery is required in Queensland, EIAs do not cover economic values, such as pastoral values. The *Regional Planning Interests Act 2014* (Qld) aims to prevent mining or infrastructure development significantly reducing or disrupting production of irrigated crops and pastures, but not of rangeland grazing.

The public generally has the right to comment at various stages of the EIA process, and their views may or may not be addressed in the final decision. In all three jurisdictions, preparation of an environmental assessment is preceded by a stage in which the terms of reference are defined, which is open to public comment. The assessment is then prepared and may be modified at the request of the relevant department, with each version being open for public comment. As stated above, comments are more likely to result in conditions being placed on a mining activity, than in the proposal being rejected.

Water resources

In Western Australia, use of water for mining activities must be licenced by the Department of Water[392]. In the Northern Territory, mineral title holders can use or divert ground or surface water for mining and exploration activities. They do not need a special permit to do so, but must include water use and management must be included in an approved Mining Management Plan[393] and is subject to environmental assessment. They must not use water stored in dams without the landholders' consent. In Queensland, permits are not required to extract groundwater for use in mining, gas or petroleum operations, and landholders are required to provide information on the property's water supplies and their locations to the miners. However, this right does not appear to extend to the use of dam water, and landholders' access to ground water must be assured.

Under the *National Partnership Agreement on Coal Seam Gas and Large Mining Development*[394], the Queensland Government can seek advice from the Independent Expert Scientific Committee about

the likely impact of CSG projects and large coal projects on water resources. Where significant impacts appear likely, the proponent must also prepare an UWIR covering:

- Underground water extraction
- Aquifer information and underground water flow
- Predicted water level declines
- Water monitoring strategy (including impacts of fraccing)
- Spring impact management strategy.

Any wider impacts should be addressed under the EIA. Where cumulative impact of one or more operators is likely to occur, UWIR responsibilities are assigned to the Office of Groundwater Impact Assessment, in the Department of Natural Resources and Mines.

CSG proposals must include a water management plan covering the amount and quality of water expected to be generated; how it is to be treated, stored, used and disposed of; and monitoring and management when acceptable levels are breached. Objections to a mining proposal being approved because of impacts on water resources or inadequacy of impact assessment are heard by the Queensland Land Court.

Practice improvement

Identification and uptake of practice improvement

The impetus for practice improvement in northern beef production is the need to improve profitability and sustainability. Inefficient herd management (especially retention of animals regardless of their contribution to turn-off) leads to poor performance and profitability, as well as unnecessarily high stocking rates and elevated carbon emissions[44,395]. Research and extension has identified where inefficiencies exist and how they can be overcome.

Extensive research has shown that reproductive performance can be improved through herd management, vaccination, supplementary feeding and matching stocking rate to long-term carrying capacity[92]. Many of these improvements not only increase herd performance but also effectively reduce stocking rates for the same level of beef production, and so have benefits to pasture production and biodiversity[396,397]. Improving efficiency of livestock production should also reduce emissions at the enterprise scale[395]. Hence, the drive to improve herd performance without increasing stock numbers is likely to have both biodiversity and carbon benefits. Land management principles to

improve sustainability and financial viability of the northern grazing lands, are also well understood and include managing stocking rates, resting pasture, managing fire and strategic placement of infrastructure[171]. Grazing extension programs, such as Grazing Land Management courses and the Grazing BMP, aim to increase uptake of these practices and cover all aspects of enterprise management[398,399], and have been shown to be successful at stimulating practice improvement[400]. The remainder of this section details each practice change identified as having financial and or environmental benefits and assesses the level of uptake based on pastoral surveys undertaken in the region between 1994 and 2011/12 and the CashCow research project undertaken in 2008-2011[a].

Land condition and economic returns

Good land condition (a healthy cover of perennial grasses, and minimal weeds or bare ground) provides good quality forage to cattle through the year, and is, therefore, essential for profitable enterprises[171]. Persistent overstocking causes land degradation, eliminating perennial grasses, exposing bare ground and increasing run-off and soil erosion. Maintaining ground cover is important for minimising soil loss from the paddock, but a good cover of deep-rooted perennial grasses is needed to minimise the runoff responsible for gully and bank erosion[402]. A long-term study at Wambiana, near Charters Towers, Queensland, demonstrated that adjusting stocking rates in response to variation in climate[280,403] not only increased profitability[85,86], but also protected the grazing resource in the long-term[404] and improved conditions for biodiversity[397]. Adjusting stocking rates to carrying capacity requires an assessment of forage availability[171].

Adjusting the stocking rate is most easily done on backgrounding properties, where weaner steers are purchased and grown for sale to feedlots[37,403]. Stocking rates can be adjusted on such properties by reducing the number of animals purchased and increasing the number sold. However, breeding properties are dependent on their reproductive stock to produce weaners for sale, so have less capacity to reduce numbers, as this also reduces capacity to re-build the herd when conditions improve. Nevertheless, modelling has also shown varying stock numbers in response to seasonal conditions can also be profitable on breeding-finishing properties[405].

[a] Surveys: Pilbara and Kimberley in 2010[28,268], in the Northern Territory in 2011-12[30], in the Burdekin Dry Tropics in 2008-9[34] and 2010[401], and in the Dalrymple region of the Burdekin Dry Tropics[226].
CashCow research project: Mitchell Grass region (Northern Downs) and remainder of the Monsoonal North (Northern Forest) in 2008-2011[60]

There is limited information about the number of pastoralists who adjust stocking rates according to carrying capacity or climatic conditions. However, these practices are used by 74% of graziers surveyed in the Burdekin Dry Tropics in 2008-9[34] and 49% of pastoralists surveyed in the Northern Territory in 2011-12[30]. Most pastoralists use personal experience rather than pasture monitoring to assess pasture condition and stocking rates, and few calculate forage budgets[a]. Condition of livestock is also used[b].

Resting pastures

Resting pastures is important to allow recovery of perennial grasses[171]. In the Monsoonal North, the most effective form of resting pastures is periodic wet season spelling. This requires the property to be divided into enough paddocks to allow stock to be removed from one paddock and distributed across the remaining paddocks. A large number of paddocks will allow rotational grazing, which will be most effective when paddocks are locked up for an entire wet season. Another option is to burn parts of a paddock to attract cattle to the new growth that follows, thereby resting the unburnt areas[406]. Surveys indicate that use of spelling has increased in the regions from less than one half of enterprises in 1994-1997[c] to in excess of 60% of enterprises in 2010-12[d].

Fire management

There is documented support for the use of fire to restore pasture by managing grazing pressure, restore the tree-grass balance, reduce the risk of wildfire and for the control of some woody weeds[407]. Fire is also used to remove rank grass and stimulate green pick. While this has merit for spreading grazing pressure, the nutritional benefits are questionable.

Outside the Northern Territory, fire use has declined over the last two decades (Table 32). In surveys undertaken before 2005, fire use was around 90-100% in all of the Monsoonal North except for north-

[a] Burdekin Dry Topics (2010): monitor ground cover 85%; calculate long-term carrying capacity: 72%, calculate forage budget: 15%[401]; North-western Western Australia (2010): visually assess forage availability 65%; pasture monitoring points 10%[28]; Northern Territory (2011-12): visually assess forage availability 78%; pasture monitoring points 10%.[30]

[b] Assessment of stocking rate based on condition of livestock was used by 38% of pastoralists in north-western Western Australia in 2010[268], 69% in the Northern Territory in 2011-12[30], and 47% in the Burdekin Dry Tropics in 2008-9[34].

[c] Spelling rates in Dalrymple region: 1994: 27%; 2004: spelling 43%[226]
Spelling rates in 1996/7: North-western Western Australia: 28%; Northern Territory: 44%; Queensland Gulf: 24%; Queensland Mitchell Grass: 32%; North Queensland: 45%[223].

[d] Kimberley (2010): spelling 61%, rotational grazing 23%[28,268]
Northern Territory (2011-12): spelling 61%, rotational grazing 23%[30]
Burdekin Dry Tropics (2008-10): spelling: 92%; wet season spelling of at least 25% of the property: 75%; rotational grazing or cell grazing[34,401]

west Queensland and the Queensland Mitchell Grass region. In subsequent surveys, fire use halved in north Queensland and declined to a trickle in the Kimberley. However, more recently, Savanna Burning projects for carbon abatement have reinstated fire use in the Kimberley (see Indigenous pastoralism).

