



ASSETS AND PRESSURES OF THE NORTHERN TERRITORY

Supplementary guide to the
2016-2020 NT NRM Plan



VISION

“Territorians working together to manage our environment’s natural, cultural and economic values for the benefit of all.”

FOR MORE INFORMATION

This publication is available on request through contacting info@territorynrm.org.au

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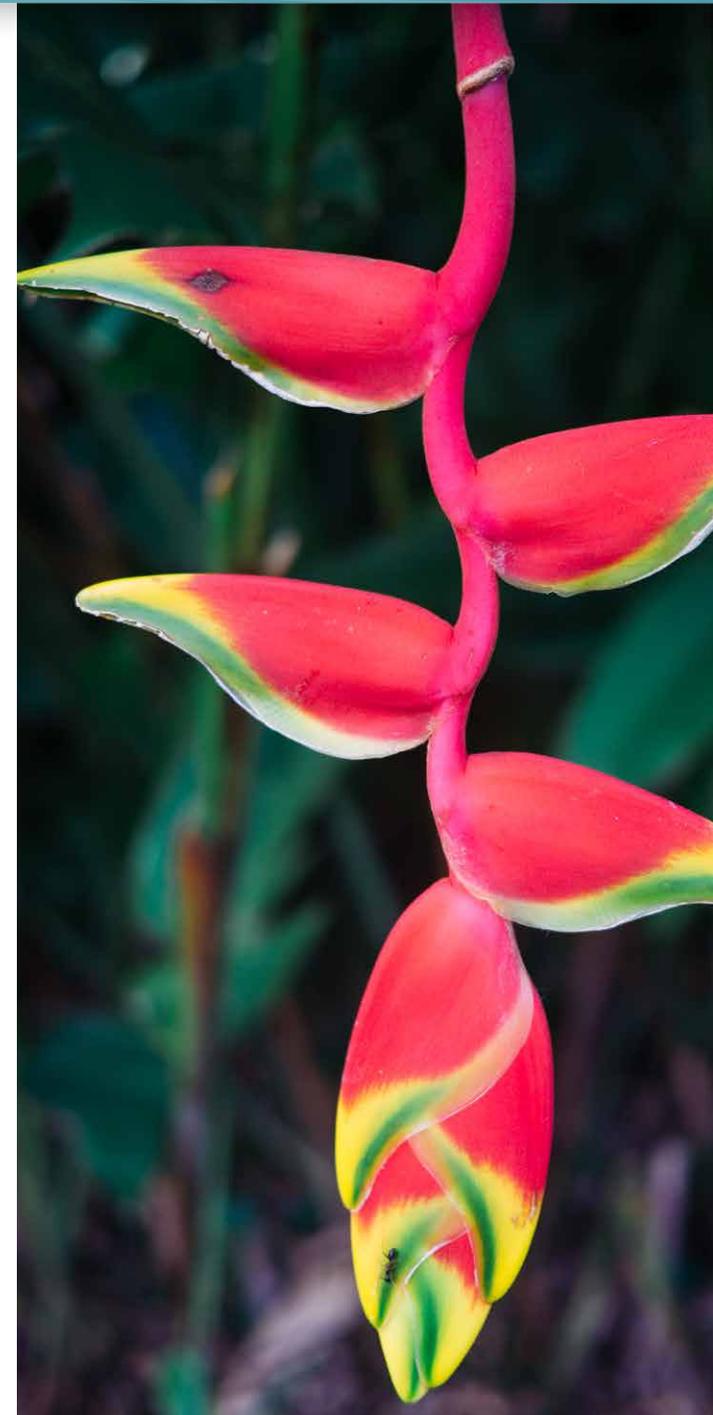
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Australian Government

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INTRODUCTION

This document, 'Natural Resource Assets and Pressures of the Northern Territory' is a supporting document to the 2016-2020 Northern Territory NRM Plan. During the planning process, there were three main classes of attributes to be protected, maintained and enhanced, including natural, cultural and social assets. These became the goals in the NRM Plan. Attributes were grouped into nine asset categories. These classifications help to link the content across all the regional plans and provide a common language in ongoing review processes.

The pressures or uses of these assets have also been given common classifications across all four regional plans in the NT. The pressures and uses on the assets were identified through the planning process and formed the basis of the Objectives in the NRM Plan. The strategies and activities were then developed to minimise this pressure and ultimately lead to the NRM Plan Goals related to the improvement of asset condition. The current asset condition and trend are not scientific assessments but based on NRM Planning workshops which helped to establish priority strategies and actions in the Plan.

This document provides further information to this information that underpins the development of the 2016-2020 NRM Plan. It is intended to be a short summary of the NT's natural resource assets and pressures to reflect the NRM planning process and as a reference for planning review processes. It will be utilised for further NRM Plan review processes and to support decisions on NRM projects in the NT.



KEY ASSETS AND PRESSURES/USES

ASSETS



Coastal and Marine

Includes mangroves, estuaries, coastal floodplains, intertidal areas, seagrass and coral reef habitat



Freshwater Systems

Includes tropical rivers, wetlands, lakes, swamps, aquifers and aquatic refugia



Healthy Soils

Includes soil fertility, structure, health and productivity



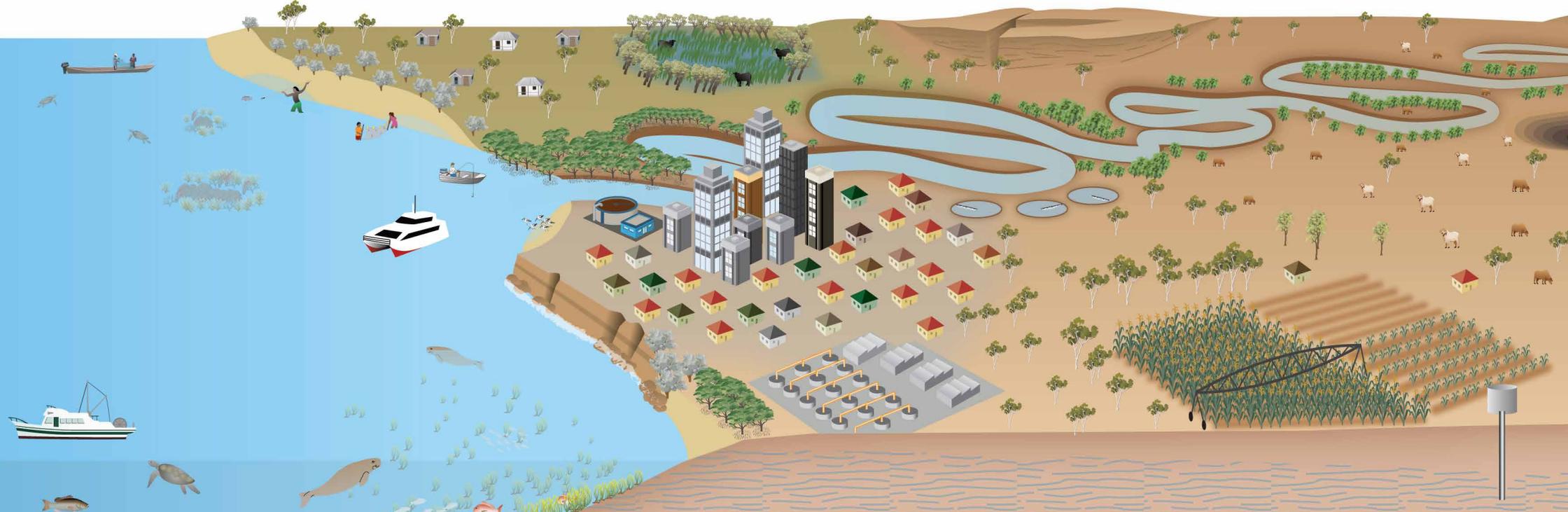
Community Knowledge

Includes Indigenous and non-Indigenous knowledge and skills and scientific knowledge



People on Country

Includes remote livelihoods of Aboriginal people, pastoralists and others living throughout the region



PRESSURES/USES



Pollution

Mining effluent, urban waste water, agriculture (nutrients), garbage and solid waste, atmospheric pollution, and toxic and hazardous substances



Climate Change and Severe Weather

Drought, cyclones/storms, flooding, temperature extremes and long-term climatic changes causing habitat shifting and alteration



Harvesting of Natural Resources

Includes non-sustainable fishing and harvesting of aquatic resources, inappropriate hunting, collecting plants and harvesting timber



Residential and Commercial Development

Urban areas, suburbs, towns, commercial and industrial areas, tourism and recreation sites



Primary Industries

Includes effects of inappropriate pastoralism, horticulture, agriculture, forestry and freshwater and marine aquaculture, and their expansion and intensification when non-sustainable

KEY ASSETS AND PRESSURES/USES



Ranges

For example, West MacDonnell Ranges, West Arnhem Plateau, Davenport and Murchison Ranges



Grasslands/Rangelands

Includes tropical savanna grasslands, tussock grasses, spinifex grasslands and introduced pasture grasses



Important Sites

Includes Aboriginal sacred sites, heritage places, Sites of Conservation Significance and iconic sites



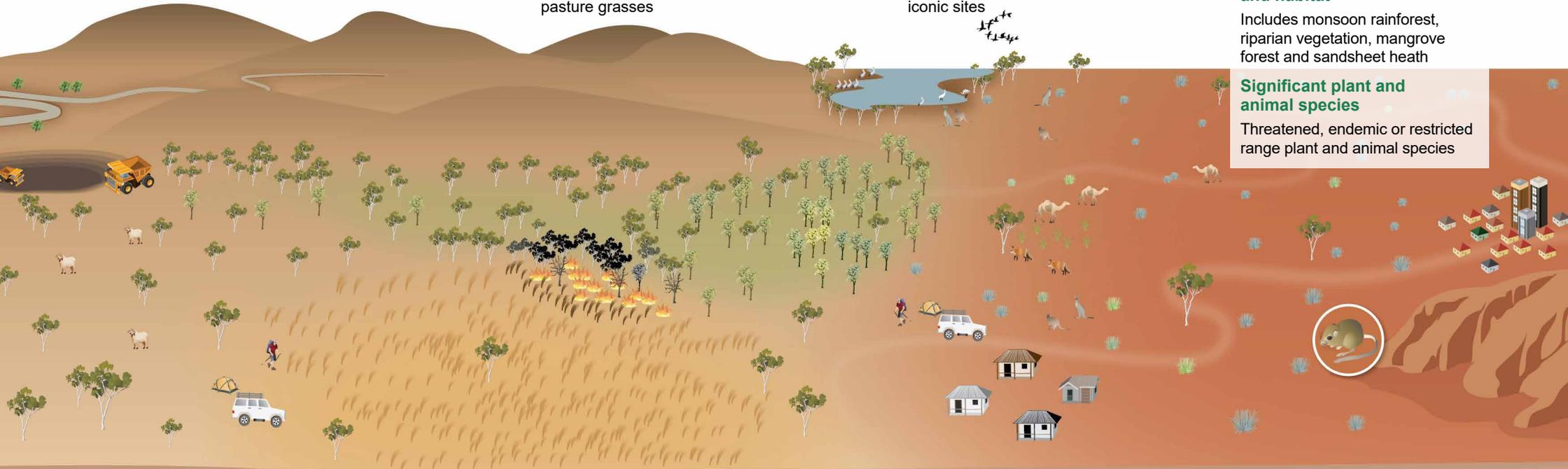
Biodiversity and Conservation Sites

Key ecosystems, landscapes and habitat

Includes monsoon rainforest, riparian vegetation, mangrove forest and sandsheet heath

Significant plant and animal species

Threatened, endemic or restricted range plant and animal species



Mining and Energy Production

Includes impacts of oil and gas drilling, mining exploration, quarries, seabed mining, energy production infrastructure, legacy mines and mining operations



Inappropriate Fire

Inappropriate fire management, suppression of or increase in fire frequency



Recreation and Other Activities

Impacts of people in natural environments, including four-wheel driving, camping and other recreation. Includes military training activities



Feral Animals

Includes introduced pest animals such as pigs, Cane Toads, cats, buffaloes, camels, etc



Invasive Plants

Includes weeds and introduced genetic material. Can include over abundant native species



Loss of Knowledge and access

Impacts relating to Aboriginal people not being able to access traditional lands (due to lack of resources and support) as well as loss of technical knowledge in NRM



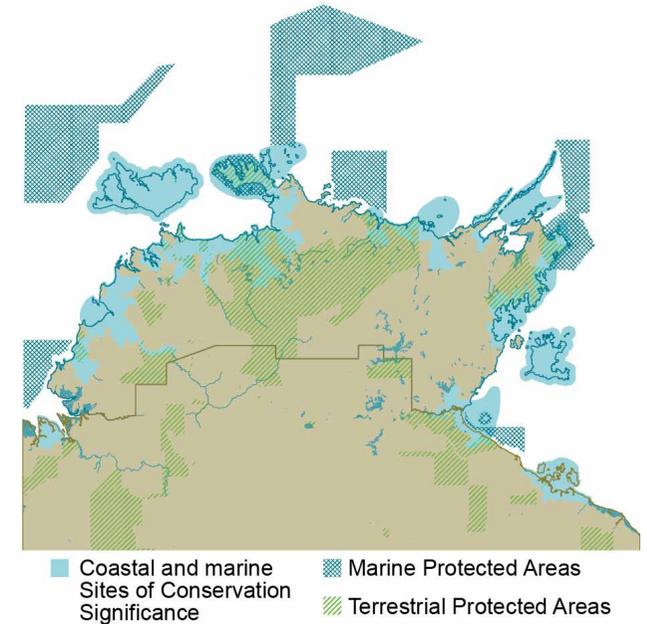
COASTAL AND MARINE

DESCRIPTION

Northern Territory coastal and marine areas have high cultural, environmental and commercial value, and offer protection to some of the world's most threatened marine creatures¹. Over 50% of the mainland coastline and most of the 887 islands have recognised international conservation values².

Offshore, seagrass beds support marine turtles, dolphins, dugongs and Grey Nurse Sharks. Reefs abound with marine fish, seahorses and sea snakes. Along the coast, sandy beaches provide important habitat for nesting seabirds and six species of marine turtles. Mudflats support millions of migratory waders, and coastal floodplains and wetlands for large congregations of waterbirds, notably Magpie Geese. Estuarine systems are home to Saltwater Crocodiles, three species of threatened sawfish and two species of threatened river sharks. Northern Territory islands are home to several plants that are found nowhere else, and provide predator-free environments for threatened mammals.

The Northern Territory's coastal and marine areas provide livelihoods for Traditional Owners and commercial fishing operations and are popular for recreational boating and fishing. About 80% of the Northern Territory's coastline is under Indigenous ownership. The sea country of Traditional Owners extends from Northern Territory waters to Commonwealth waters - well beyond the three-mile limit³. This latter area is covered by the North Marine Planning Region.



Coastal and marine Sites of Conservation significance and Protected Areas in the NT.



1 Edyvane, K. S. (2010). Update of Asset Descriptions: Coastal and Marine. Charles Darwin University and Northern Territory Department of Natural Resources, Environment & the Arts. Report to Northern Territory Natural Resource Management Board., Darwin.

2 Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M., and Lynch, B. (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Darwin, NT.

3 Armstrong, R. (2008). Northern Territory's islands are home to several plants that are found nowhere else, and provide predator-free environments for threatened mammals. North Australian Indigenous Land and Sea Management Alliance on behalf of the Indigenous Water Policy Group.



PRESSURES/USES

Coastal and marine environments face a unique range of pressures and threats. They are particularly vulnerable to pollution and overharvesting, and are exposed to the ravages of storms and cyclones. However, coastal environments are also affected by typical land-based issues, including fire, weeds and feral animals.

Fishing and access rights

Rights to grant entry and fish in Northern Territory coastal and marine waters has been contested between Traditional Owners and the Northern Territory Government. High court decisions have confirmed Native Title rights apply equally to land and sea country. However, they have also ratified the application of the NT Fisheries Act over all Northern Territory waters. The Northern Territory Government is in the process of negotiating access to Indigenous-held waters in return for funding for marine rangers and strengthening their powers, developing a fishing code of conduct and establishing an Aboriginal Regional Fisheries Committee⁴.



4 <http://www.fishing.nt.gov.au/>

Commercial fisheries and aquaculture

Commercial fishing is an important contributor to the Northern Territory's economy. Eleven fisheries operate in Northern Territory waters. Barramundi, mud crabs, pearly oysters and prawns are also grown in aquaculture. Fisheries are dependent on good water quality and flow. When managed badly, fishing can adversely affect marine biodiversity and aquaculture can cause water quality problems. Impacts of poor fishing practices include habitat destruction and bycatch of non-target species (e.g. marine turtles, dugongs, sawfish, sharks). Fishing codes of practice are in place in the Northern Territory to minimise these impacts⁵. Illegal fishing has also been an issue, with a 2% apprehension rate of the 13,000 illegal vessels estimated to be fishing in Northern Territory waters in 2005. Since then Indigenous rangers and the Northern Territory police have increased efforts to detect and deter illegal fishing⁶.

Tourism and recreation

Coastal areas often attract tourists and recreational fishers. Illegal fishing and crabbing can have an adverse impact at highly frequented sites, which may also be polluted by litter and waste. Off road use of vehicles can cause erosion. Close to Darwin, unrestricted vehicle access to nesting beaches is a problem, and disrupts the breeding of seabirds and marine turtles. Weeds can also be spread by boats, vehicles and trailers, so these should be cleaned thoroughly when entering a new area⁷. The

5 <http://www.ntsc.com.au/media-centre/publications>

6 http://www.nt.gov.au/d/Fisheries/news_media_archive_article.cfm?newsid=32&ws=1; <http://www.abc.net.au/news/5904070>

7 www.environment.gov.au/biodiversity/invasive/weeds/help/outdoors.html

Amateur Fishermen's Association of the Northern Territory has developed a recreational fishing code of practice for Mary River and Chambers Bay that includes habitat protection and sustainable fishing practices⁸.

Water extraction, pollution from sewerage and weed invasions associated with tourism infrastructure can also adversely affect nearby environments. These threats are best addressed through management planning for frequently visited areas.

Indigenous harvest, hunting and husbandry

Hunting and harvesting of native wildlife make a significant contribution to the economy of Indigenous Australians, particularly in coastal areas. Turtle, dugong and seabird eggs are part of this diet⁹. Indigenous people have been at the forefront of efforts to ensure these activities are sustainable¹⁰. Collection of crocodile eggs is also managed sustainably under a management plan, and there are hopes to extend this to safari hunting¹¹.

8 <http://afant.com.au/media-release-maryriver-chambersbay-and-finkebay-angler-code-of-conduct/>

9 Peterson, N., and Rigsby, B. (Eds) (2014) 'Customary Marine Tenure in Australia.' (Sydney University Press).

10 NAILSMA (2005) Dugong and Marine Turtle Knowledge Handbook. North Australian Indigenous Land and Sea Management Alliance & Tropical Savannas Cooperative Research Centre, Darwin.

11 DLRM (2014) Management Program for the Saltwater Crocodile in the Northern Territory of Australia, 2014-2015. Department of Land Resource Management, Darwin.



Marine debris

Marine debris is mostly composed of fishing nets and plastic bags, but can also include wood, metal, glass and footwear. This pollution strangles, chokes, disables or drowns seabirds, turtles and other marine creatures, and can lead to their starvation and death¹². Huge volumes of lost and discarded fishing nets, or ghost nets, end up in the Gulf of Carpentaria each year. Under the guise of GhostNets Australia, Indigenous ranger groups are employed in removing these nets from the ocean¹³. Efforts are also being made to reduce their disposal through education of the foreign fishing industry.

Other marine pollution

Pollution from mining, shipping and boating can threaten the Northern Territory's marine and coastal environments if these activities are not well managed and regulated. Escaping oil can form extensive slicks that smother and poison seabirds, dolphins, dugongs and other marine creatures, causing them to starve or drown. Such occurrences have been rare to date, and plans are in place to minimise them and respond when they unfortunately occur.

12 Wilcox, C., Hardesty, B.D. Sharples, R. Griffin, D.A. Lawson, T.J. and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia. *Conservation Letters* 6, 247-254.

13 Gunn, R., Hardesty, B.D. and Butler, J. (2010) Tackling 'ghost nets': Local solutions to a global issue in northern Australia. *Ecological Management & Restoration*, 11, 88-98.

Biosecurity

Proximity to Asia exposes the Northern Territory coastline to numerous pest species, diseases and pathogens that are not yet established in Australia¹⁴. Under the North Australian Quarantine Strategy, the Australian Quarantine and Inspection service engages Indigenous ranger groups in biosecurity surveillance and management to address these threats.

Pest animals

Exotic species are as much a problem in marine environments as they are on land. These are most likely to be introduced on the hulls of boats or in bilge water. Marine pests that have entered Northern Territory waters include the Black-striped Mussel. Early detection and response ensured that this animal did not become established, but continued vigilance is necessary. Tilapia also have the potential to adversely affect coastal systems should they become established in the Northern Territory.

Many coastal wetlands are affected by high densities of feral herbivore, especially water buffalo and pigs, which graze out native plants and disturb the sediment by trampling and pugging the soil. They can also prevent the regeneration of rainforests, and cause erosion, leading to saltwater intrusion¹⁵. As in other parts of the Territory, cats, rats and Cane Toads pose a threat to small animals in coastal environments. Pig predation of seabird and turtle nests is also an issue. Some islands are free of introduced pests, and are therefore important refuges for native mammals. Most species can be excluded through

14 www.agriculture.gov.au/biosecurity/australia/naqs

15 Armstrong, M., Woinarski, J., Hempel, C., Connors, G., & Beggs, K. (2002). A Plan for the Conservation of Biodiversity in the Mary River Catchment, Northern Territory. Parks and Wildlife Commission.

effective port quarantine, but this is a challenge for the hundreds of small islands with no formal port facilities. Some species can drift or swim to islands close to shore, as happened when Cane Toads washed down the McArthur River reached the Sir Edward Pellew islands.

Indigenous ranger groups are actively engaged in feral animal management in coastal areas, and have been successful in eradicating Big-Headed Ants from the Daly River catchment¹⁶. Control of feral animals needs to be integrated with other land management activities to prevent a reduction in grazing pressure being followed by uncontrolled fire or by weed invasion, as has occurred on the Adelaide River floodplain.

Weeds

Most coastal and marine environments have a low level of weeds. However, transformer weeds, including Para Grass, Olive Hymenachne and Prickly Mimosa have taken over in a number of locations. The pasture plants: Gamba Grass, Mission Grass and Guinea Grass, have spread rapidly across parts of the Darwin area and on the Tiwi Islands. These vigorous grasses transform habitats and increase fire intensity, severely degrading wetland habitat. *Salvinia* has also established at numerous locations. Management of these weeds is ongoing and requires collaboration between neighbouring landholders, and sustained financial support.

16 Hoffmann, B. (2000). Changes in ant species composition and community organisation along grazing gradients in semi-arid rangelands of the Northern Territory. *The Rangeland Journal* 22, 171-189.



Fire

Appropriate fire regimes are important for maintaining the condition of coastal wetlands and forest communities^{17,18}. Loss of fire management knowledge and practice has been identified as a threat to some significant sites. Problems include build up of fuel as a result of areas remaining unburnt for long periods¹⁹, and fires away rainforest patches. Employment of Indigenous rangers is helping to address this issue.

Water storage and extraction

Coastal environmental systems and commercial fishing depend on regular river flows and good water quality²⁰. This has been well-documented in the Northern Territory for Magpie Geese nesting and catches of Barramundi and prawns. Proposals to capture freshwater discharge from northern rivers therefore has the potential to degrade environments and reduce production. Water is also essential to maintain the cultural value of wetlands and to enable Indigenous people to undertake commercial development of their lands²¹.

- 17 Lucas, K., and Lucas, D. (1993). Aboriginal Fire Management of the Woolwonga Wetlands in Kakadu National Park. Jabiru, Northern Territory.
- 18 Russell-Smith, J., and Bowman, D.M.J.S. (1992). Conservation of monsoon rainforest isolates in the Northern Territory, Australia. *Biological Conservation* 59, 51-63.
- 19 Woinarski, J.C.Z., Brennan, K.G., Cowie, I., Fisher, A., Latz, P.K., and Russell-Smith, J. (2000). Vegetation of the Wessel and English Company Islands, North-eastern Arnhem Land, Northern Territory, Australia. *Australian Journal of Botany* 48, 115-141.
- 20 Warfe, D. M., Pettit, N. E., Davies, P. M., Pusey, B. J., Hamilton, S. K., Kennard, M. J., Townsend, S. A., Bayliss, P., Ward, D. P., Douglas, M. M., Burford, M. A., Finn, M., Bunn, S. E., and Halliday, I. A. (2011). The 'wet-dry' in the wet-dry tropics drives river ecosystem structure and processes in northern Australia. *Freshwater Biology* 56, 2169-2195.
- 21 Jackson, S., and Altman, J. (2009). Indigenous rights and water policy: perspectives from tropical northern Australia. *Australian Indigenous Law Review* 13, 27-48.

There is great pressure to increase the extraction of water for agricultural production. Water extraction impairs a number of ecological functions, affecting habitat condition and connectivity, flowing on to loss of biodiversity and biological productivity²². A reduction of water table levels is affecting springs and monsoon forests and threatened species habitat in the Darwin rural area. So water planning needs to ensure adequate supplies are allocated to environmental and cultural values and to maintain a commercially-viable fishing industry²³. This is particularly relevant downstream from the Daly and Ord River development areas.

Primary industries

Some coastal areas are under grazing lease, so grazing practices have the capacity to affect their cultural and environmental values. Wet season grazing of the floodplains can carve heavy tracks in the soil and lead to erosion, therefore exclusion of cattle through this period may be required. Even grazing higher up the catchment has the potential to affect the quality of water reaching coastal and marine environments. Maintenance of ground cover, particularly perennial grasses²⁴, will help prevent soil loss from paddocks, and retention of deep-rooted

- 22 Alison, J.K., Simon, A.T., Douglas, M.M., and Kennard, M.J. (2015) Implications of water extraction on the low-flow hydrology and ecology of tropical savannah rivers: an appraisal for northern Australia. *Freshwater Science*. 34, 741-758.
- 23 Northern Australian Land and Water Taskforce (2009). Sustainable development of northern Australia: A report to Government from the Northern Australia Land and Water Taskforce.
- 24 Bartley, R., Corfield, J.P., Hawdon, A.A., Kinsey-Henderson, A.E., Abbott, B.N., Wilkinson, S.N. and Keen, R.J. (2014) Can changes to pasture management reduce runoff and sediment loss to the Great Barrier Reef? The results of a 10-year study in the Burdekin catchment, Australia. *The Rangeland Journal*, 36, 67-84.

native vegetation on slopes and along streams will help to prevent gully erosion and loss of in-channel sediment²⁵.

Residential and commercial development

Urban and industrial development place pressure on coastal areas, first through clearance of native vegetation and changes made to drainage; and then through the associated water use, and disposal of waste water and sewerage^{26,27}. Weeds are also inevitably introduced and spread from urban centres into nearby bushland. Wild cats, dogs and rats are all also most abundant near urban centres, where they compete for resources and act as predators and vectors of disease²⁸. Several significant coastal sites near Darwin are suffering from these impacts.

Forestry

Forestry has degraded coastal values on Melville Island, with clearance of vegetation and disturbance caused by roads. Weed spread has been promoted and there is concern that timber species may establish in nearby

- 25 Brooks, A.P., Spencer, J., Olley, J., Pietsch, T., Iwashita, F., Borombovits, D. and Curwen, G. (2015) The importance of managing riparian zones for saving the Great Barrier Reef. Pp. 399-404. in *Proceedings of the 7th Australian Stream Management Conference*, Townsville. Editors. G. Vietz, I.D. Rutherford, and R. Hughes.
- 26 Welch, M., Schult, J., Padovan, A., and Territory, N. (2008) Effects of urban stormwater on heavy metal and nutrient concentrations in mangrove sediments of Darwin Harbour. Department of Natural Resources, Environment and the Arts.
- 27 Skinner, L., Townsend, S.A., Fortune, J., and Territory, N. (2009) The impact of urban land-use on total pollutant loads entering Darwin Harbour. Department Natural Resources, Environment, the Arts and Sport.
- 28 Banks, P.B., and Smith, H.M. (2015) The ecological impacts of commensal species: black rats, *Rattus rattus*, at the urban-bushland interface. *Wildlife Research*. 42, 86-97.



bushland²⁹. On the positive side, timber plantations in the Daly region do not appear to have affected regional water tables³⁰.

Mining and energy production

Mining and energy production bring many risks to marine and coastal environments, and these need to be well managed. Immediate impacts include vegetation clearance and, in some cases, drainage diversions to enable resources to be accessed. Clearance is particularly problematic for Darwin sandplains, where the sand resource extracted provides habitat for a unique vegetation community containing several threatened species. Additional impacts include noise pollution (which particularly affects marine mammals), oil and heavy metal pollution and degradation of water quality from onshore developments. Pollution from mining and refining operations can also elevate the presence of heavy metals and other toxins in coastal and marine environments^{31,32}. There is considerable community concern over pollution from the McArthur River mine³³, which has been threatened with closure because of iron sulphide

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- 29 Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M., and Lynch, B. (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Darwin, NT.
- 30 Hutley, L.B., Lancaster, I., Reilly, D., O'Grady, A.P., Almedia, A., Kraatz, M., Smith, S., Bristow, M., Sawyer, B., and Foo, D.Y. (2012) Quantifying interception associated with large-scale plantation forestry in the Northern Territory. Report to the National Water Commission.
- 31 Morrison, R.J., and Delaney, J.R. (1996) Marine pollution in the Arafura and Timor Seas. *Marine Pollution Bulletin* 32, 327-334.
- 32 Neave, M.J., Glasby, C.J., McGuinness, K.A., Parry, D.L., Stretten-Joyce, C., and Gibb, K.S. (2013) The diversity and abundance of polychaetes (Annelida) are altered in sediments impacted by alumina refinery discharge in the Northern Territory, Australia. *Marine Environmental Research* 92, 253-263.
- 33 www.abc.net.au/news/6747170

pollution³⁴. Regulations and codes of practice need to be closely followed and enforced to minimise their impacts.

Management capacity

Management of coastal and marine environments is difficult and costly. Several Indigenous ranger groups are involved in activities as diverse as land management, biosecurity surveillance, patrolling marine fisheries, and biodiversity monitoring and management. Although some activities are paid on a fee-for-service basis, funding for these groups is usually on a grant-by-grant basis, and so subject to changing government policies and programs. Security of funding is required to maintain the environmental services Indigenous ranger groups provide.

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- 34 www.abc.net.au/news/6724890

Not all environmental management to protect coastal and marine environments is on-site. Upstream management is just as important. Pastoral land holders may need assistance to adopt best practice management to prevent sediment loss into coastal wetland marine environments. Communicating the impacts of sediment loss to those building roads and other infrastructure may also assist in adoption of practices to minimise erosion³⁵.

Climate change and severe weather

The Northern Territory coasts have been severely battered by a number of serious cyclones in recent decades^{36,37}. These have eroded shorelines, destroyed vegetation and wiped out wildlife populations³⁸. Systems may recover, but this can take years, even for mobile species such as birds³⁹, and recovery may be impeded if cyclone damage is burnt. Intensity of cyclones is expected to increase under projected climate change⁴⁰. Sea-level rise is also going to affect coastal environments, with

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- 35 Shellberg, J., and Brooks, A. (2013). Alluvial gully prevention and rehabilitation options for reducing sediment loads in the Normanby catchment and northern Australia. Australian Rivers Institute, Griffith University.
- 36 Woodroffe, C.D., and Grime, D. (1999). Storm impact and evolution of a mangrove-fringed chenier plain, Shoal Bay, Darwin, Australia. *Marine Geology* 159, 303-321.
- 37 Cook, G.D., and Goyens, C.M.A.C. (2008). The impact of wind on trees in Australian tropical savannas: lessons from Cyclone Monica. *Austral Ecology* 33, 462-470.
- 38 Bowman, D. M. J. S., and Panton, W. J. (1994). Fire and cyclone damage to woody vegetation on the north coast of the Northern Territory, Australia. *Australian Geographer* 25, 32-35.
- 39 Palmer, C., Brennan, K., and Morrison, S. (2007). Short-term effects of a Category 5 cyclone on terrestrial bird populations on Marchinbar Island, Northern Territory. *Northern Territory Naturalist* 19, 15-24.
- 40 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L., and Risbey, J. (2015). *Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*. CSIRO and Bureau of Meteorology, Australia.



loss of freshwater habitats and associated species⁴¹.

Australia is expected to lose most of its mangrove forests and many of its turtle nesting beaches^{42, 43}. Increase in ocean temperature and acidification will also severely degrade marine ecosystems through coral bleaching and loss of calcium⁴⁴. These environmental impacts are also expected to have serious economic impacts⁴⁵. While little can be done to avert these changes in the short term, best practice natural resource management will help to minimise their impacts⁴⁶.

Knowledge gaps

Coastal and marine systems are complex and expensive and difficult to study. There are still many knowledge gaps, such as the drivers of, and threats to, marine biodiversity; the distribution of many threatened species (e.g. sawfish and river sharks), and where climate change impacts will be greatest⁴⁷. Indigenous ecological knowledge has much to offer to improve our understanding of environmental management needs⁴⁸, but there is still the need for targeted scientific research. Monitoring is also required to determine whether management efforts are being effective. These are tasks that are increasingly being undertaken by Indigenous ranger groups.

Indicators

- Number of coastal and marine Sites of Conservation Significance being managed for conservation values
- Number of Indigenous ranger groups actively managing these sites
- Number of active management plans covering sustainable use of coastal and marine resources
- Turtle and dugong numbers
- Seabird, shorebird and waterbird numbers
- Number of water allocation plans with adequate provision for environmental and Indigenous cultural and commercial needs
- Number of active fishing and industry codes of practice in which coastal and marine values are addressed
- Pattern of fire seasonality and extent in coastal areas

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- 41 Traill, L.W., Perhans, K., Lovelock, C.E., Prohaska, A., McFallan, S., Rhodes, J.R., and Wilson, K.A. (2011) Managing for change: wetland transitions under sea-level rise and outcomes for threatened species. *Diversity and Distributions*, 17, 1225-1233.
- 42 Lovelock, C.E., Cahoon, D.R., Friess, D.A., Guntenspergen, G.R., Krauss, K.W., Reef, R., Rogers, K., Saunders, M.L., Sidik, F., Swales, A., Saintilan, N., Thuyen, L.X., and Triet, T. (2015) The vulnerability of Indo-Pacific mangrove forests to sea-level rise. *Nature*. 526, 559-563.
- 43 Pike, D.A., Roznik, E.A., and Bell, I. (2015) Nest inundation from sea-level rise threatens sea turtle population viability. *Royal Society Open Science*. 2, 7.
- 44 Kwiatkowski, L., Cox, P., Halloran, P.R., Mumby, P.J., and Wiltshire, A.J. (2015) Coral bleaching under unconventional scenarios of climate warming and ocean acidification. *Nature Climate Change*. 5, 777-781.
- 45 Chen, P.-Y., Chen, C.-C., Chu, L., and McCarl, B. (2015) Evaluating the economic damage of climate change on global coral reefs. *Global Environmental Change*. 30, 12-20.
- 46 Abramovitz, J., Girot, P. O., Orlando, B., Schneider, N., and Spanger-Siegfried, E. (2002). Adapting to climate change: Natural resource management and vulnerability reduction. Background Paper to the Task Force on Climate Change, Adaptation and Vulnerable Communities. World Conservation Union.

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- 47 SEWPaC (2012) Marine Bioregional Plan - North Marine Region. Department of Sustainability, Environment, Water, Population and Communities, Public Affairs, Canberra.
- 48 Hill, R., Grant, C., George, M., Robinson, C.J., Jackson, S., and Abel, N. (2012) A typology of indigenous engagement in Australian environmental management: implications for knowledge integration and social-ecological system sustainability. *Ecology and Society*. 17, 1-17.