Table 32. Use of fire on grazing land of the Monsoonal North

Source: Compiled by Crowley, Felderhof, McIvor and Bolam (2013)[407]

N/R = not recorded

Year	Use fire	Wildfire prevention	Green pick/ Rank grass	Open up country	Pasture composition	Weed control	Pastoralists surveyed	Source
	(%)	(%)	(%)	(%)	(%)	(%)	(no.)	
Kimberley								
1996/7	92	77	77	27	15	N/R	26	223
2010	N/R	4	N/R	6	6	N/R	49	a
Top End								
1996/7	100	94	71	53	24	N/R	17	408
2004	96	64	44	65	3	N/R	25	227
2010	80	65	15	20	0	20	20	b
Gulf Savanna (Katherine Pastoral Region)								
2004	N/R	45	58	53	3	N/R	24	232
2010-12	90	63	65	32	3	11	62	b
Victoria River District								
1996/7	91	64	73	45	36	N/R	11	228
2010	100	72	62	33	0	17	18	b
Queensland Mitchell Grass								
1996/7	67	50	55	55	23	NR	33	223
North-west Queensland								
1996/7	59	50	66	78	19	N/R	54	223
North Queensland								
1996/7	100	58	62	73	23	N/R	52	223
Great Barrier Reef catchments								
2010	48	6	4	6	10	19	266	401
Burdekin Dry Tropics								
2010	50	N/R	N/R	N/R	N/R	N/R	60	401
Dalrymple Shire								
2004	51	20	23	27	N/R	39	53	226

Paddocks and water points

Cattle rarely venture more than 5 km from water[409], so large paddocks with few permanent waters tend to be patchily grazed, with areas close to water being over-utilised and water-remote areas being under-utilised[410]. Providing accessible water points across the property, therefore, helps to spread

[a] Department of Agriculture and Food, Western Australia unpubl. data
[b] Department of Primary Industries and Fisheries, Northern Territory unpubl. data

grazing pressure[409]. Intensification of paddocks and water points also allows paddocks to be closed-off for spelling. In the extensive rangelands, a maximum distance to water of 3-4 km is recommended, providing a grazing area of about 25 km^2 around each water point. This can be achieved using paddocks of 30–40 km^2 each having two water points. In the intensively managed areas of North Queensland, paddocks of up to 20 km^2 with two water points are recommended.

In 2008, the majority of the Monsoonal North was more than 3 km from water. Only in the Desert Uplands and around Mount Isa did the area within 3 km of water exceed 30% (Figure 38). However, Monsoonal North properties participating in the CashCow project had an average of 78-79% within 2.5 km of water, with a range of 6% to 100%[60]. In 2009-10, new water points were established on 45% of properties in the Top End and 77% of those in the Gulf Savanna, and new paddocks were constructed on 65% and 54% of properties, respectively. By 2011-12, properties in the Top End had the desired ratio between area of grazing land and number of water points[a], but those in the Gulf Savanna[b] still had half the number of water points needed for effective grazing[30]. The 2010-11 work plans of 63% of pastoral properties in the Kimberley included constructing water points and 71% included building fences[268]. Similar information is not available for other parts of the Monsoonal North.

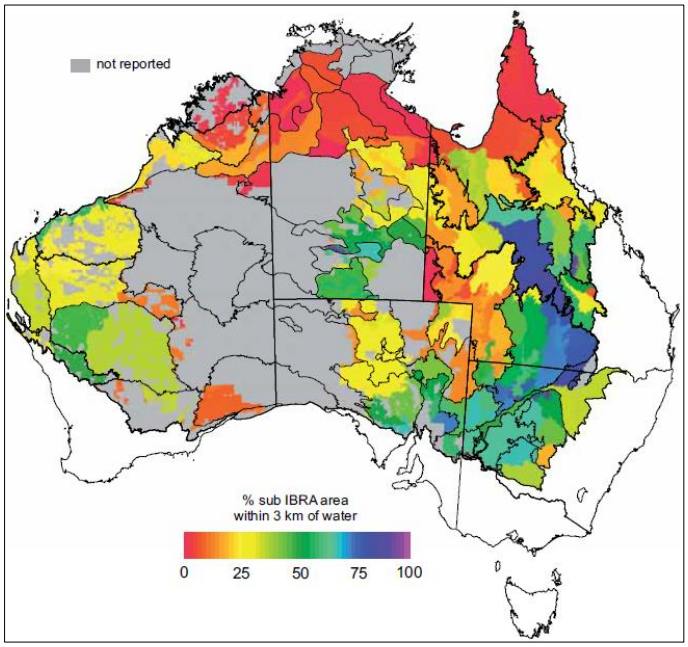


Figure 38. Percentage of grazing lands within 3 km of water

Source: Bastin and the ACRIS Management Committee (2008)[411]

[a] One point for every 24 km^2
[b] One point for every 66 km^2

Water-remote areas are important for biodiversity conservation[250,412,413]. To avoid biodiversity decline, retention of 10% of key land type as water-remote is, therefore, recommended[171]. Hence, the impact of increased infrastructure development on biodiversity will depend on its configuration. It is likely to deliver biodiversity benefits in areas where grazing pressure is reduced, but is likely to be negative where significant areas do not remain water-remote.

Fencing can also be used to separate land types with different grazing characteristics so that all parts of the paddock attract similarly moderate grazing pressure[36,409]. Survey results in the Burdekin Dry Tropics indicate the percentage properties that were fenced to land type increased from 25.5% in 2008[34] to 67% in 2010[401]. Such a massive improvement is worthy of further investigation. Similar information is not available for other parts of the Monsoonal North. However, fencing to land type may be difficulty where paddock size is large.

Herd size

Large herd size appears to be the key to enterprise profitability[78]. However, it is important that herds are not simply increased by increasing stocking rates, as this has adverse impacts on long-term viability, pasture condition and biodiversity[280,397,414]. As noted above, where substantial portions of the property are under-utilised through the lack of infrastructure, herd size may be increased by strategic placement of new fences and water points. But rather than just increasing stock numbers, strategic infrastructure development needs to spread grazing pressure and improve land condition[171]. Cattle numbers increased on 40% of Top End properties between 2004 and 2011-12, and on 38% of properties in the Gulf Savanna[30]. Decreases had occurred on only 5% and 8% of properties, respectively. Roughly half (48%) of the Monsoonal North producers in the CashCow project and only 8% of those on Mitchell Grass country had intentions to increase their herd size by at least 10%[60].

Herd management

Reproductive performance can be improved by culling infertile cows and sub-fertile bulls; early weaning; and segregating pregnant and lactating cows younger than five years for preferential nutritional management[92,415]. Culling of poor performing cows and bulls not only improves genetic stock but means non-productive animals are not eating forage that could be used by productive ones, or unnecessarily degrading pasture condition. Early weaning at the end of the pasture growth season

and segregating different classes of animal allow producers to maintain cows in good condition, maximising the number that conceive for the next breeding round[44,60,415].

In the Northern Territory, around one-third of pastoralists surveyed reported culling cows, early weaning and/or early sale of steers[30]. Across the Monsoonal North, CashCow producers routinely culled females when they reached 10 years of age, and weaned calves when they were 5 to 6 months old. Bulls with poor semen quality were culled on 29% of properties[60]. Across the study, 10-22% of cows failed to conceive, and culling and replacement of cows was suggested as a strategy for increasing production. While it appears that cows that fail to conceive are culled on some properties, the level of culling is unknown. In the Northern Territory, segregation of cattle is based on age on 37% of properties, and on pregnancy status on 27% of properties[30]. In north-western Western Australia, young heifers are held separately from other cattle on only 17% of properties[28]. Small numbers of large paddocks are an impediment to effective herd management. Along with the poor performance rates in Table 9, these figures indicate there is much room for improvement, especially in the more systematic culling of poor performing cows and bulls, and segregation of different animal classes.

Vaccination

Vaccination against reproductive disease is important for maintaining fertility, and vaccination against tick fever and botulism for reducing mortality[44,60,415]. Monsoonal North producers in the CashCow project rarely vaccinated for reproductive diseases[60]. Approximately two thirds of producers vaccinated maiden heifers and cows for botulism, and 44% vaccinated bulls. Vaccination to prevent tick fever in breeding females was practised on 14% of properties.