FRESHWATER SYSTEMS

DESCRIPTION

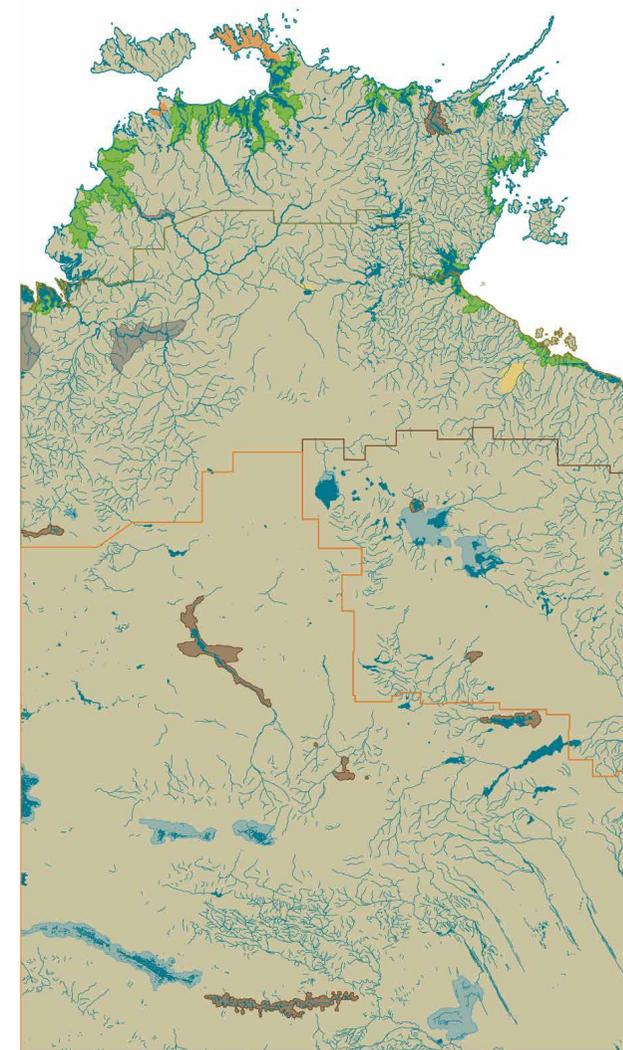
Freshwater systems in the Northern Territory include rivers, creeks, swamps, waterholes, thermal pools and underground aquifers. Over half of the Sites of Conservation Significance include freshwater wetlands¹.

Top End and Gulf Savanna systems mostly drain northward to the coast, and are either perennial or are limited to wet season flow². Flow regimes, riparian vegetation and timber in stream channels influence plant and animal species and abundance³. Early wet season rains promote wild rice growth and Magpie Goose populations. Late wet season peak flows promote catfish abundance. Extended periods of inundation increase floodplain productivity, supporting food webs beyond the river banks.

Streams of the Tablelands and Arid Lands mostly drain inland, terminating in either isolated inland lakes or dry stream beds⁴. When inundated, inland lakes support large congregations of waterbirds.

Indigenous people value freshwater systems for the provision of food, medicines and materials for arts, crafts and livelihoods, and well as for their cultural and spiritual significance and to support future economic development⁵. Customary use of a freshwater resource is embedded with a deep understanding of the system's ecology and environmental water needs⁶ (Figure 1). Indigenous interests are now recognised as central to freshwater use, development, management and research, but mechanisms for determining appropriate Indigenous allocations are still inadequate^{7,8}.

Surface and groundwater are important for commercial development, notably agriculture and mining operations⁹. However, not all economic uses of freshwater are extractive. Wet season flow and water extraction influence commercial catches of prawns and Barramundi. Freshwater systems are also integral to tourism and recreational fishing.



Coastal wetlands Rivers
Floodplains Swamps
Lakes Waterholes

Freshwater systems within Sites of Conservation Significance in the NT.

- 1 Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M. & Lynch, B. (2009) An inventory of sites of international and national significance for biodiversity values in the Northern Territory. In: Department of Natural Resources, Environment, The Arts and Sport, Darwin, NT.
- 2 Warfe, D.M., Pettit, N.E., Davies, P.M., Pusey, B.J., Hamilton, S.K., Kennard, M.J., Townsend, S.A., Bayliss, P., Ward, D.P., Douglas, M.M., Burford, M.A., Finn, M., Bunn, S.E. & Halliday, I.A. (2011) The 'wet-dry' in the wet-dry tropics drives river ecosystem structure and processes in northern Australia. *Freshwater Biology*, 56, 2169-2195.
- 3 Pettit, N.E., Warfe, D.M., Kennard, M.J., Pusey, B.J., Davies, P.M. & Douglas, M.M. (2013) Dynamics of in-stream wood and its importance as fish habitat in a large tropical floodplain river. *River Research and Applications*, 29, 864-875.
- 4 Duguid, A., Barnetson, J., Clifford, B., Pavey, C., Albrecht, D., Risler, J. & McNellie, M. (2005) Wetlands in the arid Northern Territory. A report to Environment Australia on the inventory and significance of wetlands in the arid NT. Parks and Wildlife Commission of the Northern Territory, Alice Springs.

- 5 Jackson S. and Altman J. (2009) Indigenous rights and water policy: perspectives from tropical northern Australia. *Australian Indigenous Law Review* 13, 27-48.
- 6 Woodward, E., Jackson, S., Finn, M. & McTaggart, P.M. (2012) Utilising Indigenous seasonal knowledge to understand aquatic resource use and inform water resource management in northern Australia. *Ecological Management & Restoration*, 13, 58-64.
- 7 Jackson, S., Tan, P.-L., Mooney, C., Hoverman, S. & White, I. (2012) Principles and guidelines for good practice in Indigenous engagement in water planning. *Journal of Hydrology*, 474, 57-65.
- 8 Jackson, S. & Barber, M. (2013) Recognition of indigenous water values in Australia's Northern Territory: current progress and ongoing challenges for social justice in water planning. *Planning Theory & Practice*, 14, 435-454.
- 9 Bithell, S.L., Smith, S.H. & Territory, N. (2011) The method for estimating crop irrigation volumes for the Tindall limestone aquifer, Katherine, Water Allocation Plan. Northern Territory Government.



Figure 1. Ngan'gi Seasons calendar illustrating customary use of freshwater resources (Woodward et al. 2012).

PRESSURES/USES

Northern Territory inland waters are affected by numerous threats. These include catchment modification as a result of feral animals, weeds, fire and poor agricultural practices. Management of water use to ensure appropriate allocation among social, cultural, environmental and economic interests is also an issue, and concerns have been raised over the potential impacts of gas extraction on water availability and quality.

Feral animals

Feral herbivores graze and pug wetlands, destroy native vegetation, cause erosion and reduce water quality^{10,11}. They can also cause saltwater intrusion in the near-coastal reaches of freshwater systems. Camels, pigs, horses, donkeys and feral cattle are a problem through much of the Territory, and water buffalo are a particular concern in the Top End. Other species that have adverse effects on aquatic systems include Cane Toads, which change the balance of native predators and prey^{12,13}, and the exotic fish *Gambusia*, which has established populations in central Australia¹⁴. Control of feral animals

- 10 Skeat, A.J., East, T.J. & Corbett, L.K. (1996) Impact of feral water buffalo. Landscape and vegetation ecology of the Kakadu region, Northern Australia (ed. by C.M. Finlayson and I. Von Oertzen), pp. 155-177. Springer.
- 11 Finlayson, C.M., Storrs, M.J. & Lindner, G. (1997) Degradation and rehabilitation of wetlands in the Alligator Rivers Region of northern Australia. *Wetlands Ecology and Management*, 5, 19-36.
- 12 Doody, J.S., Green, B., Sims, R., Rhind, D., West, P. & Steer, D. (2006) Indirect impacts of invasive cane toads *Bufo marinus* on nest predation in pig-nosed turtles *Carettochelys insculpta*. *Wildlife Research*, 33, 349-354.
- 13 Doody, J.S., Green, B., Rhind, D., Castellano, C.M., Sims, R. & Robinson, T. (2009) Population-level declines in Australian predators caused by an invasive species. *Animal Conservation*, 12, 46-53.
- 14 Unmack, P.J. (2001) Fish persistence and fluvial geomorphology in central Australia. *Journal of Arid Environments*, 49, 653-669.

requires ongoing management and monitoring to determine its effectiveness.

Invasive plants

Riparian areas and wetlands are particularly subject to invasion by exotic weeds¹⁵. Different weeds abound in each subregion, with Mimosa, Parkinsonia, Noogoora Bur, Para Grass and Olive Hymenachne of major concern in the northern sub-regions, and Athel Pine, Buffel and Couch Grass in the Arid Lands. These species can displace native plants, disrupt water flows, promote erosion, lower water tables and cause salinisation of the surface soils. Many of them also disrupt fire regimes, with exotic grasses increasing the frequency and intensity of biomass-fuelled fires, and prickly bushes suppressing fires altogether. Concerted efforts have been made to address these species, with major successes being recorded for Athel Pine in the Finke, Parkinsonia and other prickly bushes on the Tablelands, and Mimosa in the Top End.



Mimosa pigra

15 Grice, A.C. (2006) The impacts of invasive plant species on the biodiversity of Australian rangelands. *Rangeland Journal*, 28, 27-35.

Fire

Riparian areas often support fire-sensitive vegetation¹⁶. Intense fires, such as those fuelled by exotic grasses, remove native vegetation cover, and reduce the diversity of plants and animals¹⁷. Control of weeds in these environments is difficult, highlighting the importance of risk assessment before new weeds are introduced and early detection of the arrival of new weeds before they are established. Strategic management of both weeds and fire is required to maintain and restore the condition of vegetation associated with inland waters.



Spinifex fire

16 Andersen, A.N., Cook, G.D., Corbett, L.K., Douglas, M.M., Eager, R.W., Russell-Smith, J., Setterfield, S.A., Williams, R.J. & Woinarski, J.C.Z. (2005) Fire frequency and biodiversity conservation in Australian tropical savannas: implications from the Kapalga fire experiment. *Austral Ecology*, 30, 155-167.

17 Douglas, M.M. & O'Connor, R.A. (2004) Weed invasion changes fuel characteristics: Para Grass (*Urochloa mutica* (Forssk.) T.Q. Nguyen) on a tropical floodplain. *Ecological Management & Restoration*, 5, 143-145.

Water use

Less than 1% of the annual runoff from Northern Territory rivers is extracted for use, mostly for agricultural, household, mining and industrial purposes. Increased water demand is expected as a result of expanded agricultural activity and mining. Water extraction has potential adverse impacts on social, cultural, environmental and competing economic uses. Water allocation plans designed to minimise these impacts are in place or under development for most of the significant water resources of the Northern Territory¹⁸. However, proposed levels of water extraction in at least the Daly River are predicted to have adverse environmental impacts¹⁹. These include reduced water quality and a reduction in the survival and movement of species through the dry season, and shifts in species composition with the potential for conversion of perennial systems to systems with intermittent flow. Spring-fed swamps and forests, Barramundi and Magpie Goose are examples of species and ecosystems vulnerable to changes in water availability brought about by water extraction. Managed aquifer recharging is also being contemplated as a means of meeting increased water demand, with uncertain environmental consequences²⁰.

18 http://irm.nt.gov.au/water/water_allocation/plans

19 King, A.J., Townsend, S.A., Douglas, M.M. & Kennard, M.J. (2015) Implications of water extraction on the low-flow hydrology and ecology of tropical savannah rivers: an appraisal for northern Australia. *Freshwater Science*, 34, 741-758.

20 Lennon, L., Evans, R., George, R., Dean, F. & Parsons, S. (2014) The role of managed aquifer recharge in developing northern Australia. In: *OzWater Conference*, 8pp.

Mining and energy production

As well as water extraction, the impacts of mining can include hydraulic fracturing or fracking (injecting liquid at high pressure into subterranean rocks to force open existing fissures and extract oil or gas). Fracking has been used to a limited extent in the Northern Territory in the extraction of conventional gas since 1967, and has recently been adopted as a means of extracting coal seam gas²¹. Concerns have recently been raised over the potential social, cultural and environmental impacts of fracking, particularly on groundwater levels and contamination. Gas reserves where fracking has already occurred or may be employed include the Amadeus, Ngalia, Bonaparte, Georgina, McArthur, Pedirka, Eromanga, Wiso and Beetaloo basins. No adverse impacts have yet been established, but a ban on the use of toxic substances in fracking has been recommended.



Mustering

21 Hawke, A. (2014) Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory. Report to the Northern Territory Government.

Primary industries

Overgrazing and unrestricted cattle access to waterholes can degrade riparian vegetation and habitats, cause erosion, degrade water quality and spread weeds^{22,23,24,25}. Grazing best management recommendations therefore include maintenance of ground cover and exclusion of cattle from wetland and riparian zones²⁶. Vegetation clearance can also impact on freshwater systems, especially if undertaken in the riparian zone. Applications are required for the clearing of vegetation, and buffers are required around water features and along the riparian zone²⁷.

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- 22 Skroblin, A. & Legge, S. (2012) Influence of fine-scale habitat requirements and riparian degradation on the distribution of the purple-crowned fairy-wren (*Malurus coronatus coronatus*) in northern Australia. *Austral Ecology*, 37, 874-884.
- 23 Miller, J., Chanasyk, D., Curtis, T., Entz, T. & Willms, W. (2010) Influence of streambank fencing with a cattle crossing on riparian health and water quality of the Lower Little Bow River in Southern Alberta, Canada. *Agricultural Water Management*, 97, 247-258.
- 24 Bartley, R., Roth, C.H., Ludwig, J., McJannet, D., Liedloff, A., Corfield, J., Hawdon, A. & Abbott, B. (2006) Runoff and erosion from Australia's tropical semi-arid rangelands: Influence of ground cover for differing space and time scales. *Hydrological Processes*, 20, 3317-3333
- 25 Miller, J., Chanasyk, D., Curtis, T., Entz, T. & Willms, W. (2010) Influence of streambank fencing with a cattle crossing on riparian health and water quality of the Lower Little Bow River in Southern Alberta, Canada. *Agricultural Water Management*, 97, 247-258.
- 26 Hunt, L.P., McIvor, J.G., Grice, A.C. & Bray, S.G. (2014) Principles and guidelines for managing cattle grazing in the grazing lands of northern Australia: stocking rates, pasture resting, prescribed fire, paddock size and water points – a review. *The Rangeland Journal*, 36, 105-119.
- 27 <http://www.lrm.nt.gov.au/land-clearing>

Urban development

In urban areas, water quality can be affected by wastewater, stormwater, sewage and catchment modification for industrial and housing developments. Licensing schemes to regulate discharge to waterways apply in some instances, but their effectiveness needs to be assessed.

Climate change

The impacts of climate change on freshwater systems are likely to be significant²⁸. Altered flow regimes are expected, with pronounced rainfall extremes leading to an increase in both flooding and low water levels. This is not only expected to cause changes in channel configuration and a redistribution of plant and animal communities, but also species extinctions. Changed flow regimes have already affected sediment loads and channel configuration of the Daly River²⁹. Sea level rise is expected to cause saltwater intrusion³⁰, as is already occurring in the lower reaches of several catchments, notably Arafura Swamp, Mary River, Wildman River and the East Alligator River, although this has been exacerbated by feral animal damage. Future water extraction plans also need to be cognisant of the impact of climate change on water availability and water quality.

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- 28 Koehn, J.D., Hobday, A.J., Pratchett, M.S. & Gillanders, B.M. (2011) Climate change and Australian marine and freshwater environments, fishes and fisheries: synthesis and options for adaptation. *Marine and Freshwater Research*, 62, 1148-1164.
- 29 Morrongiello, J.R., Beatty, S.J., Bennett, J.C., Crook, D.A., Ikedife, D.N.E.N., Kennard, M.J., Kerezszy, A., Lintermans, M., McNeil, D.G., Pusey, B.J. & Rayner, T. (2011) Climate change and its implications for Australia's freshwater fish. *Marine and Freshwater Research*, 62, 1082-1098.
- 30 Finlayson, C.M., Davis, J.A., Gell, P.A., Kingsford, R.T. & Parton, K.A. (2013) The status of wetlands and the predicted effects of global climate change: the situation in Australia. *Aquatic sciences*, 75, 73-93.

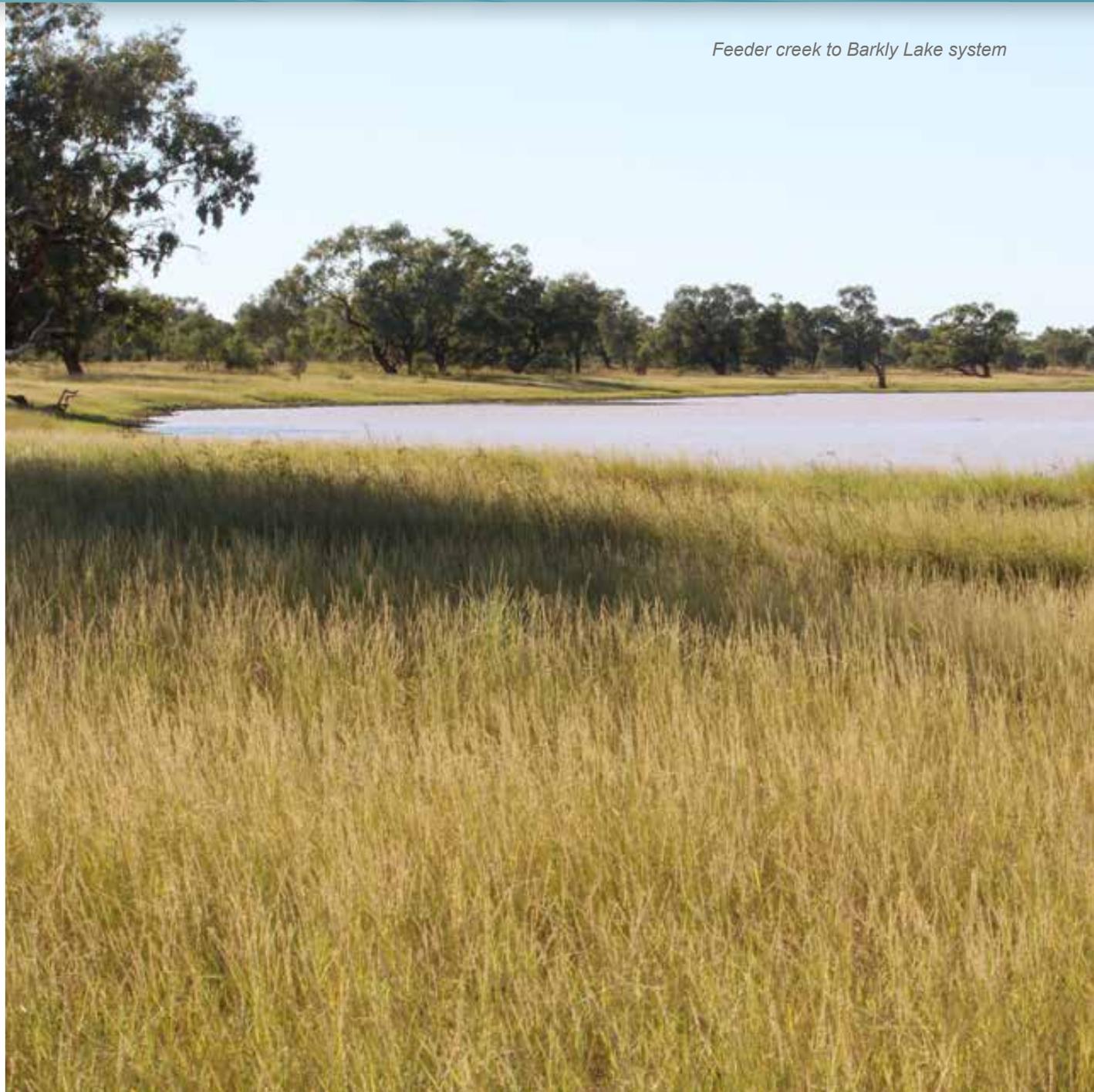
Knowledge gaps

Indigenous knowledge offers much insight into the values and functioning of freshwater systems in the Northern Territory. This should continue to be supplemented by biophysical research to assess the impact of water extraction and climate change. Improved dissemination and sharing of information will also benefit the management of these systems.

Indicators

- River discharge and flooding
- Density and diversity of birds using wetlands for nesting and breeding
- Commercial catches of Barramundi and prawns
- Presence and absence of indicator species such as freshwater turtles and snakes
- Mapped weed extent in areas being actively managed
- Mapped feral management effort and impact
- Patterns of fire seasonality and extent
- Water quality

Feeder creek to Barkly Lake system





HEALTHY SOILS

DESCRIPTION

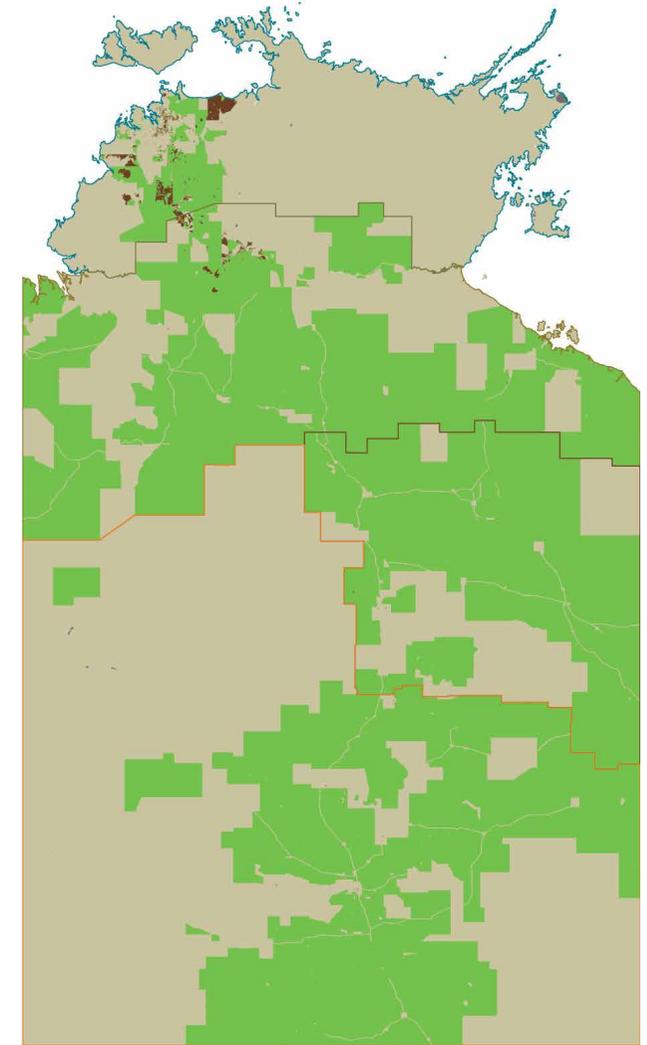
Healthy soils are stable, have good structure, nutrient exchange capacity, water-holding capacity, fertility, organic matter, and biological activity. Healthy soils provide important water and nutrient cycling functions and support plant and animal life¹. They also help to regulate water flow and quality, and greenhouse gases.

Most soils in northern Australia that have agricultural potential are shallow, infertile, low in organic carbon, highly erodible, have low infiltration rates and water holding capacity, and are susceptible to surface sealing². They are threatened by any loss of vegetation cover, exposing them to erosion from wind or water, acidification, and salinisation. The risk of erosion is particularly severe in wet season storms in the Top End.

Most Northern Territory soils are used for pastoralism. The Barkly Tablelands and Victoria River District are the most productive areas for pastoral production, with high quality Mitchell and Flinders Grass pastures on cracking black soils. There are limited areas of soils that are suitable for other forms of agriculture and are accessible to suitable water reserves. These are mostly located between the

Douglas- Daly and Mataranka^{3,4,5}. Small-scale horticulture is also important in the Darwin rural area and around Alice Springs.

Management practices to maintain and improve soil condition are well understood. Retention of vegetation cover, ground cover and crop residues help to reduce the risk of wind and water erosion, lower greenhouse gas emissions and improve water use efficiency^{6,7}. For broadscale agriculture, best practice soil management includes selection of appropriate crop types, minimum till with seeding into crop residue; testing soil pH and nutrient status before applying fertiliser; and using lime or dolomite to address soil acidity⁸. Grazing best practice includes fencing to land type, matching stocking rates to forage availability (which requires pasture monitoring),



- Production from relatively natural environments
- Production from irrigated agriculture
- Production from dryland agriculture and plantations
- Intensive uses

Land use in the NT

1 Dominati, E., Patterson, M. & Mackay, A. (2010) A framework for classifying and quantifying the natural capital and ecosystem services of soils. *Ecological Economics*, 69, 1858-1868.

2 Wilson, P.L., Ringrose-Voase, A., Jacquier, D., Gregory, L., Webb, M., Wong, M.T.F., Powell, B., Brough, D., Hill, J., Lynch, B., Schoknecht, N. & Griffin, T. (2009) Chapter 2. Land and soil resources of northern Australia. Northern Australia Land and Water Science Review 2009. Department of Infrastructure, Transport, Regional Development and Local Government.

3 Pascoe-Bell, A., Green, C., Lynch, B., Hill, J., Tickell, S.J., Cameron, A. & Smith, S. (2014) Potential Land for Long-term Sustainable Food Production. Soil and Water Suitability Assessment, 2nd Edition. October 2014. Department of Land Resource Management, Palmerston, Northern Territory.

4 Webster, T., Rippin, L., Morison, J., Herr, A., Abel, N., Taylor, B., Clark, E. & Stone, P. (2009) Chapter 10. Irrigated agriculture: development opportunities and implications for northern Australia. Northern Australia Land and Water Science Review 2009. Department of Infrastructure, Transport, Regional Development and Local Government.

5 Ash, A., Gleeson, T., Cui, H., Hall, M., Heyhoe, E., Higgins, A., Hopwood, G., MacLeod, N., Paini, D., Pant, H., Poulton, P., Prestwidge, D., Webster, T. & Wilson, P. (2014) Northern Australia: Food and fibre supply chains study project report. CSIRO & ABARES.

6 Dilshad, M., Motha, J. & Peel, L. (1996) Surface runoff, soil and nutrient losses from farming systems in the Australian semi-arid tropics. *Australian Journal of Experimental Agriculture*, 36, 1003-1012.

7 Turmel, M.-S., Speratti, A., Baudron, F., Verhulst, N. & Govaerts, B. (2015) Crop residue management and soil health: A systems analysis. *Agricultural Systems*, 134, 6-16.

8 Barson, M., Mewett, J. & Paplinska, J. (2012) Land management practice trends in Australia's broadacre cropping industries. Caring for our Country Sustainable Practices fact sheet 3. Department of Agriculture, Fisheries and Forestry.

wet season spelling and managing fire⁹. Control of feral animals to reduce total grazing pressure and prevent erosion are also important across the Territory. These practices are also important for protecting water quality in downstream freshwater and marine environments^{10,11}. A guide is available to help Northern Territory landholders select land uses based on land capability¹². Before deciding on a land use, landholders should also establish which areas are subject to waterlogging or erosion because of erodible or unstable soils or steep slopes¹³. Best practice management guides have been produced for agricultural production¹⁴ and grazing land management for each pastoral region¹⁵.

9 Hunt, L.P., McIvor, J.G., Grice, A.C. & Bray, S.G. (2014) Principles and guidelines for managing cattle grazing in the grazing lands of northern Australia: stocking rates, pasture resting, prescribed fire, paddock size and water points – a review. *The Rangeland Journal*, 36, 105-119.

10 Bartley, R., Roth, C.H., Ludwig, J., McJannet, D., Liedloff, A., Corfield, J., Hawdon, A. & Abbott, B. (2006) Runoff and erosion from Australia's tropical semi-arid rangelands: Influence of ground cover for differing space and time scales. *Hydrological Processes*, 20, 3317-3333.

11 Thorburn, P.J. & Wilkinson, S.N. (2013) Conceptual frameworks for estimating the water quality benefits of improved agricultural management practices in large catchments. *Agriculture, Ecosystems and Environment*, 180, 192-209.

12 Northern Territory Government (2013) Northern Territory Land Suitability Guidelines. Darwin.

13 <https://nt.gov.au/environment/soil-land-vegetation>

14 O'Gara, F.P. (1998) Striking the balance: Sustainable farming & grazing systems for the semi-arid tropics of the Northern Territory. In. Department of Primary Industries and Fisheries, Darwin.

15 <https://futurebeef.com.au/resources/publications/>

PRESSURES/USES

Past practices

Poor pastoral management in the past, especially overstocking, has left a legacy of land degradation in all subregions. Without management intervention, these lands may take decades to recover. As well as minimising grazing pressure from livestock and feral animals, restoration of degraded lands requires changing drainage patterns to reduce erosion and allow the build-up of organic matter^{16,17}.

Land use and development

There is increasing interest in developing northern Australia¹⁸, including to:

- open up new areas to cattle grazing
- increase the number of stock on currently grazed lands
- grow pasture crops as part of extensive cattle grazing enterprises
- increase the area under irrigated agriculture

It is important that these activities are situated in areas with suitable land capabilities to avoid land degradation¹⁹.

16 Tongway, D.J. & Ludwig, J.A. (1996) Rehabilitation of semiarid landscapes in Australia. I. Restoring productive soil patches. *Restoration Ecology*, 4, 388-397.

17 Yates, C.J., Norton, D.A. & Hobbs, R.J. (2000) Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology*, 25, 36-47.

18 Australian Government (2015) Our North, Our Future: White paper on developing northern Australia.

19 Conacher, A. & Conacher, J. (2000) Environmental planning and management in Australia. Oxford University Press.

Practice uptake

Despite a good knowledge of soil conservation principles and their benefits for productivity and profitability, uptake of best management practice recommendations has been slow. Data collected between 2007/8 to 2010/11 showed low and declining levels of broadscale agricultural businesses undertaking best practices²⁰. There was also a steep decline in pasture monitoring on grazing properties and a low and declining percentage of businesses achieving minimum ground cover targets. The Department of Primary Industries and Fisheries, peak industry groups and Territory NRM all support best practice adoption through providing information resources and extension programs. These efforts can be assisted through improved understanding of the motivations of land managers, their approach to risk management and the constraints they face^{21,22}.



20 Barson, M. (2013) Land management practice trends in northern and remote Australia's agricultural industries. Caring for our Country Sustainable Practices fact sheet 36. Department of Agriculture, Fisheries and Forestry.

21 Greiner, R. & Gregg, D. (2011) Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia. *Land Use Policy*, 28, 257 - 265.

22 Greiner, R., Patterson, L. & Miller, O. (2009) Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems*, 99, 86-104.

Vegetation clearance and modification

Vegetation clearance is necessary for some land uses, but, if not managed well, can cause soil degradation and loss^{23,24}. Soil exposed to desiccation by vegetation clearance also produces more greenhouse gas emissions than does soil under vegetation cover²⁵. Vegetation clearance should only be undertaken on suitable sites. Natural drainage should be maintained, ground cover quickly established and land managed to ensure ground cover is maintained.

Woody thickening resulting from poor grazing and fire management can also reduce landscape productivity as perennial grass cover declines and runoff increases due to vegetation thickening in grazed landscapes^{26, 27}.

- 23 Lindenmayer, D. & Burgman, M. (2005) Chapter 9 Vegetation loss and degradation. Practical Conservation Biology. CSIRO Publishing.
- 24 Ludwig, J. & Tongway, D. (2002) Clearing savannas for use as rangelands in Queensland: altered landscapes and water-erosion processes. Rangeland Journal, 24, 83-95.
- 25 Grover, S., Livesley, S., Hutley, L., Jamali, H., Fest, B., Beringer, J., Butterbach-Bahl, K. & Arndt, S. (2012) Land use change and the impact on greenhouse gas exchange in north Australian savanna soils. Biogeosciences, 9, 423-437.
- 26 Drucker, A.G., Garnett, S.T., Luckert, M.K., Crowley, G.M. & Gobius, N. (2008) Manager-based valuations of alternative fire management regimes on Cape York Peninsula, Australia. International Journal of Wildland Fire, 17, 660-673.
- 27 Muñoz-Robles, C., Reid, N., Tighe, M., Briggs, S.V. & Wilson, B. (2011) Soil hydrological and erosional responses in patches and inter-patches in vegetation states in semi-arid Australia. Geoderma, 160, 524-534.

Feral animals

Grazing, trampling and pugging by feral herbivores reduce ground cover, compact soil and cause erosion and pollution of waterways^{28, 29, 30}. Pigs and water buffalo are of serious concern in the Top End and Gulf Savanna, as are donkeys and horses on the Barkly Tablelands and camels, horses, donkeys, rabbits in the Arid Lands. Strategic and sustained control of these animals is needed.

Fire

Widespread fires can lead to soil erosion, especially when fires occur close to the first heavy wet season downpour³¹. Minimising extent of fire, patch-burning and ensuring unburnt buffers are left along watercourses should help to minimise erosion from fires³².

- 28 Bradshaw, C.J.A., Field, I.C., Bowman, D.M.J.S., Haynes, C. & Brook, B.W. (2007) Current and future threats from non-indigenous animal species in northern Australia: a spotlight on World Heritage Area Kakadu National Park. Wildlife Research, 34, 419-436.
- 29 Edwards, G.P., Zeng, B., Saalfeld, W.K., Vaarzon-Morel, P. & McGregor, M. (2008) Managing the impacts of feral camels in Australia: a new way of doing business. In. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs.
- 30 Bengsen, A.J., Gentle, M.N., Mitchell, J.L., Pearson, H.E. & Saunders, G.R. (2014) Impacts and management of wild pigs *Sus scrofa* in Australia. Mammal Review, 44, 135-147.
- 31 Russell-Smith, J., Yates, C. & Lynch, B. (2006) Fire regimes and soil erosion in north Australian hilly savannas. International Journal of Wildland Fire, 15, 551-556.
- 32 Cawson, J.G., Sheridan, G.J., Smith, H.G. & Lane, P.N.J. (2012) Surface runoff and erosion after prescribed burning and the effect of different fire regimes in forests and shrublands: a review. International Journal of Wildland Fire, 21, 857-872.

Road and infrastructure construction

Poorly constructed roads, railway lines and fence-lines are a potential source of soil erosion³³. Best practice management needs to be used in the construction, and remediation where problems already exist³⁴.

Residential and commercial development

Management of drainage in residential and industrial areas is essential to prevent erosion and soil waterlogging and to prevent seepage of sewerage into the soil profile³⁵.



Feral herbivore damage to riparian areas

- 33 Vo, P.T., Ngo, H.H., Guo, W., Zhou, J.L., Listowski, A., Du, B., Wei, Q. & Bui, X.T. (2015) Stormwater quality management in rail transportation — Past, present and future. Science of The Total Environment, 512–513, 353-363.
- 34 Hadden, K. (1993) Soil Conservation Handbook for Parks and Reserves in the Northern Territory. In. Conservation Commission of the Northern Territory Technical Report no. 54. Conservation Commission of the Northern Territory, Darwin.
- 35 Hazelton, P. & Murphy, B. (2011) Understanding soils in urban environments. CSIRO publishing.

Climate change & severe weather

Intense wet season rainfall can cause erosion of bare soil, even when there is minimal slope³⁶. Waterlogging is also an issue in low-lying areas of the Top End, which can cause a range of problems from poor crop growth to undermining buildings and roads. Expected increases in the intensity of rainfall will make these problems harder to manage. Conversely, increased temperatures are expected to adversely affect soil moisture, forage production, surface cover and hydrology, exposing the soil to desiccation, wind erosion and degradation³⁷. Widespread adoption of best practice management will be required to minimise these impacts.

Indicators

- Integrated land use plans that consider and address land degradation issues
- Adoption of best management practice in the pastoral, agricultural and horticultural industries
- Productivity and health of soils in horticultural areas
- Sediment load in watercourses
- % Ground cover – soil stability

³⁶ <https://nt.gov.au/environment/soil-land-vegetation>

³⁷ McKeon, G., Stone, G., Syktus, J., Carter, J., Flood, N., Ahrens, D., Bruget, D., Chilcott, C., Cobon, D. & Cowley, R. (2009) Climate change impacts on northern Australian rangeland livestock carrying capacity: a review of issues. *The Rangeland Journal*, 31, 1-29.





COMMUNITY KNOWLEDGE

DESCRIPTION

Cultural and natural resource management requires knowledge and skills, whether this is to fulfil Caring for Country obligations, restore biodiversity values or undertake sustainable production.

Traditional knowledge, handed down through generations, ensures that younger generations know about the past, how to fulfil their obligations to country, and how to live in the landscape^{1,2,3}.

Management of biodiversity is made difficult by a lack of understanding about where species live, their habitat requirements and how various threats are affecting them. Considerable effort has gone into researching biodiversity in the Territory, but we still don't know how best to manage it to prevent its decline. Indigenous knowledge is contributing to this understanding⁴.

Pastoral production is also based on a large body of knowledge about natural resource management developed in the 150 years or so since cattle livestock first grazed in the Northern Territory. This knowledge can be lost when pastoralists leave the industry. It may be passed on to younger generations, but pastoralists coming from different environments may not always benefit from an effective handover period, and people coming with fresh ideas may not always appreciate the wisdom of old ways. Similarly, if lessons learnt from the horticultural and agricultural industries' successes and failures are not passed on, the next generation of producers may be destined to make the same mistakes.

Many projects have been conducted to capture, store and pass on community knowledge to appropriate recipients in the Territory. Territory NRM has supported Indigenous communities to undertake intergenerational TEK projects⁵. The North Australian Aboriginal and Torres Strait Islander Alliance and other Indigenous groups hold forums at which rangers can share their knowledge and experiences⁶. Well-respected pastoralists have been interviewed to capture their ideas on best practice management⁷, and webinars are being held to enable pastoralists to share their experiences⁸.

There is the need for new knowledge to be incorporated into the knowledge base. Indigenous people are also increasingly incorporating western approaches into their management, while still performing traditional cultural management^{9,10,11,12}. They are using cultural mapping to aid intergenerational knowledge transfer, to demonstrate connection to land and Native Title rights, and to ensure country is looked after¹³. Extension programs are assisting graziers and growers to identify the best management practices to suit their operations^{14,15,16,17}.