Supplementation

Soils in the grazing lands of the Monsoonal North are typically phosphorus-deficient (Figure 39). This impedes both weight gain and reproductive productivity[416]. Phosphorus supplements are, therefore, important for maintaining the nutritional health and productivity of cattle, particularly in the wet season, when grass contains high levels of protein needed for animal production[44,415,417]. Phosphorus supplementation is of particular interest because of the poor performance of cattle on most performance measures when compared with other parts of northern Australia where phosphorus availability is higher[60].

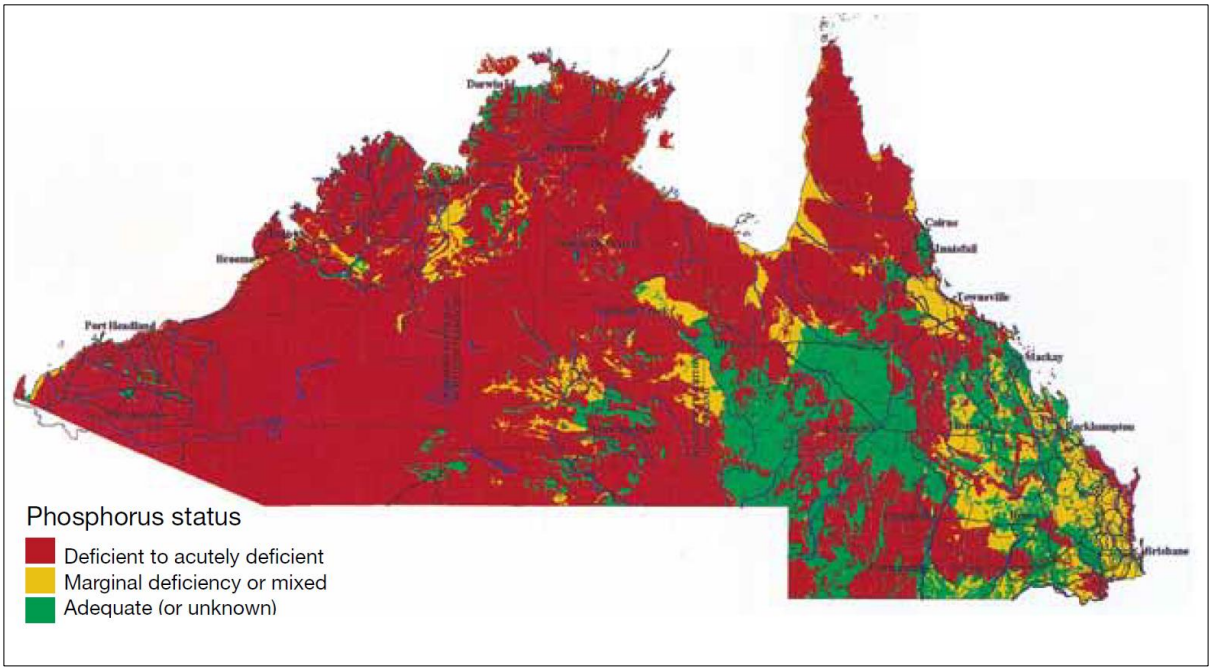


Figure 39. Soil phosphorus status across northern Australia

Source: Jackson et al. (2012)[416] adapted from McCosker and Winks (1994)[418] Reproduced courtesy of Meat & Livestock Australia Limited - www.mla.com.au

In Mitchell Grass country, where phosphorus availability is higher than in the rest of the Monsoonal North, 31% of CashCow properties provided supplements in both seasons[60]. In the rest of the Monsoonal North, 87% fed supplements to their cattle in the dry season and 63% in the wet season[60]. In the Kimberley, mineral supplements are fed to cattle in the dry season on about 60% of pastoral properties and on about one-quarter of properties in the wet season[28]. The effectiveness of current phosphorus supplementation patterns are unclear and require further research[60]. However, care must be taken that wet season nutrient supplementation does not also increase the grazing pressure on perennial grasses, which are most vulnerable to wet season grazing[419,420].

Introduced pasture species

Cattle raised on introduced grasses with either legumes or nitrogen supplements outperform animals raised on native pastures, allowing them to be sold at a premium into high value markets (Figure 16)[421-423]. Concerted efforts have, therefore, been made to find exotic plants that will reliably boost cattle production. Through the course of the 20th century, CSIRO introduced at least 2,250 grasses and 2,691

legume species, mostly for assessing their grazing potential[424]. Several exotic pasture species have had adverse impacts on the natural environment, as has the tree clearing that is often required to establish introduced pastures[424,425]. In northern Australia, the most vigorous introduced grasses—Gamba Grass (*Andropogon gayanus*), Para Grass (*Urochloa mutica*), Olive Hymenachne (*Hymenachne amplexicaulis*), Aleman Grass (*Echinochloa polystachya*), Buffel Grass (*Cenchrus ciliaris* or *Pennisetum ciliare*) and Mission Grass (*Pennisetum polystachion* and *P. pedicellatum*)—are called "transformer" species or "green bulldozers"[a] because they exclude other species and the increased fuel loads they produce can cause fires of sufficient intensity to destroy canopy trees[426-430]. Five of these grasses have been identified as key threats to biodiversity conservation[431]. Gamba Grass is a Weed of National Significance[432], and a management plan has been prepared for its containment and control in the Northern Territory[433]. Buffel Grass has become invasive to the detriment of biodiversity in both central Australia and Queensland sections of the Monsoonal North[428,434-437], but has not been identified as an issue in the Top End or Gulf Savanna. Some pastoralists are also concerned about their ability to control the spread of Gamba Grass, Wynn Cassia, Leucaena (*Leucaena leucocephala*), Mission Grass, *Stylosanthes* spp. and Indian Blue Grass (*Bothriochloa pertusa*)[224,227].

Despite adverse biodiversity effects, introduced pastures continue to be an important part of productivity improvement. In the Northern Territory, exotic pasture species are used on most Top End Properties and around half the properties in the Gulf Savanna (Katherine Pastoral region), but only cover a small proportion of each region (Top End: 3%, Gulf Savanna: 4.8%)[30]. The main species used in the Top End are Jarra Grass (*Digitaria milanjiana*), Tully Grass, (*Brachiaria humidicola*), Seca Stylo (*Stylosanthes scabra*) and Wynn Cassia (*Chamaechrista rotundifolia*); and in the Gulf Savanna are Buffel Grass, Nixon Sabi Grass (*Urochloa mosambicensis*), Seca Stylo and Verano (*Stylosanthes hamata*). The most common use of exotic pasture species is to over-sow native pastures to improve diet quality (Top End: 56%, Gulf Savanna: 61%), followed by hay production (56%, 32%) and improved pasture systems (67%, 19%)[30]. Most Top Enders (80%) and 29% of Katherine pastoralists planned to increase their use of exotic pasture species between 2011 and 2014[30]. Pasture species recommended for irrigated forage production include the low impact species Rhodes Grass (*Chloris gayanus*), Forage Sorghum (*Sorghum* spp. hybrids) and Lablab (*Lablab purpureus*), but also include some invasive species, such as Buffel Grass[59].

[a] http://www.abc.net.au/am/content/2007/s2144436.htm

Reef water quality

Efforts to reduce sediment and chemicals in run-off to the Great Barrier Reef have been a significant driver of practice change in the Burdekin Dry Tropics and other reef catchments since 2010[375]. These efforts have been spearheaded by industry bodies, NRM groups and the Queensland and Australian Government. Details of legislation underpinning practice improvement are covered under Legal and regulatory environment.

The most damaging sediment to reef water quality is fine material that remains suspended in the water column long enough to reach the reef lagoon[438,439]. Flood plumes laden with this fine sediment both smother the coral and stimulate growth of the macro-algae that provide food for Crown of Thorns Starfish (COTS)[440]. COTS outbreaks are also driven by nutrients from cane fields[438,441]. While COTS outbreaks are a natural phenomenon associated with elevated river discharge, their frequency has increased roughly five-fold over historical times[440], in response to increases river loads of both sediment and nitrogen of similar magnitude[442].