Research is required to continue building the knowledge base. However, it needs to be targeted to real world

- 1 Russell-Smith, J., Lucas, D., Gapindi, M., Gunbunuka, B., Kapirigi, N., Namingum, G., Lucas, K., Giuliani, P. & Chaloupka, G. (1997) Aboriginal resource utilisation and fire management practice in western Arnhemland, monsoonal northern Australia. Notes for prehistory, lessons for the future. *Human Ecology*, 25, 159-195.
- 2 Burgess, C.P., Johnston, F.H., Bowman, D.M.J.S. & Whitehead, P.J. (2005) Healthy Country: Healthy People? Exploring the health benefits of Indigenous natural resource management. *Australian and New Zealand Journal of Public Health*, 29, 117-122.
- 3 Johnson, S. (2009) Kantri is for Laif: a Strategy for the Promotion of Indigenous Knowledge and the Development of Indigenous Livelihoods on the Remote north Australian Indigenous Estate. In: A LWA, CRC-TSM and NAILSMA Project Initiative
- 4 Ziembicki, M.R., Woinarski, J.C.Z., and Mackey, B. (2013) Evaluating the status of species using Indigenous knowledge: Novel evidence for major native mammal declines in northern Australia. *Biological Conservation*. 157, 78-92.

- 5 Moxham, N., and Mitchell, P. (2011) Indigenous Ecological Knowledge Program NT 2007 – 2010. Evaluation September 2011. Territory NRM, Darwin
- 6 www.nailsma.org.au/hub/events
- 7 Sullivan, S., Kraatz, M., Tapsall, S., Tubman, W., and O'Donnell, K. (2006) 'Perspectives on managing grazing country: Pastoralists talk about successfully managing their country. Sturt Plateau.' (Tropical savannas CRC: Darwin).
- 8 <https://futurebeef.com.au/resources/multimedia/>

- 9 Fitzsimons, J.A. & Wescott, G. (2004) The classification of lands managed for conservation: existing and proposed frameworks, with particular reference to Australia. *Environmental Science & Policy*, 7, 477-486.
- 10 Gorman, J. & Vemuri, S. (2012) Social implications of bridging the gap through 'caring for country' in remote Indigenous communities of the Northern Territory, Australia. *The Rangeland Journal*, 34, 63-73.
- 11 Muller, S. (2012) Two Ways: Bringing indigenous and non-indigenous knowledges together. Country, native title and ecology (ed. by J.K. Weir), pp. 59-79. Australian National University e-press and Aboriginal History Incorporated (Monograph 24), Canberra.
- 12 Preuss, K. & Dixon, M. (2012) 'Looking after country two-ways': Insights into Indigenous community-based conservation from the Southern Tanami. *Ecological Management & Restoration*, 13, 2-15.
- 13 Strang, V. (2010). Chapter 7. Mapping histories: cultural landscapes and walkabout methods. pp. 132-156 in *Environmental social sciences: methods and research design*. Edited by I. Vacarro, E.A. Smith and S. Aswani. Cambridge University Press: Cambridge.
- 14 DRDP/IFR (2013) Cattle and land management best practices in the Top End region. Department of Regional Development Primary Industry Fisheries and Resources, Northern Territory Government.
- 15 Walsh, D., and Cowley, R.A. (2013) Best-bet practices for managing grazing lands in the Victoria River District of the Northern Territory: A technical guide to options for optimising land condition, animal production and profitability Northern Territory Government.
- 16 Walsh, D., and Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Barkly Tableland region of the Northern Territory. Northern Territory Government.
- 17 Walsh, D., Kain, A., and Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Alice Springs region of the Northern Territory. Northern Territory Government.



COMMUNITY KNOWLEDGE

issues and, to have maximum impact, should be done in partnership with the resource managers, rather than delivered fait accompli¹⁸. Participatory action research can be integrated with extension and planning.

Planning, evaluation and improvement cycles are required if knowledge is to be used effectively for natural resource management. Best practice country plans and property management plans set priorities and objectives and identify activities¹⁹. After an implementation cycle, these are evaluated to see if activities were undertaken and had the desired effect. Continuous improvement is dependent on the planning cycle being finalised and completed, and priorities and activities being re-assessed.

Finally, formal training and education has a role in ensuring natural resource managers have the understanding they need to manage effectively. Courses available in the Territory include informal programs (e.g. Grazing Land Management²⁰ and Ecosystem Management and Understanding²¹), through certificate-level courses on primary industries and conservation land management²² to tertiary level courses on Indigenous knowledge, languages and environmental science and management²³. There do not appear to be any courses on Indigenous Land Management in the Northern Territory at present, although this qualification is available at institutions elsewhere in the country.



18 Crowley, G., Dale, A., Banks, R., Barclay, S., Birch, P., Buchan, A., Cocco, R., Crase, J., Crawford, S., Dielenberg, J., Donohoe, P., Edgar, B., Franklin, J., Frazer, B., Harper, P., Hinchley, D., Hoogwerf, T., Ikin, N., Johnson, S., Mackay, G., Maher, E., May, K., Miley, D., Mitchell, C., Moller, M., Morris, S., Musgrove, R., Peake, K., Pearson, D., Pentz, D., Schuntner, G., Sinclair, I., Standley, P.-M., Sweatman, C., Tambling, L., Wessels, A., and Wilson, B. (2014) Environmental research plan for natural resource management organisations and Regional Development Australia boards in northern Australia. Reef and Rainforest Research Centre, Cairns.

19 Nelson, B.S., and Robinson, E. (2009) Critical success factors of a whole of business extension approach for increased capacity of beef producers and improved enterprise profit and sustainability. The Rangeland Journal. 31, 61-68.

20 https://www.bmpgrazing.com.au/images/module/modules/130910%20-%20grazing%20bmp_glm%20module%20north%20v15_lowres.pdf

21 www.emuproject.org.au

22 www.cdu.edu.au/cdu-vet/primary-industries; <http://www.batchelor.edu.au/students/courses/>

23 <http://www.batchelor.edu.au/students/courses/>; <http://stapps.cdu.edu.au/?p=100:30:930152688823234>



PRESSURES/USES

Loss of community knowledge seriously impedes our capacity to appreciate and manage the environment, or to run successful businesses based on natural resources.

Lack of access

Loss of knowledge has had a significant impact on the capacity of Indigenous people to manage cultural landscapes and sites²⁴. Traditional knowledge is reaffirmed by continually being on country. Separation from country, as has happened across much of the continent when people were placed in missions or moved to towns, makes it hard to maintain the connections that underpin the knowledge. Even where people have remained on country, changes in lifestyle and living arrangements have meant that much of the country was not easily accessible. Access can be most difficult in rugged and remote areas, or in the wet season, when roads are cut, and may be prevented when the land has non-aboriginal tenure.

Access tracks and roads may need to be upgraded to allow access to some areas²⁵, and Indigenous Land Use and Access Agreements can be negotiated over pastoral properties. Sustainable economic development in remote Indigenous communities, particularly the provision of housing, infrastructure, and accessible jobs and training,

24 State of the Environment 2011 Committee (2011). Australia state of the environment 2011. Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities. Australian Government, Canberra.

25 Northern Australia Land and Water Taskforce (2009). Sustainable development of northern Australia: A report to Government from the Northern Australia Land and Water Taskforce.

will enable Indigenous people to remain on their country and be effective custodians of traditional knowledge²⁶.

Lack of respect

Knowledge can also be undermined by an education system that does not value it²⁷. There is a need for an education system in remote communities that incorporates traditional knowledge as a legitimate form of learning. This should include visits to country to provide opportunities for intergenerational transfer. Projects to protect and transfer Indigenous Ecological Knowledge in the Northern Territory have been highly successful, but there is further work to be done²⁸. While traditional knowledge has a role in conservation planning and management, it is important that ownership of traditional knowledge is respected, and that knowledge is not misappropriated²⁹.

26 Altman, J., N. Biddle, and G. Buchanan (2012) The Indigenous hybrid economy: can the NATSISS adequately recognise difference, in Survey Analysis for Indigenous Policy in Australia: Social Science Perspectives. ANU ePress Canberra. p. 163-192.

27 Fogarty, W.P. (2010) Learning through country: competing knowledge systems and place based pedagogy. Australian National University. <http://hdl.handle.net/1885/11712>

28 Moxham, N., and Mitchell, P. (2011). Indigenous Ecological Knowledge Program NT 2007 – 2010. Evaluation September 2011. Territory NRM, Darwin.

29 Hill, R., Grant, C., George, M., Robinson, C.J., Jackson, S., and Abel, N. (2012) A typology of indigenous engagement in Australian environmental management: implications for knowledge integration and social-ecological system sustainability. Ecology and Society. 17, 1-17.

Lack of capacity

Knowledge building takes time and commitment. Many natural resource managers are busy with other priorities. They need to be convinced of the value of new knowledge before they can commit the time and energy required. Overcoming resistance to new ways of doing things is one of the biggest challenges extension services face. Most success has been achieved when they incorporate recognition of prior learning, and provide opportunities for hands-on experience and sharing the experiences of respected members of the industry³⁰.

Lack of resources

Effective extension is costly. Governments have decreased their investment in extension programs over the last few decades³¹. Increased funding is required, especially if extension services are to be strategically delivered with follow-up support³².

30 Lankester, A.J. (2013) Conceptual and operational understanding of learning for sustainability: A case study of the beef industry in north-eastern Australia. Journal of Environmental Management. 119, 182-193

31 Marsh, S.P., and Pannell, D. (2000) Agricultural extension policy in Australia: the good, the bad and the misguided. The Australian Journal of Agricultural and Resource Economics. 44, 605-627.

32 Babacan, H., Dale, A., Andrews, P., Beazley, L., Horstman, M., Campbell, A., Morris, S., Webb, B., Rowlands, M., and Bowen, L. (2012) Science engagement and tropical Australia: Building a prosperous and sustainable future for the north. Prepared by the Expert Working Group on Science Engagement Into and For Australia's Tropical Region as part of Inspiring Australia.



Climate Change

Climate change projections for the Northern Territory include increases in: temperature, frequency of cyclones, droughts and floods, and fire intensity; as yet unknown changes in average annual rainfall; and sea level rise³³. Destruction of cultural sites as a result of these changes will also affect the traditional ecological knowledge associated with them. Also, as temperatures increase, potentially making out-door work unsafe for long periods of time, many people may choose to change careers or leave the Territory altogether, taking their knowledge and experience with them^{34,35}.

Indicators

- Number of Indigenous Ecological Knowledge projects
- Number of pastoral and agricultural knowledge-sharing projects
- Number of opportunities for intergenerational knowledge transfer
- Number of properties/land trusts with property/NRM plans
- Utilisation of traditional and scientific knowledge systems in NRM
- Number of plans/projects that utilise two knowledge systems in management
- Number of active property management plans
- Participation rates in formal and informal courses



33 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.

34 Currie, B. (2011). Environmental Change, Global Warming and Infectious Diseases in Northern Australia. *Environmental Health* 1, 34-43.

35 Green, D., Jackson, S., and Morrison, J. (Eds) (2009). Risks from Climate Change to Indigenous Communities in the Tropical North of Australia. A scoping study for the Commonwealth Department of Climate Change and Energy Efficiency, the Western Australian Department of the Environment and Conservation and the Northern Territory Department of Natural Resources. Commonwealth of Australia.



PEOPLE ON COUNTRY

DESCRIPTION

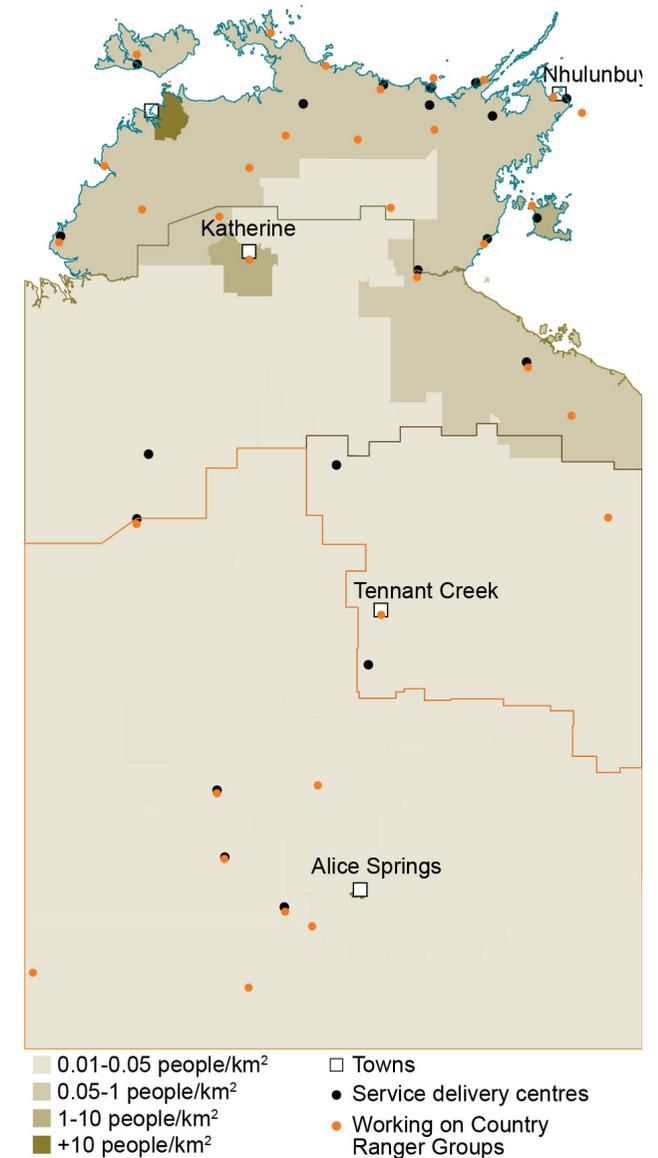
The Northern Territory has a low population base, with most people living in Darwin or Alice Springs. Vast areas of country have fewer than five people per 100 square kilometres. Most of these areas have a fairly stable population, but Arnhem Land's population declined by about 600 people with the closure of the alumina refinery at Nhulunbuy in 2014¹.

People are needed on country to manage fire, weeds and feral animals, and to fulfil customary obligations to care for country and perform ceremonies. People in remote areas need a means of survival. Many Indigenous communities operate under a hybrid economy, in which part of their livelihood is derived through paid employment and part from customary practices, such as hunting and gathering². Ranger groups, largely funded through the Working on Country program and North Australian Quarantine Strategy³, provide paid employment for many Indigenous people to manage country. The White Paper on developing northern Australia also committed the Australian Government to support Indigenous employment by favouring tenders from Indigenous businesses⁴. However, many Indigenous people are trapped into accepting short-term employment that has

little cultural relevance and few social, environmental or economic benefits⁵.

The Australian and Northern Territory Governments have designated 20 towns across the Territory as centres for providing services to Indigenous communities⁶. This approach has not delivered services equitably to remote communities⁷. More recently, the Northern Territory Government committed to improving services and living conditions for Indigenous people living on more than 500 homelands and outstations⁸.

The beef industry has also been an important source of employment on pastoral lands, with staff responsibilities extending to weed, feral animal and fire management⁹. Some pastoral operations also support Indigenous people by providing contract work¹⁰.



Working on Country funded Ranger groups, towns and population density

1 Australian Bureau of Statistics cat. no. 3218.0. Regional Population Growth, Australia, 2013-14.
 2 Altman, J.C. (2004) Economic development and Indigenous Australia: contestations over property, institutions and ideology^{*}. Australian Journal of Agricultural and Resource Economics, 48, 513-534.
 3 <http://www.environment.gov.au/indigenous/workingoncountry/> <http://www.agriculture.gov.au/biosecurity/australia/naqs>
 4 Australian Government (2015) Our North, Our Future: White paper on developing northern Australia.

5 Concu, N. (2013) Indigenous development through payments for environmental services in Arnhem Land, Australia: A critical analysis. Governing the Provision of Ecosystem Services (ed. by R. Muradian and L. Rival), pp. 171-189. Springer.
 6 Markham, F. & Doran, B. (2015) Equity, discrimination and remote policy: Investigating the centralization of remote service delivery in the Northern Territory. Applied Geography, 58, 105-115.
 7 Markham, F. & Doran, B. (2015) Equity, discrimination and remote policy: Investigating the centralization of remote service delivery in the Northern Territory. Applied Geography, 58, 105-115.
 8 <https://dlgs.nt.gov.au/homelands-and-remote-communities>
 9 Ash, A. & Smith, M.S. (2003) Pastoralism in tropical rangelands: seizing the opportunity to change. The Rangeland Journal, 25, 113-127.
 10 Priest, J. & Priest, M. (2015) MTP Contracting: Running a remote NRM business on the Barkly Tablelands. Innovation in the Rangelands: 18th Australian Rangeland Society Conference, Alice Springs.



Horticultural production also provides many jobs in the regions, but is largely dependent on temporary visa holders. The Australian Government has recently broadened visa conditions to increase the opportunities for producers to employ overseas workers. The Australian Government's Green Army initiative aims to provide employment in NRM jobs, but most funded projects are located in the populous areas of southern and eastern Australia.

PRESSURES/USES

Policies and funding

Natural resource management is beset by short-term funding cycles, which are an impediment to achieving enduring improvements to environmental conditions^{11, 12}. Indigenous people are also concerned that policies imposed by Australian and Northern Territory Governments have reduced the well-being of their communities and their capacity for environmental management and undertaking cultural obligations to country¹³. Policy changes outside a strategic framework can have unintended adverse effects¹⁴. An example is the recent change to working visa arrangements discounting

- 11 Dale, A.P., Crowley, G.M., Brewer, T., Andrews, K., Vella, K. & Potts, R. (in press) Governing the community based NRM domain in northern Australia: challenges and opportunities.
- 12 May, K. (2010) Government support for Indigenous cultural and natural resource management in Australia: The role of the Working on Country program. *The Australian Journal of Social Issues*, 45, 395-416.
- 13 Petheram, L., Zander, K.K., Campbell, B.M., High, C. & Stacey, N. (2010) 'Strange changes': Indigenous perspectives of climate change and adaptation in NE Arnhem Land (Australia). *Global Environmental Change*, 20, 681-692.
- 14 Dale, A.P. (2015) Time for the 'green tape' debate to mature: jobs and the environment are not implacable foes. *The Conversation*, August 25, 2015.

volunteer work, thereby reducing access of small horticultural operations to seasonal workers¹⁵.