The main water quality issue for pastoral operations in the Burdekin catchment is loss of fine-grained sediment. Most of the damaging suspended sediment fraction reaching the Great Barrier Reef lagoon comes from the Bowen (~45%) and Upper Burdekin (~27%) and Lower Burdekin (~26%) sub-catchments (Figure 40)[443]. In the absence of the filtering effect of the Burdekin Falls Dam, the Upper Burdekin would be by far the greatest contributor. Features that render these sub-catchments most vulnerable to sediment loss are the erodible soils and high relief (Table 33). Only the Bowen catchment, which enters the Burdekin down-stream of the Burdekin Falls Dam, has both high levels of exposed soil and high contributions to reef sediment.

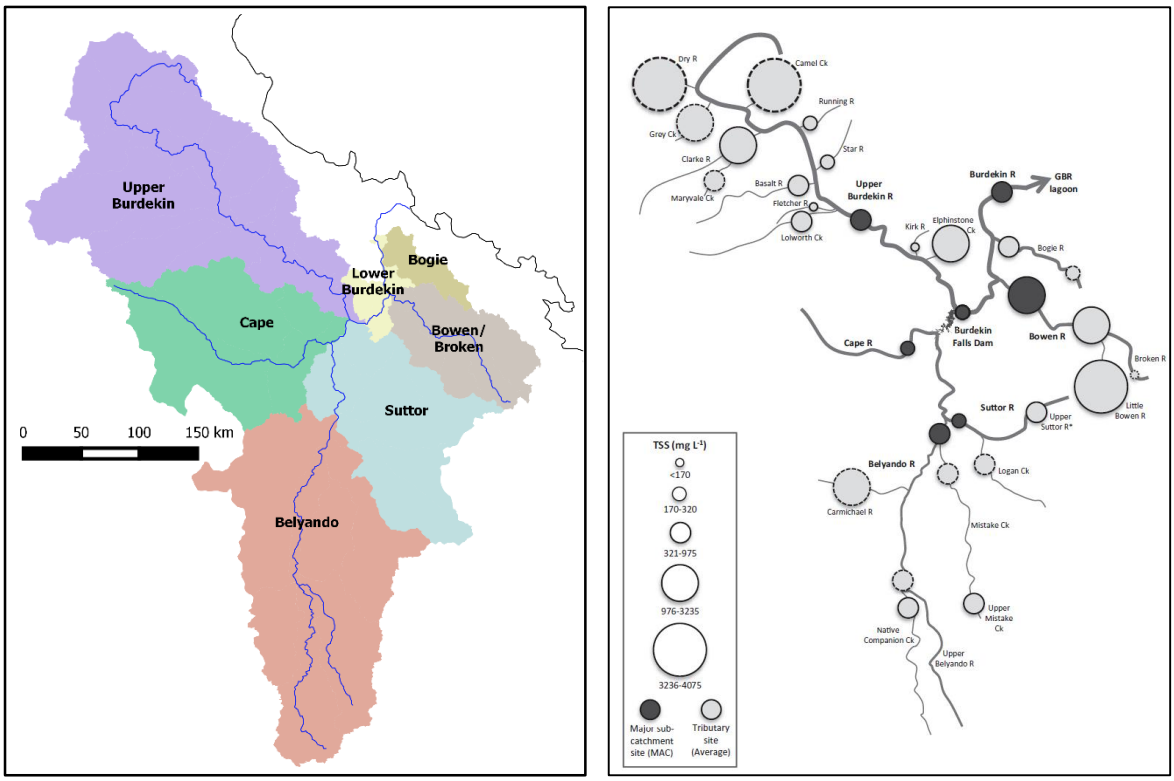


Figure 40. Sub-catchments of the Burdekin catchment (left) and their contribution to suspended sediments (right)

Source: Catchment data: NQ Dry Tropics (2015)[444]; Righthand image: Bainbridge, Lewis, Smithers, Kuhnet, Henderson and Brodie (2014)[443] ©2014 American Geophysical Union.

Table 33. Characteristics of the Burdekin River sub-catchments

Source of data: Ground cover: calculated from NQ Dry Tropics (2015)[444]; all other parameters from Bainbridge, Lewis, Smithers, Kuhnet, Henderson and Brodie (2014)[443]

Upstream area	Terrain	Soils	Land use	Area with <50% ground cover	Sediment to GBR
(km^2)				(%)	(%)
Below Burdekin Falls Dam					
Bowen					
7,110	Steep	Red-brown earths, yellow soils, granite/sandstone-derived gravely/ sandy soils, black earths	Grazing	36	45
Lower Burdekin/Bogie					
129,600	Low relief alluvial levees, floodplains and delta	Black cracking clays, silts, sands, duplex and sodic soils	Cane & grazing	19.6	26
Above Burdekin Falls Dam					
Upper Burdekin					
36,140	Steep	Erodible red duplex soils, black & red basaltic soils, sodic duplex soils	Grazing	11	27
Cape					
15,860	Gently undulating	Remnant sedimentary basins, cracking clay soils	Grazing	46	<11%
Belyando					
35,055	Gently undulating	Remnant sedimentary basins, cracking clay soils, grey/ brown clays, red/yellow earths	Grazing & dryland cropping	48	<11%
Suttor					
10,870	Gently undulating	Remnant sedimentary basins, cracking clay soils, grey/ brown clays, red/yellow earths	Grazing & dryland cropping	41	<11%

Efforts to reduce erosion rates in the Burdekin region focus on maintaining high levels of ground cover. Loss of groundcover can lead to increased run-off and soil loss from hillslopes[402,445]. Increased run-off also drives gullying downslope, producing even more sediment loss[402]. Most sediment reaching the Great Barrier Reef is lost from subsurface soils coming out of gullies[446]. While lower levels of ground cover may be necessary for maintaining surface soil and pasture productivity, retention of 75% ground

cover appears to be necessary to ensure water from high rain events infiltrate the soil rather than run across the surface[402,447].

Of particular concern is the percentage of the region with less than 50% ground cover which reached a peak in 1996 and 2004, both after dry spells of several years (Figure 41). However, ground cover fluctuates between years depending on rainfall and grazing pressure (Figure 42). Therefore, particular attention needs to be paid to ground cover in dry years.

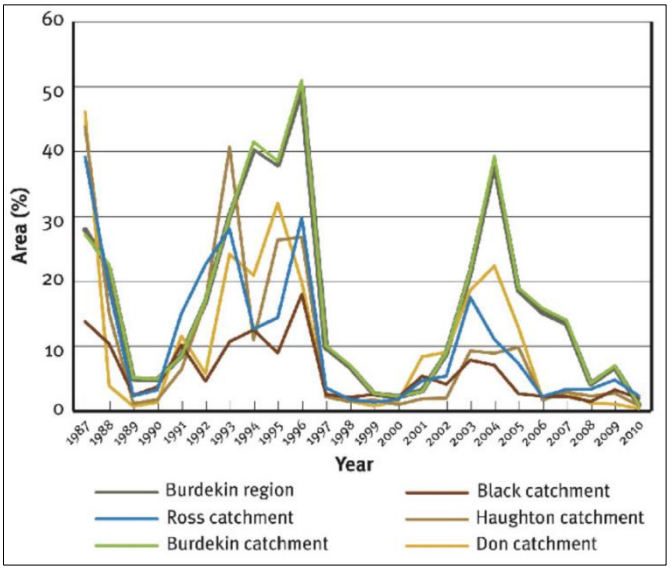


Figure 41. Percentage of Burdekin Dry Tropics with less than 50% ground cover, 1987-2010

Source: Department of Environment and Heritage Protection (2015)[448]

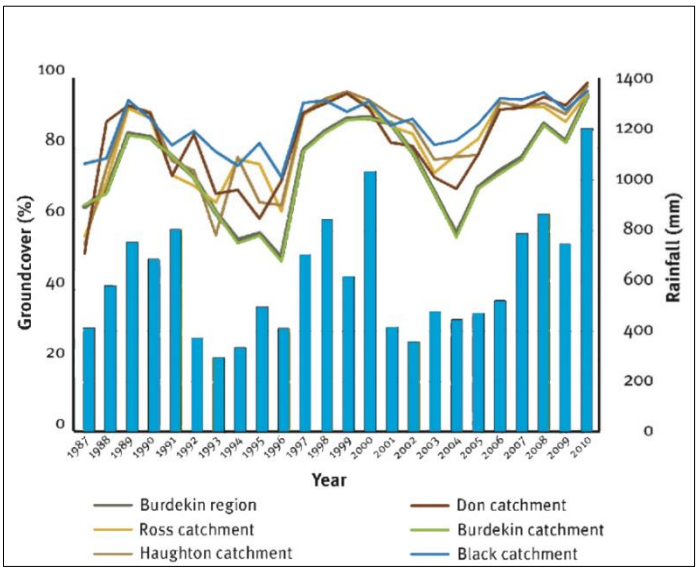


Figure 42. Ground cover in the Burdekin Dry Tropics in relation to annual rainfall, 1987-2010

Source: Department of Environment and Heritage Protection (2015)[448]

Efforts to maintain ground cover have involved implementing best practice grazing management to maintain land condition (see Land condition and economic returns), initially as part of the Reef Regulations[374] and later as part of the Grazing Best Management Practice Program (BMP) (see Legal and regulatory environment). The Grazing BMP has been developed by AgForce and the Fitzroy Basin Association in partnership with Queensland Department of Agriculture and Fisheries (QDAF), with the Queensland Department of Environment and Heritage Protection (QEHP) having oversight of reef-related elements. The industry partners are responsible for benchmarking the performance of cattle producers.

The Grazing BMP program goes beyond reef regulations requirements and guides pastoralists through a self-assessment process to identify practice improvements that could help improve the long term profitability of their enterprise[324]. It includes modules on:

- Animal health and welfare
- Animal production
- Grazing land management
- People and business
- Soil health.

By June 2015, 1,300 pastoralists were participating in the Grazing BMP[449], by September 2015, 1,000 pastoralists had completed an Accelerated Grazing BMP course[324], and by the end of October, 450 pastoralists had completed all five modules[a]. This means that 6.7 million ha of land in Queensland under the ownership of people who have completed the Grazing BMP modules.

Use of Tebuthiuron to control regrowth on grazing lands is also a concern as elevated levels of this herbicide have been found in reef waters off the mouth of Burdekin River[450], where it is likely to reduce photosynthesis of mangroves, seagrass and marine algae[451]. The Reef Regulations also required pastoralists in the Burdekin Catchment to record their use of Tebuthiuron. Use of this herbicide also requires a Commercial Operators Licence or national competencies for preparing, transporting chemicals and controlling weeds. Record keeping protocols have been incorporated into the Grazing BMP.

[a] http://www.abc.net.au/news/6897372

Greenhouse gas budgets

Agriculture produces around 13.5% of global GHG emissions[452] and 16% of emissions generated in Australia[453]. However, agriculture is not currently included in emission reduction targets at a national or global level, so farmers are not required to reduced their emissions[454] although this reprieve may be short-lived[455]. It has been estimated that mitigation actions could reduce emissions from Australian agriculture by around 126 Mt CO_2-e per year[456].

Beef cattle produced about 6.8% of the Australia's GHG emissions in 2012[a] and 10-12% of global emissions[459]. As well as methane produced from enteric fermentation, pastoral operations generate significant GHG emissions through electricity and fuel consumption[460]. Global demand for beef is, therefore, an important driver of GHG emissions[461]. So it is important that beef is produced as efficiently as possible to minimise contribution to climate change, with emphasis being on production efficiency (i.e. carbon-equivalent units per kilogram of meat, rather than total GHG emissions)[462].

Livestock grazing is the only agricultural land use that can be undertaken sustainably on savanna grasslands and open woodlands while maintaining its ecological values[463]. GHG emissions from grassfed beef production in Australia has been estimated at 12 CO_2-e/kg meat produced, which is low relative to world standards[464], and agricultural emissions per unit of land in the Monsoonal North are amongst the lowest in the country (Figure 43).

[a] Beef cattle were estimated to produce 1.8 Mt CH_4 in 2012, with 0.06% generated by manure management and the remainder from enteric fermentation[457]. This constitutes 42.5% of Australia's agricultural GHG emissions, which is in turn 16.1% of Australia's total GHG emissions[458].

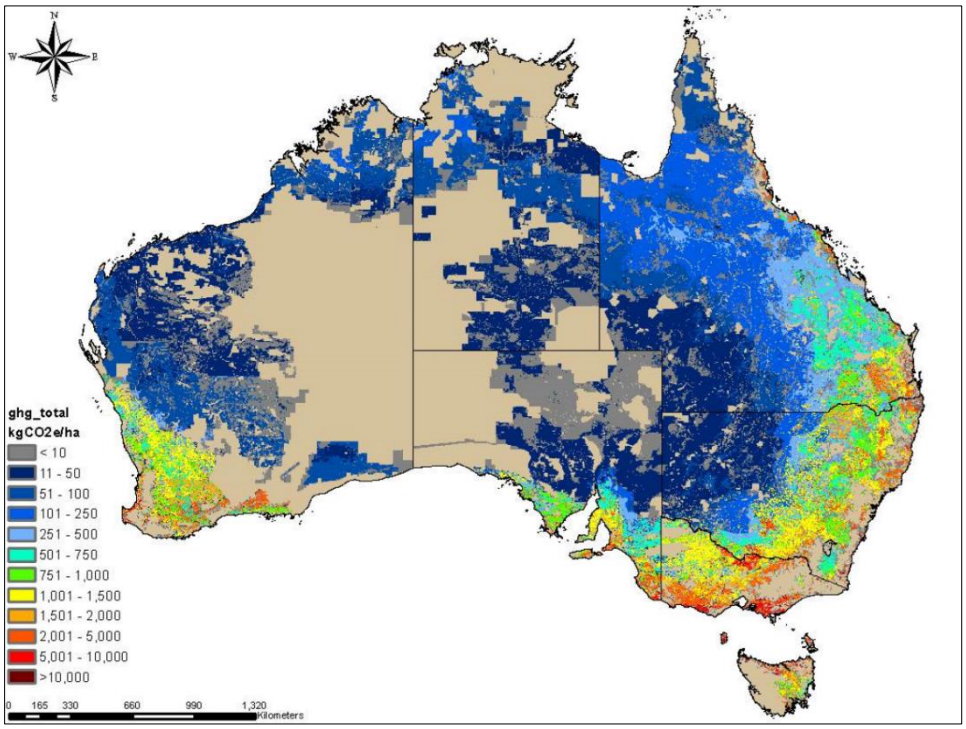


Figure 43. Greenhouse gas emissions from agriculture

Source: Navarro, Bryan, Marinoni, Eady and Halog (2013)[465]

Even though cattle producers are not required to reduce their carbon footprint, the industry is cognisant of the need to reduce emissions[455]. Improvements to energy use, animal husbandry and land management have been identified as ways to achieve emission reduction and many are already being implemented (Table 34). In summary, management practices that improve herd performance, including through improved land condition, breeding rates and liveweight gain all decrease the carbon input required to produce a kilogram of meat. Furthermore, of the diversification options identified in the next section, forage cropping and savanna burning can also improve the carbon budget at an enterprise level.

Table 34. Strategies to improve greenhouse gas footprint of pastoral properties

* = ERF/CFI methodology approved (see Environmental service delivery)

Strategy	Sources
Energy consumption and production	
Switch to renewable energy	462
Produce biofuel crops	456
Improve feed conversion efficiency	
Genetic selection of livestock	462,455,466,467
Nitrogen and phosphorus supplements, especially in the wet season*	468
Phosphorus supplements, especially in the wet season	469
Improved feed-base	462
Dietary additives e.g. Saponins	470
Reduce ruminant protozoa	471
Improve feed quality	
Moderating stocking rate to improve pasture quality	455,456
Grain-based feed-lotting	462,472,473,474
Improve herd management and growth rates	
Genetic selection of livestock	474
Herd management (e.g. Improve reproductive performance, Culling infertile cows, Early joining)*	462,471,475
Property infrastructure	462
Sequester carbon	
Restore native tree cover through planting and/or regrowth*	456,181
Improve soil carbon (e.g. by promoting deep-rooted perennial grasses)*	456
Abate greenhouse emissions	
Fire management to reduce extent of late dry season fires (Savanna Burning/Fire management)*	456,476

Animal welfare and community expectations

The Australian community expects meat to be humanely produced, whether it is slaughtered in Australia or after it leaves the country[423]. On 30 May 2011, community outcry against the live export trade was roused when mistreatment of Australian cattle in Indonesian abattoirs was broadcast on an Australian Broadcasting Corporation *Four Corners* program[a]. The footage revealed cattle experiencing slow and painful deaths, as well as being actively taunted and tortured. In response to this program, the Australian Government suspended the live cattle export trade on 8 June 2011 while it reviewed options for imposing more stringent conditions on export operations. Animals Australia[477], World Animal Protection[478] and RSPCA[479] were at the forefront of the campaign to ban live export.