Lack of access

Much of the Northern Territory is remote from the sealed road network and even sealed roads can be cut off by wet season rains¹⁶. Poor access not only affects the ability to access land to carry out cultural and natural resource management, but stresses remote communities and properties, by reducing access to basic services, such as food and health care.

Climate change & severe weather

Outdoor work can be challenging under the hot conditions that prevail through much of the Territory, and access can be difficult in the wet season. These difficulties are likely to intensify as the climate changes, with increase in heatwaves and rainfall extremes expected^{17, 18}. Road access is also likely to be affected by increased frequency of heavy storms and cyclones¹⁹.

- 15 <http://www.abc.net.au/news/2015-09-03/changes-second-working-holiday-visa/6742428>
- 16 Pollard, C. (2013) Selecting interventions for food security in remote Indigenous communities. *Food Security in Australia* (ed. by Q. Farnar-Bowers, V. Higgins and J. Millar), pp. 97-112. Springer.
- 17 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) *Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*. CSIRO and Bureau of Meteorology, Australia.
- 18 Bastin, G., Stokes, C., Green, D. & Forrest, K. (2014) *Australian rangelands and climate change—pastoral production and adaptation*. Ninti One Limited and CSIRO, Alice Springs.
- 19 CSIRO, Maunsell Australia Pty Ltd, and Phillips Fox, Infrastructure and climate change risk assessment for Victoria. 2007, CSIRO Report to the Victorian Government, Victorian Government.

Indicators

- Number of NRM enterprises
- Number of viable communities/outstations
- Economic status of communities and outstations
- Number of Indigenous ranger groups engaged in cultural and natural resource management
- Level of funding for Indigenous ranger programs
- Population statistics





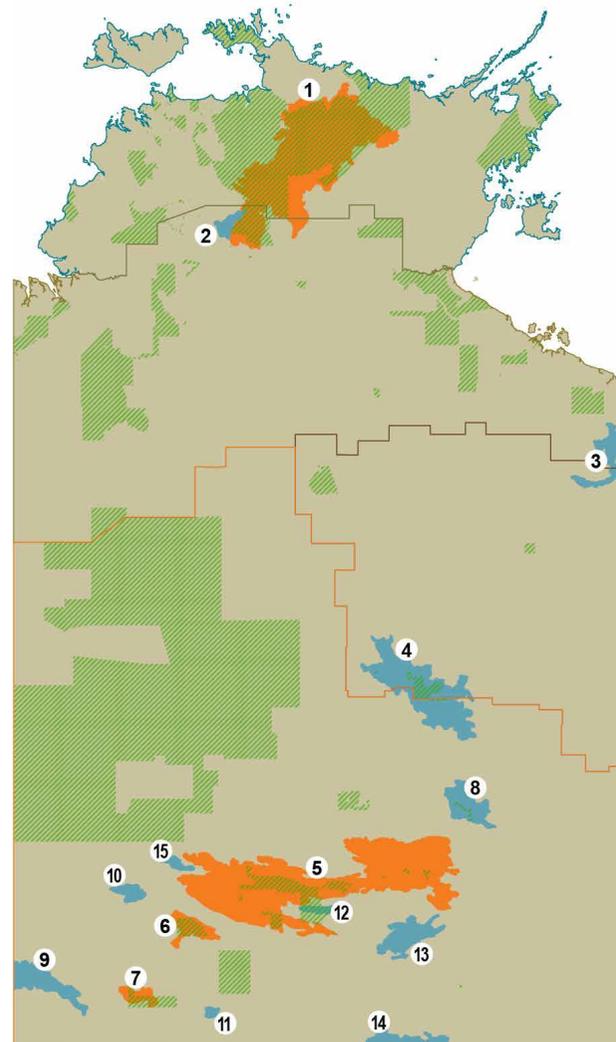
RANGES

DESCRIPTION

Ranges and plateaus are important habitats and refuges areas, and have significant cultural scenic values. Their gullies and gorges provide refugia for moisture-loving and fire-sensitive species. They influence the local climate, generating cloud formation and rainfall, and the runoff generated feeds streams, waterholes and swamps, providing wetland habitat for wildlife downstream.

Fifteen of the Northern Territory's Sites of Conservation Significance are ranges or plateaus (Table 1)¹. These include four sites of international significance. Most are in Central Australia, where they provide a striking contrast to extensive arid areas of low relief.

Many species are only found in ranges. These include MacDonnell Ranges Cycad and Black-footed Rock Wallaby in the Arid Lands, the Carpentarian Rock Rat and Carpentarian Grasswren at Wollogorang/China Wall, and the Arnhem Land Egernia and White-throated Grasswren on the Western Arnhem Plateau. These species persist in moist or fire-protected pockets.



- International significance
- National significance
- Protected areas



Black-footed Rock-wallaby

¹ Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M., and Lynch, B. (2009). An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Darwin, NT.

Sites of Conservation Significance which are ranges or plateaus

Table 1. Northern Territory's significant ranges

Site	Significance	Area (km ²)	Protected (%)	Notable features
Top End/Gulf Savanna				
1. Western Arnhem Plateau	International	32,000	59	Richest biodiversity in the Northern Territory, including 32 threatened and several endemic species. Numerous rainforest pockets, including most stands of <i>Allosyncarpia</i> .
Gulf Savanna				
2. Yinberrie Hills	National	1,025	7	Gouldian Finch habitat
Gulf Savanna/Tablelands				
3. Wollogorang & China Wall sandstone ranges	National	3,485	0	Rich sandstone fauna (Rock Ringtail Possum, Short-eared Rock-wallaby, Sandstone Antechinus, Carpentarian Grasswren and Carpentarian Rock-rat). Rich monsoon rainforest refugia.
Tablelands/Arid Lands				
4. Davenport & Murchison Ranges	Regional	10,885	10	Long-lasting and permanent waterholes that are refuges for a diverse range of arid land fish species and meet Ramsar criteria. Habitat for Central Rock-Rat and Black-footed Rock-wallaby. Devils Marbles.
Arid Lands				
5. Greater MacDonnell Ranges	International	31,326	10	At least 53 threatened species (including Marsh Club-rush, Slater's Skink, Central Rock-rat, Crest-tailed Mulgara and Southern Marsupial Mole) and 28 endemic species, notably land snails. Long-lasting and permanent springs and wetlands that meet Ramsar criteria.
6. George Gill Range & surrounds	International	1,990	43	Long-lasting and permanent springs and rock holes in sheltered gorges and gullies are refuges for restricted range and relictual species and meet Ramsar criteria. Eleven threatened species including Mala and Southern Marsupial Mole.
7. Uluru & surrounds	International	1,181	45	Pitjantjatjara sacred site. Habitat of nine threatened species (including Great Desert Skink, Brush-tailed Mulgara, Fawn Hopping-mouse and Southern Marsupial Mole). Rich reptile fauna.
8. Dulcie Range & surrounds	National	2,983	6	Long-lasting and permanent springs and waterholes in sheltered gorges and gullies are likely refuges for wetland species and meet Ramsar criteria.
9. Petermann Ranges & surrounds	National	3,392	0	Habitat of Black-footed Rock-wallaby, Brush-tailed Mulgara and Great Desert Skink. Only known location of <i>Goodenia rupestris</i> .
10. Cleland Hills & surrounds	National	1,027	0	Habitat of four threatened species, including largest known population of Long-tailed Dunnart in the Northern Territory.
11. Mount Conner & surrounds	National	338	0	Habitat of Dwarf Desert Spike-rush, Black-footed Rock-wallaby & Southern Marsupial Mole.
12. Waterhouse Range	National	573	80	Refuge area for Minnie Daisy, Slater's Skink, Black-footed Rock Wallaby and Australian Bustard.
13. Rodinga Range & adjacent ranges	National	3,324	0	Habitat of five threatened species, including Brush-tailed Mulgara and Crest-tailed Mulgara. Only known location of <i>Eremophila</i> sp. Arookara Range
14. Beddome Range & Wilyunpa Tablelands	National	3,392	0	Habitat of 11 threatened species, including Tjilpi Wattle, Plains Mouse, Thick-billed Grass-wren and Bronzeback Snake-lizard. Ephemeral waterholes and swamps of the Finke floodout forest meet Ramsar criteria.
15. Mount Liebig & surrounds	National	574	0	Permanent spring and associated wetland harbour restricted range and relictual plant species. Two plant species are known only from the site. Habitat for four threatened species (Black-footed Rock-wallaby, Brushtailed Mulgara, Southern Marsupial Mole and Great Desert Skink).

PRESSURES/USES

Ranges in the Northern Territory experience the same pressures and threats as the rest of the landscapes, but also face some particular challenges. Many of the sites of high cultural and biodiversity value are tucked away in gorges and gullies, where access is often difficult. Fire spread is exacerbated by terrain, and weed-spread along drainage lines is difficult to monitor and manage. Many ranges are also important for pastoral production. So it is important that production needs are balanced with cultural and biodiversity values.

Fire

Poor fire management is a threat to biodiversity and cultural values throughout much of the Territory. In the Arid Lands, intermittent periods of above average rainfall generate massive fuel loads and fires that can spread over hundreds of square kilometers. Fires can be particularly intense in ranges, where fires spread rapidly up steep terrain. Fires are also fuelled by exotic pasture grasses, such as Buffel Grass.

On the Arnhem plateau, fires have reduced the size of rainforest patches² and are a key threat to heathlands³. Many threatened species also need protection from fires, and while ranges also provide refugia, strategic early dry season burning is needed to reduce fire extent. Fire-sensitive species include Graveside Gorge Acacia, Gouldian Finch and MacDonnell Ranges Cycad.

- 2 Russell-Smith, J., and Bowman, D. M. J. S. (1992). Conservation of monsoon rainforest isolates in the Northern Territory, Australia. *Biological Conservation* 59, 51-63.
- 3 Russell-Smith, J., Ryan, P. G., and Cheal, D. C. (2002). Fire regimes and the conservation of sandstone heath in monsoonal northern Australia: frequency, interval, patchiness. *Biological Conservation* 104, 91-106.

Invasive weeds

Weeds are as much of a management issue in ranges as they are throughout the rest of the Northern Territory. However, their control can be most challenging in remote and rugged ranges, as access can be difficult.

The most significant weeds in ranges are pasture grasses that replace native vegetation and generate intense fires⁴ and species that spread along drainage lines. Of the former, Buffel Grass is particularly problematic in many of the Arid Land sites⁵, where its impacts could be minimised through development and adoption of a code of practice⁶. Of the latter, Athel Pine is an issue in the Greater MacDonnell Ranges and Mesquite on the West Arnhem plateau. Control of these weeds is ongoing and needs continuing support.



- 4 Department of Sustainability, Environment, Water, Population and Communities (2012) Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses. Commonwealth of Australia.
- 5 Smyth, A., Friedel, M. & O'Malley, C. (2009) The influence of buffel grass (*Cenchrus ciliaris*) on biodiversity in an arid Australian landscape. *The Rangeland Journal*, 31, 307-320.
- 6 Grice, A.C., Friedel, M.H., Marshall, N.A., and Van Klinken, R.D. (2012). Tackling contentious invasive plant species: A case study of buffel grass in Australia. *Environmental Management* 49, 285-294.

Feral Animals

Feral animals are a problem through most of the Northern Territory, including in the ranges. The Western Arnhem Plateau is stronghold for Water Buffalo which have caused substantial damage to streams and wetlands. Pig damage is evident in many gorges through Wollogorang and China Wall and is affecting recruitment of rainforest species. Camels, donkeys and horses have caused major damage to many of the Arid Lands sites. Introduced crustaceans and three species of introduced fish are present and affecting native fish habitat in the Davenport Ranges⁷. Indigenous rangers and other landholders have invested many resources in controlling feral animals⁸. Some of these efforts have been effective, but sustained efforts are required. Numbers of camels have been reduced, but vigilance is required to prevent large populations from re-establishing⁹.

- 7 Duguid, A., Barnetson, J., Clifford, B., Pavey, C., Albrecht, D., Risler, J., and McNellie, M. (2005). Wetlands in the arid Northern Territory. A report to Environment Australia on the inventory and significance of wetlands in the arid NT. Parks and Wildlife Commission of the Northern Territory, Alice Springs.
- 8 Altman, J.C., and Whitehead, P.J. (2003) Caring for country and sustainable Indigenous development: Opportunities, constraints and innovation. Centre for Aboriginal and Economic Policy Research, Canberra.
- 9 McGregor, M., Hart, Q., Bubba, A., and Davies, R. (Eds) (2013). Managing the impacts of feral camels across remote Australia – final report of the Australian Feral Camel Management Project. Ninti One Limited.

Primary industries

While substantial portions of some sites are under conservation management, most are managed for pastoralism. Ranges are vulnerable to overgrazing and resultant erosion. Adoption of sustainable grazing practices are therefore essential to maintain cultural and biodiversity values¹⁰. These include maintaining a good cover of perennial grasses and periodic spelling of paddocks in the wet season¹¹. Water points should not only be strategically placed to spread grazing pressures, but to ensure some water-remote areas remain ungrazed¹². Where this is not possible, high-conservation-value areas should be fenced to exclude cattle. Exclusion of cattle from gorges and waterholes is particularly important to protect cultural values and water quality, both in the Arid Lands and at Wollogorang and China Wall. Integrated property planning should be undertaken to balance pastoral production with biodiversity conservation.

Tourism and associated infrastructure

The high scenic and conservation values of ranges often attract tourists. Highly frequented areas can be spoiled by waste, and access tracks can be eroded. Water extraction, pollution from sewerage and weed invasions associated with tourism infrastructure can also adversely affect nearby environments. These threats can usually be addressed in management plans.

10 Fisher, A. & Kutt, A.S. (2006) Biodiversity and land condition in tropical savanna rangelands: summary report. Tropical Savannas CRC, Darwin.

11 Walsh, D., Kain, A. & Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Alice Springs region of the Northern Territory. Northern Territory Government.

12 James, C.D., Landsberg, J. & Morton, S.R. (1999) Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments* 41, 87-121.

Feral animals

Feral grazing animals, such as rabbits, donkeys, horses, buffalo and camels, degrade pastoral values by adding to total grazing pressure¹³. This further reduces the quality of habitat for native species, and exposes the soil to erosion. These animals also degrade waterholes and wetlands by trampling and selective grazing on wetland plants. Large feral animals can damage fences, interfering with efforts to control livestock movements and grazing pressure. Cats and foxes are significant predators of native species, which benefit from a reduction in their numbers. Feral animal control needs to be both strategic and sustained, reducing animal numbers below threshold levels. Collaboration and coordination between managers of neighbouring properties will reap the best results.

Management capacity

As with managing other environmental assets, limited numbers of people and management resources limit management capacity¹⁴. Investment in Indigenous ranger programs, with targeted training, is essential to ensure the presence of an effective workforce to undertake many of the tasks that are required. Pastoral landholders also need extension support to help them understand and adopt sustainable practices, and financial support to undertake management that is beyond their duty-of-care obligations, such as fencing out land for conservation purposes or undertaking landscape-scale weed and feral animal management. Cross-tenure and cross-property

13 Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A. & Watson, I. (2004) Review of total grazing pressure management issues and priorities for biodiversity conservation in rangelands: A resource to aid NRM planning. Desert Knowledge CRC, Alice Springs, and Tropical Savannas Management CRC., Darwin.

14 Bowman and Prior 2004; Bowman et al. 2001, 2004

collaboration will increase the effectiveness of the management capacity that does exist. This is particularly important for weed, fire and feral animal management.

Climate change & extreme weather

Much of the top half of the Northern Territory has recently been subjected to drought conditions, which has put stress on pastoral enterprises and pasture condition. Climate change is expected to increase the intensity of droughts, and even where rainfall remains stable, increased temperatures may create drought-like conditions¹⁵. Frequency of cyclones and torrential rains are also expected, increasing erosion risk. While managers have little capacity to influence the climate, they can improve the resilience of natural and production systems to such conditions by maintaining the landscape in good condition. This means managing weeds, fire and feral animals and adopting sustainable grazing practices, as described above. Torrid climatic conditions will also make working conditions uncomfortable, and potentially unsafe, for much of the year¹⁶.

15 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.

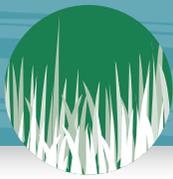
16 Green, D., Jackson, S., and Morrison, J. (Eds) (2009) 'Risks from Climate Change to Indigenous Communities in the Tropical North of Australia.' A scoping study for the Commonwealth Department of Climate Change and Energy Efficiency, the Western Australian Department of the Environment and Conservation and the Northern Territory Department of Natural Resources (Commonwealth of Australia).

Indicators

- Number of ranges identified as Sites of Conservation Significance being managed for conservation values
- Number of Indigenous ranger groups actively managing these sites
- Number of active weed management plans and codes of practice on these sites
- Number of active feral animal management plans on these sites
- Number of conservation agreements on pastoral lands on these sites that include:
 - livestock exclusion from high conservation value areas
 - retention of water in remote areas
 - control of grazing pressure through moderate stocking rates and/or wet season spelling
- Extent of Buffel Grass on non-pastoral land (Arid Lands)
- Number of waterholes fenced to exclude livestock and feral animals
- Patterns of fire seasonality and extent in ranges

Western Macdonnell Ranges





GRASSLANDS/RANGELANDS

DESCRIPTION

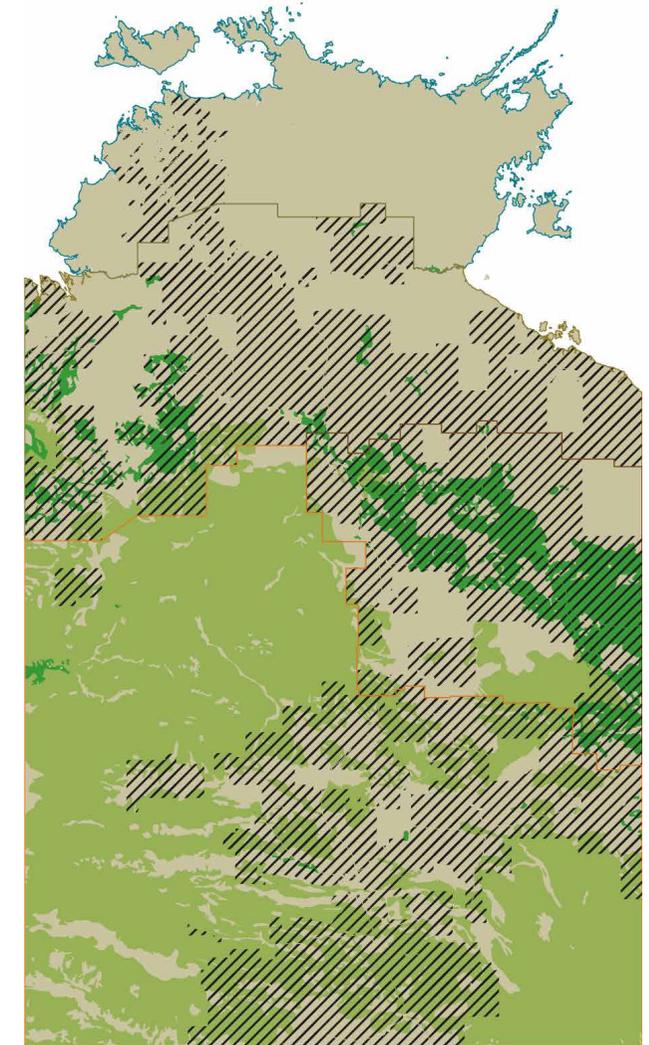
Nearly half the land area of the Northern Territory is used for grazing cattle in open rangelands¹. The premier grazing lands of the Territory are the tussock grasslands of the Barkly Tablelands and parts of the Victoria River District. Elsewhere in the top half of the Territory, grazing is undertaken in Eucalypt woodlands and open woodlands that have an understorey of perennial and annual grasses². Arid Lands grazing lands are mainly spinifex grassland or acacia shrubland with an understorey of spinifex and other grasses.