On 6 July 2011, the Australian Department of Agriculture lifted the trade suspension and introduced ESCAS in addition pre-existing obligations for exporters to comply with Australian Standards for the Export of Livestock (see Legal and regulatory environment). Live export resumed in August 2011. While ESCAS has done much to improve animal welfare, and the Four Corners program exposed no

[a] http://www.abc.net.au/4corners/special_eds/20110530/cattle/

instances of shipboard maltreatment, objections to the live export trade remain. Some of these objections are based on opposition to any animal being raised for slaughter[115]. RSPCA's campaign website indicates an opposition to live export regardless of conditions:

> *RSPCA Australia is opposed to the export of live food animals for immediate slaughter or further fattening. RSPCA Australia will continue to pressure government to end the live export trade in favour of a chilled and frozen meat-only trade.*[a]

Although introduced as an animal welfare measure[37], the live export ban led to thousands of cattle suffering starvation on properties where there was inadequate feed, or being transported thousands of kilometres by road to Australian abattoirs[115]. The sea journey between northern Australian and Asian ports is relatively short and cattle often arrive in better condition than they were in when they left[480]. Even before ESCAS, mortalities during live export were very low, with mortality rates on voyages to south-east Asia averaging 0.08%, and 45% of all voyages reporting zero deaths[44]. Rates of 0.04% were recorded in 2010, 2011 and 2012, after which shipboard performance reports were no longer issued[165-167]. Over these three years, between 49% and 53% of shipments from northern ports were death-free. These mortality rates are an order of magnitude better than required by the Australian standard[481] and compare favourably with the only available assessments of mortalities during land transport[482]. Welfare issues related to feed and water deprivation, heat stress, physical exhaustion and rough treatment[483] appear more easily managed on dedicated cattle ships, where feed and water are continually provided, than they are in trucks or rail carriages.

Once the export ban was lifted, many of animals that had been destined for Indonesia now exceeded the size permitted, and so were retained on properties to the detriment of pasture and environmental conditions. There were claims that producers were driven to shooting cattle because the properties had run out of feed and the prices of cattle would not cover the cost of transporting them to saleyards[b]. So the animals, the environment and the pastoralists all suffered[51].

De-horning and de-budding are also in the sights of the animal welfare lobby[484]. Investments have been made into selecting poll breeding stock that are naturally hornless[c]. Campaigns within Australia have also seen major supermarkets sourcing hormone-free beef[485] and food that is humanely produced[486,487], and some beef is specifically promoted as being grass-fed[485]. Certification by Meat

[a] Policy was last reviewed on 24 Dec 2012, and website indicated it was still current 27 Jan 2016
[b] http://www.abc.net.au/news/4671318, http://www.theaustralian.com.au/news/latest-news/farmer-shoots-cattle-as-a-result-of-live-export-ban-says-chamber-of-commerce/story-fn3dxiwe-1226100150834
[c] http://www.abc.net.au/news/5322242

Standards Australia (MSA) assures the consumer that the animals have been well-treated, because mishandling affects meat quality[488]. However, long transport distances prevent many cattle enterprises in the Monsoonal North from being able to submit cattle to MSA for grading[142].

Complying with improved animal handling imposes costs on producers and can require changing on-farm handling procedures or breeds and selection of animals for different markets[118]. Hence, community expectations are significant drivers of animal handling procedures and associated input costs.

Climate change adaptation

While the extent of the projected impacts of climate change on the northern pastoral industry could be seen as dispiriting, options have been identified for providing resilience for the industry to weather these impacts. Most of the enterprise-level options (Table 35) are consistent with current best practice and are already incorporated into extension programs. Industry resilience will, therefore, benefit from continued support for extension programs and best-practice frameworks.

Table 35. Enterprise-level options to facilitate climate change adaptation

Source: Howden, Crimp and Stokes (2008)[173]

Options
Pasture productivity and grazing pressure
Select sown pastures and forage crops adapted to higher temperatures and water constraints
Revise fertiliser management through sown legumes and phosphate fertilisation where appropriate
Provide urea and phosphates directly to stock via reticulation and use effective supplementary feeding strategies
Increase use of strategic spelling
Use fire to control woody weeds
Use responsive stocking rate and rotation strategies based on seasonal climate forecasting, alter crop/livestock mix
Develop regional safe carrying capacities i.e. constant conservative stocking rate
Where appropriate, develop software to assist pro-active decision making at the on-farm scale
Improve water management, particularly for pasture irrigation
Pests, disease and weeds
Increase use of biological and other controls (cautiously)
Increase use of insect traps for sentinel monitoring and for population control
Adopt alternative chemical and mechanical methods for reducing woody weeds
Use pest predictive tools and indicators
Use quantitative modelling of individual pests to identify most appropriate time to introduce controls
Animal husbandry and health
Select animal lines that are resistant to higher temperatures but maintain production
Modify timing of mating based on seasonal conditions
Modify timing of supplementation and weaning
Construct shading and spraying facilities to reduce heat stress
Increase use of trees to provide shade and reduce wind erosion

Similarly, peak bodies and government agencies are already progressing industry-wide and policy-level options (Table 36). These efforts were spearheaded by the cross-regional collaboration under NABIWG, and will further benefit from other collaborative initiatives, such as growNORTH and several of the commitments from the Northern Australia and the Agricultural Competitiveness white papers. Despite the progress that was made through NABIWG, there was no indication in either white paper that this working group is likely to be re-established.

Table 36. Industry and policy-level options to facilitate climate change adaptation

Source: Howden, Crimp and Stokes (2008)[173]

Details
Policy
'Mainstream' climate change into existing government policies and initiatives (e.g. on drought, greenhouse sinks, natural resource management, water resource allocation, rural development) and into integrated catchment management.
Managing transitions
Policies and mechanisms to provide technical and financial support during transitions to new systems that are more adapted to the emerging climate.
Communication
Ensure communication of broader climate change information as well as industry-specific and region-specific information as it becomes available.
Climate data and monitoring
Maintenance of effective climate data collection, distribution and projection systems with monitoring and analysis systems addressing livestock sector-specific impacts to support/facilitate adaptive management.
Research and development and training
Undertake further adaptation studies that include broad-based costs and benefits to inform policy decisions. Maintain the research and development base (people, skills, institutions) to enable ongoing evaluation of climate/CO_2/industry/management relationships, and to streamline rapid research and development responses. This research and development needs to be developed in a participatory way so that it can contribute to training to improve self-reliance in the agricultural sector and to provide the knowledge base for farm-scale adaptation.
Breeding and selection
Maintain public sector support for agricultural biotechnology and conventional breeding with access to global gene pools so as to have suitable options for higher temperature regimes and changed moisture availability and possible more climate variability.
Model development and application
Develop livestock systems models that can translate climate/CO_2 information to economic outputs, to implications for enterprises, livelihoods, industries and regions for use in decisions from enterprise to policy scale.
Improve pest predictive tools and indicators.
Improve quantitative modelling of individual pests to identify most appropriate time to introduce controls.
Seasonal forecasting
Facilitate the adoption of seasonal climate forecasts (e.g. those based on El Niño and La Niña, sea-surface temperatures, etc.) to help farmers, industry and policy incrementally adapt to climate change whilst managing for climate variability. Maximise the usefulness of forecasts by combining them with on-ground measurements (i.e. soil moisture, standing forage), market information and systems modelling.
Pests, diseases and weeds
Maintain or improve quarantine capabilities, sentinel monitoring programs and commitment to identification and management of pests, diseases and weed threats. Improve the effectiveness of pest, disease and weed management practices through predictive tools such as quantitative models, integrated pest management, area-wide pest management, routine record keeping of climate and pest/disease/weed threat, and through development of resistant bloodlines and improved management practices.