Mitchell grasslands are the most productive grazing lands, and carry most of the Territory's cattle. Their fertile heavy clay cracking soils inhibit the establishment of trees, although fire and extreme climate can also be a cause of treelessness. These landscapes are robust and are generally in good condition.

Spinifex dominates the Arid Lands rangelands, either forming extensive hummock grasslands or the understorey beneath acacias and desert oak. These rangelands have shallow, sandy soils and experience long dry periods, broken by intense rainfall followed by extensive fires. They are sensitive to overgrazing and some areas have been severely degraded. Their soils can blow and wash away once the ground cover is removed by overgrazing.

Rangelands have conservation as well as production values (Table 2). Significant examples include the Gouldian Finch habitat of the Yinberrie Hills, which supports the largest known breeding population of this species, and the Flock Bronzewing habitat on the Mitchell Grass across the Tablelands region. Several grassland species, such as the Australian Painted Snipe and Night Parrot, are elusive and may be more widespread than appears.

Not all grasslands are used for pastoralism. Much of the spinifex grasslands of the Tanami, Sandy and Simpson deserts are too dry to support grazing enterprises, and Arnhem Land's rugged terrain has impeded pastoral development. Thirty-four of the Northern Territory's 67 Sites of Conservation Significance contain grasslands, often within a complex of other vegetation types³. Grasslands across extensive coastal floodplains are significant for their congregations of migratory waders and waterbirds, and as habitat for threatened species, including the Alligator Rivers Yellow Chat. Barkly lakes also periodically support large congregations of waterbirds, and are important habitat for black-soil dependent fauna, and provide a stronghold for the Flock Bronzewing. Spinifex grasslands provide habitat for many Arid Land threatened species, several of which have declined to the extent that they are rarely seen.



■ Spinifex Grassland ▨ Grazing
■ Tussock Grassland

Grassland types and area under formal grazing in the NT

1 Owen, G. and Meakin, C. (2003) Land Use Mapping of the Northern Territory. Prepared for the Northern Territory Department of Infrastructure, Planning and Environment. Northern Territory. Australia.
2 Wilson, B., Brocklehurst, P., Clark, M., and Dickinson, K. (1990) Vegetation survey of the Northern Territory, Australia. Conservation Commission of the Northern Territory Technical Report 49.

3 Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M. and Lynch, B. (2009) An inventory of sites of international and national significance for biodiversity values in the Northern Territory. Department of Natural Resources, Environment, The Arts and Sport, Darwin, NT.



Table 2. Examples of threatened species dependent on grassland and grassy woodland habitat

Conservation status: CE = Critically Endangered, EN = Endangered, V = Vulnerable, DD = Data Deficient, LC = Least Concern⁴

Species	Status		Key sites			
	NT	National	Top End	Gulf Savanna	Tablelands	Arid Lands
Australian Bustard <i>Ardeotis australis</i>	V	LC		Daly River VRD	Barkly	Tanami
Singing Bushlark <i>Mirafra javanica melvillensis</i>	V	LC	Tiwi Islands			
Alligator Rivers Yellow Chat <i>Epthianura crocea tunneyi</i>	EN	V	Adelaide/Alligator Rivers floodplains			
Northern Hopping Mouse <i>Notomys aquilo</i>	V	V	Eastern Arnhem Land			
Partridge Pigeon Geophaps smithii smithii	V	V	Western Top End, Tiwi Islands			
Gouldian Finch <i>Erythrura gouldiae</i>	V	EN		Yinberrie Hills		
VRD Blacksoil Ctenotus <i>Ctenotus rimacola camptris</i>	V	LC		Ord/Keep Rivers floodplains		
Flock Bronzewing <i>Phaps histrionica</i>	NT	LC			Mitchell Grass	
Australian Painted Snipe <i>Rostratula benghalensis australis</i>	V	EN			Tarrabool Lake, Lake Woods	
Night Parrot <i>Pezoporus occidentalis</i>	CE	EN				Unknown
Plains Wanderer <i>Pedionomus torquatus</i>	DD	V				Unknown
Sandhill Dunnart <i>Sminthopsis psammophila</i>	DD	EN				Unknown
Greater Bilby <i>Macrotis lagotis</i>	V	V				Tanami
Mulgara <i>Dasycercus cristicauda</i>	V	EN				Simpson Desert
Great Desert Skink <i>Egernia kintorei</i>	V	V				Tanami, Uluru

⁴ <https://landresources.nt.gov.au/flora-fauna>

PRESSURES/USES

Maintaining the condition of rangelands and grasslands is important for both biodiversity conservation and pastoral production. There are significant challenges for both, and in most cases, efforts to protect and improve grazing land condition will also benefit biodiversity. However, there are some situations in which either biodiversity or production need to be prioritised.

Fire

Fire is an important shaper of landscapes, and can either be a threat or a management tool⁵. Disruption to fire regimes has contributed to loss of biodiversity and the degradation of grazing lands. Restoring fire regimes by reducing their frequency, severity and extent is important for many species and helps regenerate pasture. A patchy fire regime will provide shelter for species that like to feed in the open, but also need protection from predators, such as cats. Species that are particularly vulnerable to extensive fires include the Gouldian Finch, Partridge Pigeon, Northern Quoll and Brush-tailed Phascogale in the northern subregions and Carpentarian Grasswren and Carpentarian Antechinus in the western parts of the Gulf Savanna and Barkly Tablelands. In the Victoria River District (VRD), hot fires are required to maintain pastures where woody species, such as Nutwood and Rosewood, have increased in abundance.

⁵ Dyer, R., Jacklyn, P., Partridge, I., Russell-Smith, J. & Williams, R. (2001) Savanna Burning: understanding and using fire in northern Australia. Tropical Savannas Cooperative Research Centre, Darwin.



Invasive weeds

Several introduced grasses have become a problem in the Northern Territory because of their ability to entirely transform native vegetation and generate intense fires⁶. This includes Gamba Grass and Mission Grass in the Top End. The fires generated by these grasses destroy canopy trees. In the Arid Lands, Buffel Grass - a useful pasture grass - is also changing fire regimes to the detriment of native species⁷. These transformer grasses promote high intensity fires, leading to ecosystem degradation, habitat loss and species declines.

The other significant species are those that proliferate along drainage lines. Mimosa has transformed large areas of near-coastal floodplains in the Top End, displacing native species and reducing pasture quality⁸. Similarly, Parkinsonia, Prickly Acacia and Mesquite have invaded drainage lines in the Tablelands subregion, and - along with Rubber Bush - are also establishing across the blacksoil plains⁹. Control efforts of landholders are being successful at reducing these weeds, but need to be sustained to ensure they do not re-establish.

6 Department of Sustainability, Environment, Water, Population and Communities (2012) Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses. Commonwealth of Australia.

7 Smyth, A., Friedel, M. & O'Malley, C. (2009) The influence of buffel grass (*Cenchrus ciliaris*) on biodiversity in an arid Australian landscape. *The Rangeland Journal*, 31, 307-320.

8 Bailey, K. (2009) Review of Progress Towards the National Mimosa Strategic Plan 2008–2009. National Mimosa Management Committee for the Department of Natural Resources Environment, the Arts and Sport, Alice Springs.

9 Walsh, D. & Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Barkly Tableland region of the Northern Territory. Northern Territory Government

Primary industries

Pastoralism, by its nature, places pressure on grassland-reliant species, as cattle preferentially graze the most palatable species, remove cover, forage and seed used by native animals, and - in some cases - promote shrub and tree growth. These pressures are greatest close to watering points¹⁰. Sustainable grazing practices, including maintaining a good cover of perennial grasses and periodic spelling of paddocks in the wet season^{11,12,13,14}, benefit most native species¹⁵. However, with ongoing pastoral expansion and intensification, it is important for some areas in all landscapes to be precluded from grazing. This can be achieved through fencing high-conservation-value areas and strategic placement of water points. Integrated property planning can cater for the needs of both pastoral production and biodiversity conservation.

10 James, C.D., Landsberg, J. & Morton, S.R. (1999) Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments*, 41, 87-121.

11 DRDPiFR (2013) Cattle and land management best practices in the Top End region. Department of Regional Development Primary Industry Fisheries and Resources, Northern Territory Government

12 Walsh, D. & Cowley, R.A. (2013) Best-bet practices for managing grazing lands in the Victoria River District of the Northern Territory: A technical guide to options for optimising land condition, animal production and profitability Northern Territory Government.

13 Walsh, D. & Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Barkly Tableland region of the Northern Territory. Northern Territory Government

14 Walsh, D., Kain, A. & Cowley, R.A. (2014) Best-bet practices for managing grazing lands in the Alice Springs region of the Northern Territory. Northern Territory Government.

15 Fisher, A. & Kutt, A.S. (2006) Biodiversity and land condition in tropical savanna rangelands: summary report. Tropical Savannas CRC, Darwin.

Feral animals

Feral grazing animals, such as rabbits, donkeys, horses, buffalo and camels, degrade pastoral values by adding to total grazing pressure¹⁶. This further reduces the quality of habitat for native species, and exposes the soil to erosion. These animals also degrade waterholes and wetlands by trampling and selective grazing on wetland plants. Large feral animals can damage fences, interfering with efforts to control livestock movements and grazing pressure. Cats and foxes are significant predators of native species, which benefit from a reduction in their numbers. Feral animal control needs to be both strategic and sustained, reducing animal numbers below threshold levels. Collaboration and coordination between managers of neighbouring properties will reap the best results.

16 Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A. & Watson, I. (2004) Review of total grazing pressure management issues and priorities for biodiversity conservation in rangelands: A resource to aid NRM planning. Desert Knowledge CRC, Alice Springs, and Tropical Savannas Management CRC., Darwin.



Climate change & extreme weather

Much of the top half of the Northern Territory has recently been subjected to drought conditions, which has put stress on pastoral enterprises and pasture condition. Climate change is expected to increase the intensity of droughts, and even where rainfall remains stable, increased temperatures may create drought-like conditions¹⁷. Frequency of cyclones and torrential rains are also expected, increasing erosion risk. While managers have little capacity to influence the climate, they can improve the resilience of natural and production systems to such conditions by maintaining the landscape in good condition. This means managing weeds, fire and feral animals and adopting sustainable grazing practices, as described above.

Indicators

- Condition of native pastures, notably perennial grass cover
- Proportion of extent of soft native perennials
- Presence and abundance of grazing sensitive and grassland dependent species
- Extent of Buffel Grass on non-pastoral land (Arid Lands)
- Fire extent, season and patchiness
- Extent of long-unburnt areas

¹⁷ Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.





IMPORTANT SITES

DESCRIPTION

Indigenous Australians have a strong connection to country. Their traditional land- and seascapes hold the meaning of existence, ancestry and identity, and provide spiritual and material sustenance¹. Within these estates are sacred sites that may be story-places shaped by the activities of ancestral beings, sites where ancestors were born or buried, places where ceremonies are held or where rock art has been painted.

Sacred sites are features in the landscape - rocks, trees, hills or waterholes - but they exist in the context of a wider cultural landscape, providing meaning and connection to country². These relationships are frequently represented in Aboriginal art.

Language is also inextricably linked to Indigenous cultural landscapes³. Indigenous languages represent “a great storehouse of knowledge and tradition about the environment and ancient culture”⁴. There are at least 40 language groups in the Northern Territory^{5,6}, each with

their own traditional estates, rights and customs⁷, and many of them are endangered.

Traditional Owners have obligations to respect, visit, manage and perform ceremonies on country^{8,9,10}. These obligations are handed down through generations along with traditional knowledge about the past and how to live in the landscape. Indigenous people are also increasingly incorporating western approaches into their management, while still performing traditional cultural management^{11,12,13,14}.



- 1 Layton, R. (1997) Representing and translating people's place in the landscape of Northern Australia. Pp 122-143 in *After writing culture: epistemology and praxis in contemporary anthropology*. Edited by A. Dawson, J. Hockey and A. James. Routledge.
- 2 Faulstich, P. (1998) Mapping the mythological landscape: An aboriginal way of being-in-the-world. *Philosophy & Geography*, 1, 197-221.
- 3 Biddle, N. & Swee, H. (2012) The relationship between wellbeing and Indigenous land, language and culture in Australia. *Australian Geographer*, 43, 215-232.
- 4 McConvell, P. & Thieberger, N. (2001) State of Indigenous Languages in Australia - 2001. Australia State of the Environment Technical Paper Series (Natural and Cultural Heritage), Series 2. Department of the Environment and Heritage, Canberra
- 5 Dixon, R.M.W. (2011) *The languages of Australia*. Cambridge University Press.
- 6 Horton, D.R. (1996) Aboriginal Australia wall map. In. Australian Institute of Aboriginal and Torres Strait Islander Studies & Auslig/ Sinclair, Knight, Merz, Canberra.

- 7 Hill, R., Pert, P., Davies, J., Robinson, C., Walsh, F. & Falco-Mammone, F. (2013) Indigenous land management in Australia: Extent, scope, diversity, barriers and success factors. CSIRO Ecosystem Sciences, Cairns.
- 8 Russell-Smith, J., Lucas, D., Gapindi, M., Gunbunuka, B., Kapirigi, N., Namingum, G., Lucas, K., Giuliani, P. & Chaloupka, G. (1997) Aboriginal resource utilisation and fire management practice in western Arnhemland, monsoonal northern Australia. Notes for prehistory, lessons for the future. *Human Ecology*, 25, 159-195.
- 9 Burgess, C.P., Johnston, F.H., Bowman, D.M.J.S. & Whitehead, P.J. (2005) Healthy Country: Healthy People? Exploring the health benefits of Indigenous natural resource management. *Australian and New Zealand Journal of Public Health*, 29, 117-122.
- 10 Johnson, S. (2009) Kantri is for Laif: a Strategy for the Promotion of Indigenous Knowledge and the Development of Indigenous Livelihoods on the Remote north Australian Indigenous Estate. In. A LWA, CRC-TSM and NAILSMA Project Initiative
- 11 Fitzsimons, J.A. & Wescott, G. (2004) The classification of lands managed for conservation: existing and proposed frameworks, with particular reference to Australia. *Environmental Science & Policy*, 7, 477-486.
- 12 Gorman, J. & Vemuri, S. (2012) Social implications of bridging the gap through 'caring for country' in remote Indigenous communities of the Northern Territory, Australia. *The Rangeland Journal*, 34, 63-73.
- 13 Muller, S. (2012) Two Ways: Bringing indigenous and non-indigenous knowledges together. *Country, native title and ecology* (ed. by J.K. Weir), pp. 59-79. Australian National University e-press and Aboriginal History Incorporated (Monograph 24), Canberra.
- 14 Preuss, K. & Dixon, M. (2012) 'Looking after country two-ways': Insights into Indigenous community-based conservation from the Southern Tanami. *Ecological Management & Restoration*, 13, 2-15



IMPORTANT SITES

Some landscapes are recognised as being nationally or internationally significant because of their stunning scenery, unique landforms and largely intact Indigenous culture. Kakadu National Park and Uluru Kata Tjuta are World Heritage listed for these reasons¹⁵. Wurrwurrwy stone arrangements is also one of the few places to be listed on the National Heritage list¹⁶. Other sites are recognised because of their place in the history of contact between Aboriginal people and Europeans. Wave Hill and Hermannsburg are included for this reason. Several other sites are listed on the Northern Territory Heritage Register because of their significance to either Indigenous or non-Indigenous Territorians.

Nearly 50 Indigenous ranger groups operate across the Northern Territory¹⁷. Most are supported by the land councils or receive funding from the Australian Government. They undertake standard forms of natural resource management, including fire, weed and feral animal management, biosecurity surveillance and marine debris collection. They also perform Caring for Country activities, such as hunting and harvesting wildlife, undertaking ceremony, traditional knowledge transfer and producing art and crafts¹⁸. These activities also

have demonstrated health benefits¹⁹. Many Traditional Owner groups wanting their land or seas to be managed for cultural and natural resource management into the future have declared Indigenous Protected Areas, which now make up the majority of the conservation estate in the Northern Territory. Co-management arrangements on government controlled land are also providing opportunities for Indigenous people to 'Care for Country'²⁰.

Cultural mapping is enabling Traditional Owners to demonstrate their connection to land and Native Title rights²¹. It is also helping to ensure these sites are looked after and that traditional knowledge is passed on to the younger generation. Custodians of sacred sites can request the sites be included on the Northern Territory Sacred Sites Register to protect them from being damaged by inappropriate development²². Over 2,000 sacred sites are currently included in this register.



Elders planning for country



15 DEWHA (2010). Australia's National Heritage. Department of the Environment, Water, Heritage and the Arts, Canberra.

16 <https://www.environment.gov.au/heritage/places/national-heritage-list>

17 www.environment.gov.au/indigenous/workingoncountry/projects/nt/index.html; www.nailsma.org.au/working-together/map-indigenous-land-and-sea-managers-north-australia; www.nlc.org.au/articles/info/ranger-programs1/; www.clc.org.au/articles/info/clc-rangers1

18 Morrison, J. (2007). Caring for country. Coercive reconciliation. Stabilise, normalise, exit Aboriginal Australia. Melbourne: Arena Publications Association, 249-261.

19 Burgess, C.P., F.H. Johnston, D.M.J.S. Bowman, and P.J. Whitehead (2005) Healthy Country: Healthy People? Exploring the health benefits of Indigenous natural resource management. *Australian and New Zealand Journal of Public Health* 29, 117-122.