…/continued

Table 36. continued

Details
Water
Increase water use efficiency by: i. a combination of policy settings that encourage development of effective water-trading systems that allow for climate variability and climate change and that support development of related information networks ii. improve water distribution systems to reduce leakage and evaporation iii. developing farmer expertise in water management tools and enhancing adoption of appropriate water-saving technologies. Land use change and diversification: Undertake risk assessments to evaluate needs and opportunities for changing species, management or land use/location in response to climate trends or climate projections. Support assessments of the benefits (and costs) of diversifying farm enterprises.
Natural resource base
Determine the impact of climate change (interacting with land management) on natural resource degradation issues such as erosion and salinisation risks and inform policymakers.

Diversification

The difficult financial situation faced by many in the northern pastoral industry is a driver to find other sources of income to future-proof pastoral businesses. So, many enterprises already derive income from off-farm work (Figure 11). On-farm diversification opportunities for northern pastoral operations include forage crops, crop production and ecosystem service delivery[37].

Forage crops

Small-scale production of irrigated pasture and pasture crops on the most fertile parts of the property to allow animals to be fattened on the property has been proposed as means of improving enterprise profitability[59,136]. It is thought that most properties in northern Australia have adequate water and soil resources to support such development. Modelling was undertaken of the economics of rearing cattle on native pasture then supplementing their diet with irrigated pasture crops in late spring and summer. Three test properties used for the modelling were three hypothetical properties in the Monsoonal North and adjoining Barkly Tablelands with typical stocking rates. The models were used to find the best outcome from different combinations of irrigated crops and stocking rates. The most profitable scenarios used irrigated tropical perennial grass or Lablab with between 18% more and 8% fewer stock that was typical for the area (Table 37). In comparison to cattle reared under no-irrigation scenarios, cattle finished on the irrigated pastures were shown to have faster growth rates and improved reproductive rates, thus allowing early weaning and an increased turn-off of superior quality animals. Increased growth rates also means that animals should be market-ready at a younger age, and thus can be sold in higher value markets (see Figure 16). Hence, the modelled scenarios increased

both beef production and profitability. It has been estimated that up to 120,000 ha of irrigation is possible across the north, with the potential to increase beef exports by $150-250 million annually[489].

Table 37. Details of the most profitable mosaic irrigation scenarios modelled for northern Australian beef cattle enterprises

Source: Grice, Watson and Stone (2013)[59]

		Kimberley Western Australia	North Queensland	Barkly Northern Territory
Property size	(km^2)	2,795	300	5,000
Irrigated area	(ha)	300	550	50
Pasture grown		Tropical perennial grass (e.g. Perennial Rye Grass)		Tropical legume (Lablab)
Return on investment	(%)	19	24	20
Total stock carried				
- baseline	(AE^1)	10,876	2,867	26,774
- with irrigation development	(AE^1)	12,378	2,647	31,502
Change	(AE^1)	+13.8	-7.7	+17.7

[1]AE = Animal equivalents, allows standardised adjustment of stocking rate based on feed requirements, as follows: Weaner up to 18 months: AE=0.5; Heifer, 18–30 months: AE=0.75; 2-year old steer: AE=0.8; 3-year old, non-breeding animal of 450 kg: AE=1; Breeder cow or 4-year old steer, AE=1.2; Bull: AE=1.5[490].

Production of forage crops on Indigenous-held pastoral land also has the potential to boost Indigenous employment and economic development. However, mosaic irrigation may also adversely affect Indigenous interests through physical damage to sacred sites; impact of groundwater extraction on significant springs or in-stream pools; and impact on fish resources[59,491]. On non-Indigenous pastoral leases, production of irrigated pasture crops for use on the property are likely to be viewed as within current lease conditions, and so not invoke Native Title conflicts[59].

Additional adverse environmental impacts potentially include soil disturbance; decline in plant species richness as a result of vegetation clearance; conditions conducive to weed spread; risk of pollution from fertiliser and pesticide over-application; changed hydrology; and salinisation. The authors consider that, as the operations are of a small scale (covering less than 0.1% of the northern pastoral area), adverse impacts should also be minimal and manageable[59]. However, the sites most suitable for mosaic irrigation—the most fertile and well-watered areas—are also likely to have the highest natural and cultural values[59]. Such areas are already the focus of grazing operations across the rangelands and so may be in an already degraded condition and in need of restoration[186]. Careful placement of irrigation developments, with reference to the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) and relevant state or territory legislation will, therefore, be required to minimise risks to endangered flora and fauna or sites of high cultural or biodiversity value.

What is not discussed in the report is how pastoralists using mosaic irrigation will change their management of grazing pressure on the non-irrigated parts of the property. Managed wisely, mosaic irrigation should allow stocking rates to be adjusted in line with land condition. However, by providing feed during the late dry season "protein drought"[59], pastoralists may be tempted to maintain herds at unsustainable densities through the wet season. This appears to be the intention of the *Water for Food* program in the Kimberley, which has identified mosaic irrigation as a means of producing dry season feed[317]. Also, while the pasture species used in the model have a low invasion risk, any use of more invasive species, such as Gamba Grass, would have serious implications for biodiversity. It is, therefore, important that pastoralists are provided with suitable advice and extension services to enable them to adopt sustainable irrigation practices[37]. Equally important will be continuing extension programs, such as the GLM courses, that explain maintenance of land condition and its link to profitability.

Fencing, water points and irrigation all require up-front capital investment [59]. Where a business case demonstrates suitable return on investment, mosaic irrigation is likely to attract investment, as it has been endorsed as a viable investment by ANZ economists (along with the dismissal of other forms of agricultural expansion as unprofitable)[489]. However, capital will be hard to raise for enterprises already having difficulty servicing their debts[78] or where security of land tenure is uncertain[349].

Other cropping

Another option for pastoral enterprises to improve their profitability may be a shift into broadscale agriculture. An assessment of the potential for irrigated agriculture across northern Australia concluded that small-scale irrigation enterprises are likely to be viable on most northern properties. However, it identified limited potential to expand extensive irrigated agriculture. The most suitable areas have access to reliable overland flow (such the Ord, Douglas-Daly, Mitchell, Lower Burdekin, Flinders and Gilbert catchments) or are fed by identified ground-water resources (Daly-Mataranka area of the Northern Territory)[19,59,492]. The viability of such schemes has been questioned[489], as more northern irrigation schemes have failed than have succeeded, although failures have been more the result of bad management than of difficult environmental conditions[5].

Irrigated agriculture may conflict with Indigenous interests, which are required to be addressed where Native Title coexists with pastoral operations[491,493]. Moreover, until recently, irrigated agriculture on pastoral leases was not permitted under land tenure conditions across the three jurisdictions unless it contributed to cattle production on the property. Hence, land tenure reforms to support

diversification have been made, or are underway, in all jurisdictions[349]. An amendment to the Northern Territory *Pastoral Land Act* in 2013 enables permission to be granted for non-pastoral uses, as long as Native Title considerations are addressed. However, tenure issues remain a barrier to diversification in Western Australia[a], and while the Queensland Government claims that permits for non-pastoral uses can be granted within Native Title constraints[494], no information on applying for such permits is available on any Queensland Government website.

Any venture into irrigated agriculture will involve substantial costs to pay for water and agricultural infrastructure, water access permits, skills training and high labour requirements[37,59], so will probably require financial backing. ANZ's assessment of broadscale irrigated agriculture as financially unviable may cause difficulties for those seeking venture capital to underwrite such projects[489].

Environmental service delivery

Environmental service delivery presents additional opportunities for northern pastoralists to diversify their businesses. The majority of pastoralists across the Monsoonal North are receptive to the idea of incorporating fee-for-service biodiversity conservation on their land[495]. Payments required to attract participation vary from $1–$32 per hectare per year depending on land productivity, and there is a preference for short-term contracts with flexible arrangements that allow for exceptional circumstances. A thorough assessment of ecosystem services opportunities in the Monsoonal North has identified improved herd and fire management as options with the greatest potential for earning income from GHG abatement on pastoral lands[373]. In priority areas, the cost of managing parts of the property for biodiversity may be subsidised in return for conservation management. However, the greatest financial returns for environmentally sensitive management will come from the improved profitability gained from adopting best practice herd and pastoral land management.

Pastoralists are concerned that entering into Savanna Burning GHG abatement fire management projects may not be compatible with beef production. These projects use strategic early dry season burning to reduce the spread of late dry season wildfires. Early dry season burning in the Victoria River District has been estimated to result in production losses of $85/km^2 annually because of the resultant woody thickening and pasture degradation[273,409]. Woody thickening may also have biodiversity implications[274,275,496,497]. However, using early dry season burning to create strategic fire breaks to reduce the costs of fighting wildfires can be profitable at a whole-of-enterprise scale[270]. Moreover,

[a] http://www.abc.net.au/news/6677232

Savanna Burning projects can be used to subsidise fire management in undeveloped sections of the property that have low grazing value, and thereby reduce fire risk across the whole property[498].

Natural resource management implications

Herd building

Asian economic growth is driving demand for beef from north Australia. All northern governments have a policy of increasing herd size across the region, and recent studies show that enterprise viability improves with herd size[78]. Property development for herd building proceeds apace in the Northern Territory and the Kimberley[28,30]. However, market analysis continually shows that cattle price is highly sensitive to supply and demand ratios, so to ensure industry profitability it is important that herds do not grow faster than demand. Price instability continued through 2015, with prices rising and falling in response to changing supply and demand. However, despite short-term fluctuations, oversupply appears unlikely in the near future, as the cattle herd is currently expected to take several years to recover to the peak numbers of 2013[49]. So herd-building is likely to continue whether or not it is specifically supported by governments.

Herd growth in recent years has been achieved through both expansion of area grazed and stocking rate, raising fears about the impact on environmental capital[78]. Overstocking of many parts of Australia was identified as an issue more than three decades ago[35,42,43], and since then stock numbers have almost doubled. Most research and extension programs stress the importance of using moderate stocking rates to protect land condition and long term production and profitability[171,280,403]. So it is important for the industry that herd building is not done through increasing stocking rates beyond sustainable carrying capacity. It is also important for biodiversity, as most biodiversity measures improve with improving land condition and deteriorate with increasing grazing pressure[249,397].

Herd building is also being achieved by grazing previously underutilised sections of the northern landscape. These areas are important as refuges for rare species[231] and even non-threatened species decline in abundance around water points because of grazing impacts[250]. Grazing management guidelines, therefore, recommend that 10% of key land types on any property are excluded from grazing, along with 5% of more resilient landscapes[171,499,500]. Development of underutilised areas both through the development of waters on individual properties and the expansion of cattle operations

across undeveloped lands therefore risks the loss of important biodiverse areas as well as a general decline in biodiversity condition across the northern landscape.

Some areas are more robust to grazing than others. Grazing trials at Pigeon Hole, in the Victoria River District, showed biodiversity was relatively insensitive to different levels of grazing up to 20% utilisation rates[501]. Work at Mornington, in the Kimberley, showed significant species recovery when grazing was excluded[502]. However, biodiversity failed to recover in response to withdrawal of grazing pressure in the Queensland Gulf region[503].

Undoubtedly, grazing pressure will increase across northern Australia, whether it is by increased stock numbers or expansion of area grazed. It is, therefore, important that areas with high biodiversity values are identified and managed appropriately and that impacts of any increases in grazing pressure on grazing land condition and biodiversity are properly assessed. Development of Beetaloo Station on the Barkly Tableland, Northern Territory, aims to combine intensifying production with enhancing biodiversity values, and has instituted a monitoring program to test the success of their efforts[504]. Their results should be instructive for other property developers.

Performance improvement

Increasing stocking rates and herd size is not the only means of increasing production and enterprise profitability. Good herd management—retaining only cattle that are contributing to reproduction and keeping animals healthy to improve pregnancy rates and liveweight gain—results in significant increases in meat production at the same or reduced stocking rates (see Herd performance and market access). Moreover, the healthier, faster growing animals produced can be sold more profitably at the high end of the market (Figure 16). When combined with moderate stocking rates that are adjusted for climatic variation, which also improves liveweight gain and profitability[280,403,405], improving herd performance could, therefore, be one of the most significant contributions to biodiversity health.

Mosaic agriculture and irrigated cropping

Capacity to finish cattle on-property also improves market access and prices that can be achieved. So mosaic irrigation of pasture crops is another development that can increase meat production without substantial increases in stocking rates (see Diversification). Where such developments occur on land that is already developed, the impact on regional scale biodiversity values are likely to be minimal,

particularly as these developments are likely to cover less than 0.1% of the region[59]. However, the areas of fertile alluvial soils along drainage lines with a good supply of surface or groundwater that are most suitable for irrigated crops are also likely to have high biodiversity values[7,505,506]. And even a local lowering of groundwater could adversely affect biodiversity that remains in these areas[177,507]. Hence, "the impact of grazing is often disproportionately higher on the more fertile, alluvial parts of the landscape, riparian zones beside watercourses, and on important refugial habitats"[506]. These are the very areas that are most likely to be developed for mosaic irrigation. Again, while mosaic irrigation is a good thing for enterprise viability, it needs to be progressed in sympathy with biodiversity values.

Extending diversification to include other irrigated crops raises even greater biodiversity concerns. The land clearing and water extraction needed to support viable agricultural enterprises is at least an order of magnitude greater than that required for production of pasture crops. In addition, water impoundments may exclude bottom-dwelling species, such as the Vulnerable Freshwater Sawfish (*Pristis microdon*) and Freshwater Whipray (*Himantura dalyensis*) from critical habitat.

Environmental services

Many pastoral companies have entered into conservation agreements, particularly in the Northern Territory (see Environmental service delivery). While these are useful for assisting parts of pastoral properties to be managed for conservation, they do not provide a regular income stream. Currently Savanna Burning is the only payment of environmental services system that is providing ongoing income on pastoral properties. This is despite both conceptual models being developed and willingness of pastoralist to participate being demonstrated. Offset programs hold the most promise as governance arrangements are already in place.

The rapid uptake of Savanna Burning Carbon Farming by pastoralists across northern Australia demonstrates the willingness of pastoralists to diversify into areas that do not impinge on pastoral production. Along with carbon abatement, reduction of late dry season fires provides many indisputable biodiversity benefits[508-511]. However, caution should be exercised where biodiversity has evolved under a diversity of fire regimes[512,513]. Moreover, repeated early dry season burning may degrade pasture condition and result in woody thickening, particularly when combined with grazing[273]. So, as with all changes in management, a thorough assessment of the values and consequences should be undertaken before entering into a Savanna Burning program and the outcomes for biodiversity and grazing land condition should be assessed.

Enterprise viability and uptake of sustainable practices

While the outlook for the northern beef industry is positive, and further growth is projected, many enterprises are under pressures threatening their viability. Live export has periodically improved income on many northern pastoral properties, particularly in the Northern Territory and the Kimberley. However, market volatility, especially the live export ban in 2001, pushed many enterprises further into debt (see Profitability). Market volatility has flow on effects for land condition, with between one-third and one-half of pastoralists affected by the live export ban believing that their inability to sell stock had caused land degradation[46,88]. Elevated stocking rates continued for some time after the ban was lifted, as there was no market for cattle that were now too heavy to be exported to Indonesia[46].

Historical assessment of northern herd dynamics indicates that managing resource condition is challenging in a volatile market, even without closure of the dominant live export market. Increases in demand and price stimulate herd building, but decreases in price make it unprofitable to destock, as the resultant oversupply keeps prices low for an extended period[41]. This has led to continual increases in cattle numbers along with grazing pressure on the land.

Practices to improve viability and resource condition mostly go hand in hand, but the many publications reviewed for this report indicate that many enterprises are so stretched that they have neither the human, nor the financial capacity to make the changes required. Not only are staff numbers low on most properties, but many owners/managers are undertaking off-farm work just to survive. Added pressures of projected climate change, such as having to recover from category five cyclones on a regular basis, will create extra difficulties for programs to improve practices or resource condition.

It is widely believed that landholders are more likely to adopt sustainable practices if these are perceived to improve profitability[514]. However, this was not found to be the case among pastoralists in the Burdekin Dry Tropics[515], even though financial, climate and policy impediments rated as the highest disincentives to adopting best practice management. What does seem to be clear is that pastoralists are most likely to overstock when they are under severe financial pressure. Therefore, finding pathways to guide struggling enterprises back into the black should be a high priority for any program promoting sustainable natural resource management.

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