20 Ross, H., Grant, C., Robinson, C. J., Izurieta, A., Smyth, D., and Rist, P. (2009). Co-management and Indigenous protected areas in Australia: achievements and ways forward. *Australasian Journal of Environmental Management* 16, 242-252.

21 Strang, V. (2010). Chapter 7. Mapping histories: cultural landscapes and walkabout methods. pp. 132-156 in *Environmental social sciences: methods and research design*. Edited by I. Vaccaro, E.A. Smith and S. Aswani. Cambridge University Press: Cambridge.

22 www.aapant.org.au/sacred-sites



PRESSURES/USES

Disruption to Indigenous land management, particularly fire management, and introduction of exotic plants and animals has degraded cultural landscapes, and prevented Indigenous people from undertaking their obligation to country. Capacity to Care for Country is gradually being restored with the funding of ranger groups. Other challenges include urban, industrial and mining development, visitor management and climate change.

Fire

Since European settlement, fires have become more extensive in many parts of the Northern Territory and less frequent in others²³. Uncontrolled fire can also damage cultural sites, especially rock art²⁴. Reinstatement of fire management practices that meet cultural obligations is important for restoring natural and cultural values²⁵, and is being assisted by funding for ranger programs and carbon abatement projects²⁶.

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- 23 Russell-Smith, J., Yates, C., Edwards, A., Allan, G. E., Cook, G. D., Cooke, P., Craig, R., Heath, B., and Smith, R. (2003). Contemporary fire regimes of northern Australia, 1997–2001: change since Aboriginal occupancy, challenges for sustainable management. *International Journal of Wildland Fire* 12, 283-297.
 - 24 Ward, G.K. (1993). Conservation of rock imagery in Australia: Funding support, protection projects and related research. *Rock Art Research* 10, 65-67.
 - 25 Vaarzon-Morel, P., and Gabrys, K. (2009). Fire on the horizon: contemporary Aboriginal burning issues in the Tanami Desert, central Australia. *GeoJournal* 74, 465-476.
 - 26 Whitehead, P. J., Purdon, P., Russell-Smith, J., Cooke, P. M., and Sutton, S. (2008). The management of climate change through prescribed savanna burning: emerging contributions of Indigenous people in Northern Australia. *Public Administration and Development* 28, 374-385.

Invasive plants

The most significant weeds in the Northern Territory are weeds that transform large tracts of habitat. These include some of the most vigorous pastoral grasses (e.g. Gamba Grass, Buffel Grass and Para Grass) and the prickly bushes. Weeds are generally less abundant on Indigenous-held lands than on lands of other tenure types²⁷, but are still an issue²⁸. Weed management is one of the main roles undertaken by Indigenous ranger groups in the Territory²⁹.

Feral animals

Feral pigs, cattle, camels, horses, donkeys and buffalo degrade landscapes by reducing ground cover, causing erosion and fouling waterways³⁰. They pose a particular threat to springs and waterholes, many of which are sacred sites³¹. People are needed on country to manage feral animals, whose numbers can be particularly high

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- 27 Preece, N., Harvey, K., Hempel, C., and Woinarski, J. C. Z. (2010). Uneven distribution of weeds along extensive transects in Australia's Northern Territory points to management solutions. *Ecological Management & Restoration* 11, 127-134.
 - 28 Gardener, M. (2005). Towards more strategic management of weeds on Top End Aboriginal Lands. Tropical Savannas CRC, James Cook University, Townsville.
 - 29 Smith, N., and Northern Land Council (2002). 'Not from here: Plant invasions on Aboriginal lands of the Top End.' (Tropical Savannas CRC)
 - 30 Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A. & Watson, I. (2004) Review of total grazing pressure management issues and priorities for biodiversity conservation in rangelands: A resource to aid NRM planning. Desert Knowledge CRC, Alice Springs, and Tropical Savannas Management CRC., Darwin.
 - 31 Jackson, S., and Altman, J. (2009). Indigenous rights and water policy: perspectives from tropical northern Australia. *Australian Indigenous Law Review* 13, 27-48.

on National Parks³². However, some feral animals have also been incorporated in Indigenous culture, so it is important that the values people hold for the animals and the animals' impacts are considered in consultative control programs³³.

Mining and energy production

Mining ventures can provide opportunities and income to underwrite Indigenous land management. However, there are also considerable disadvantages to mining, notably the impact on cultural sites and landscapes and social disruption^{34, 35}. Traditional Owners do not always have the ability to understand impacts or the power to prevent them³⁶. Protection of cultural heritage and generation of social benefits need to be negotiated as part of development approvals³⁷, and governance systems in place to ensure these outcomes are delivered³⁸.

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- 32 Woinarski, J. C. Z., Green, J., Fisher, A., Ensby, M., and Mackey, B. G. (2013). The effectiveness of conservation reserves: Land tenure impacts upon biodiversity across extensive natural landscapes in the tropical savannahs of the Northern Territory, Australia. *Land* 2, 20-36.
 - 33 Robinson, C. J., and Wallington, T. J. (2012). Boundary work: engaging knowledge systems in co-management of feral animals on Indigenous lands. *Ecology and Society* 17, 16.
 - 34 O'Faircheallaigh, C. (2008). Negotiating Cultural Heritage? Aboriginal-Mining Company Agreements in Australia. *Development and Change* 39, 25-51
 - 35 Taylor, A., and Carson, D. B. (2014). It's raining men in Darwin: Gendered effects from the construction of major oil and gas projects. *Journal of Rural and Community Development*: 9, 24-40.
 - 36 Howitt, R. (2002). *Rethinking resource management: justice, sustainability and indigenous peoples*. Routledge, London.
 - 37 Langton, M. (2013). *Boyer Lectures 2012: The quiet revolution: Indigenous people and the resources boom*. HarperCollins, Australia.
 - 38 Dale, A. P. (2014). *Beyond the north-south culture wars: Reconciling northern Australia's past with its future*. Springer, London.



IMPORTANT SITES

Residential and commercial development

Inappropriate residential or commercial development can put pressure on cultural sites and landscapes³⁹. As well as causing direct physical damage, development often results in water extraction and weed introduction. Water quality of sacred sites can also be affected by poor management of wastewater, stormwater, sewage, and catchment modification associated with such developments. These issues are a particular concern for rapid development associated with mining, oil and gas developments. Some of these issues can be averted by developers negotiating with Traditional Owners and using best-practice management to minimise adverse impacts. As with mining, lack of negotiating power and governance frameworks are an issue for residential and commercial development.

Recreation & other activities

Numerous Indigenous rock art sites attract many visitors each year, providing an opportunity to build cross-cultural appreciation. However, unrestricted access to sites may breach customary law or result in sites being damaged and their environments degraded. Sensitive areas must be clearly marked as off-limit. Subtle means can be used to restrict visitor access as necessary and prevent damage⁴⁰. The appearance of active management, such as evidence of an active ranger group, is one of the most effective deterrents to will-full damage.

39 Barber, M., and Jackson, S. (2011). Aboriginal water values and resource development pressures in the Pilbara region of north-west Australia. *Australian Aboriginal Studies* 2, 32-49.

40 Ward, G. K. (1993). Conservation of rock imagery in Australia: Funding support, protection projects and related research. *Rock Art Research* 10, 65-67.

Management capacity

Restoration of cultural landscapes and protection of cultural sites requires active management to fulfil cultural obligations and manage fire, weeds and feral animals. While funding for ranger groups has increased in recent years, only a few rangers are employed in each organisation. The Australian Government has stated a commitment to ongoing funding for land and sea management, and this is being bolstered by carbon abatement programs and fee-for-service activities, such as biosecurity surveillance and ghost net removal. However, additional sources of funding are required if a significant proportion of Indigenous communities are to be employed in Caring for Country activities.

Loss of knowledge/lack of access

Caring for Country activities require access to land and seas, which can be difficult in rugged and remote areas, or in the wet season, when roads are cut. Some roads may need to be upgraded or sealed and groups need resources to enable them to access the most difficult areas⁴¹. Access to cultural sites on leasehold land may also require an Indigenous Land Use and Access Agreement. Sustainable economic development in remote Indigenous communities, particularly the provision of housing, infrastructure, and accessible jobs and training, are likely to ensure that the landscape continues to be both populated and managed⁴².

41 Northern Australia Land and Water Taskforce (2009). Sustainable development of northern Australia: A report to Government from the Northern Australia Land and Water Taskforce.

42 Altman, J., N. Biddle, and G. Buchanan (2012) *The Indigenous hybrid economy: can the NATSISS adequately recognise difference*, in *Survey Analysis for Indigenous Policy in Australia: Social Science Perspectives*. ANU ePress Canberra. p. 163-192.

Loss of knowledge has had a significant impact on the capacity of Indigenous people to manage cultural landscapes and sites⁴³. Projects to protect and transfer Indigenous Ecological Knowledge in the Northern Territory have been highly successful, but there is further work to be done⁴⁴.

Climate Change

Climate change projections for the Northern Territory include increases in: temperature, frequency of cyclones, droughts and floods, and fire intensity; as yet unknown changes in average annual rainfall; and sea level rise⁴⁵. As well as degrading landscapes and potentially damaging sites, and preventing access following floods, these changes will mean working conditions will be uncomfortable, and potentially unsafe for long periods of time.

43 State of the Environment 2011 Committee (2011). Australia state of the environment 2011. Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities. Australian Government, Canberra.

44 Moxham, N., and Mitchell, P. (2011). Indigenous Ecological Knowledge Program NT 2007 – 2010. Evaluation September 2011. Territory NRM, Darwin.

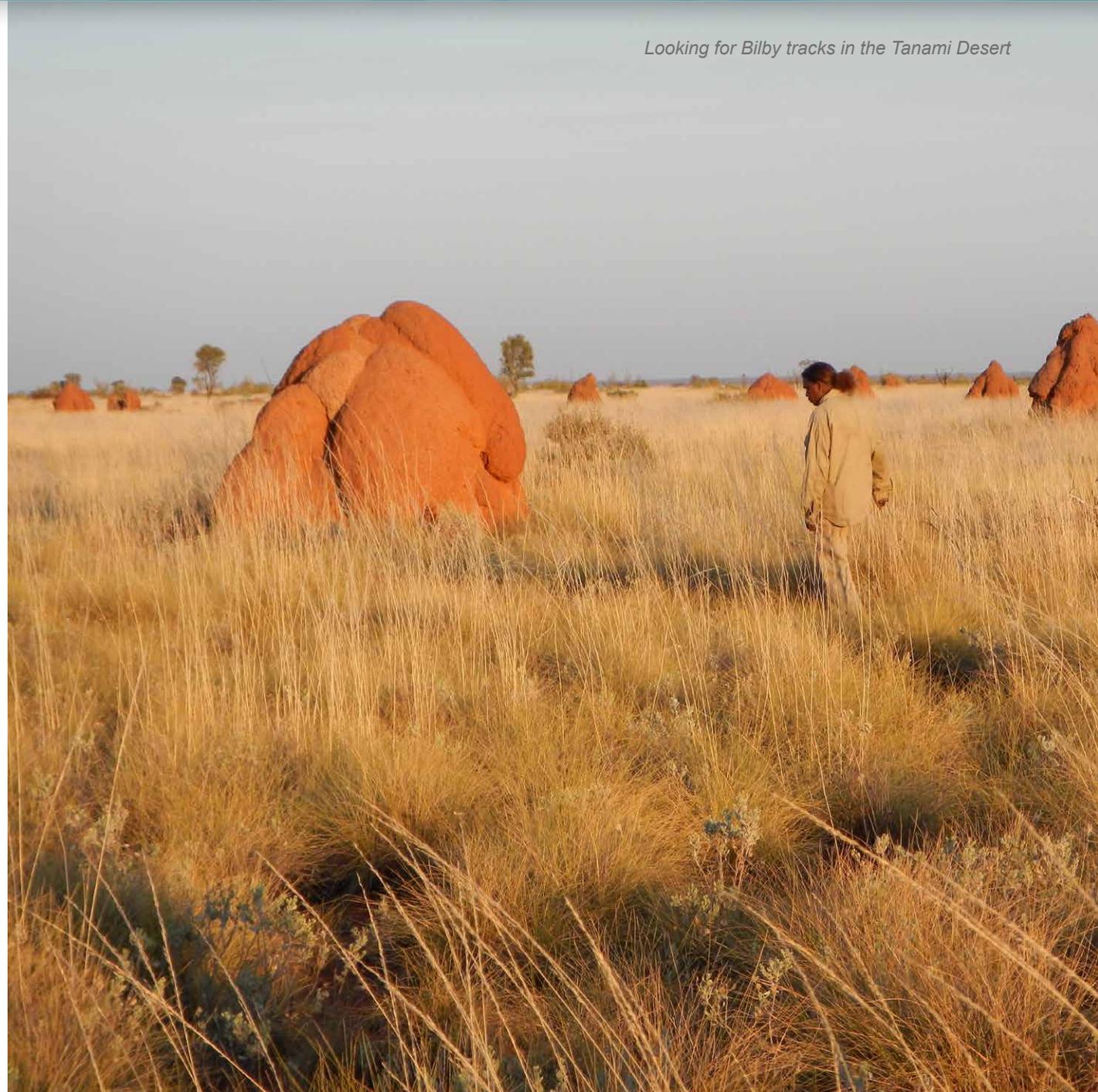
45 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.



Indicators

- Number of Indigenous Protected Areas being managed for cultural values
- Number of Indigenous ranger groups actively managing for cultural values
- Number of species retained at sites
- Severity of fires around significant cultural sites
- Number of sites recorded and listed under legislation
- Number of Indigenous ranger groups actively managing for cultural values
- Number of significant species at key sites
- Number of feral species at key sites
- Severity of fires around significant cultural sites
- Number of Indigenous Ecological Knowledge projects
- Number of cultural sites being visited annually
- Number of sacred sites being actively managed
- Number of ranger groups reporting access issues

Looking for Bilby tracks in the Tanami Desert





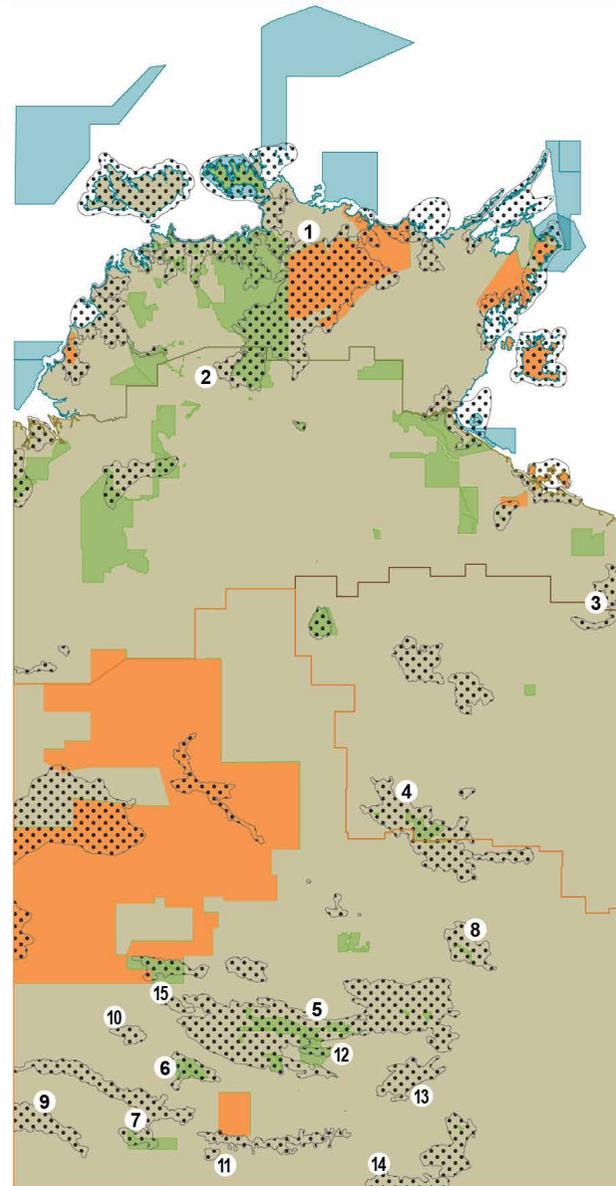
BIODIVERSITY AND CONSERVATION SITES

DESCRIPTION

The Northern Territory is known for its extensive natural environments and key conservation sites. Among the most spectacular sites, Kakadu and Uluru-Kata Tjuta National Parks are internationally recognised for their World Heritage values; and Kakadu and Cobourg Peninsula are Ramsar wetlands. These environments provide habitat for the Territory's unique biodiversity as well as refuges for many species that have disappeared elsewhere in the continent.

Eucalypt and acacia woodlands, and savanna and spinifex grasslands are the most extensive vegetation communities. There are also significant areas of other vegetation communities. Monsoon rainforest and stands of rare palms and cycads grow in the wettest areas and on moist, fire-protected sites. Mangrove forests in coastal environments and those lining the estuarine reaches of river channels play an important role in nutrient cycling and provide fish nurseries. Riparian vegetation communities offer important habitat for species in all regions. Wetlands are particularly important refuges that help species persist through dry periods. Even the most rocky outcrops can provide habitat for snail species which may be restricted to an area of a few hectares.

The Northern Territory is particularly important for species that are found nowhere else, or for species that are threatened elsewhere, but still have healthy populations in the Territory. These include the Bare-rumped Sheath-tailed Bat, Carpentarian Rock Rat, Speartooth Shark, Quandong, Northern Quoll, Golden-backed Tree-Rat, Grey Currawong, Bednall's Land Snail and the Australian Snubfin Dolphin.



Sites of Conservation Significance
 Marine protected area
 Indigenous Protected Areas
 Terrestrial protected area



Great Desert Skink



Agile Wallaby



PRESSURES/USES

Low levels of vegetation clearance and development have largely protected the Territory's environments from the biodiversity loss that has occurred further south. Extensive conservation reserves provide environments that are rich in biodiversity, and have few weeds and minimal grazing pressure from cattle, but do suffer damage from feral pigs¹. The intact vegetation and generally low levels of grazing pressure on surrounding pastoral and Aboriginal lands means they are also valuable for conservation. In recent years, biodiversity conservation has benefited from the growth of Indigenous ranger schemes and the areas protected as Indigenous Protected Areas or under conservation agreements². However, increasing stock numbers and increasing density of watering points on pastoral lands pose challenges for biodiversity conservation.

A total of 17 mammal and two bird species have disappeared from the Northern Territory and many more are threatened. Most of these were Arid Land species that disappeared late century. More recently, populations of fifteen medium-sized (0.1-5.5 kg) and two larger marsupial species have collapsed across the Top End³.

- 1 Woinarski, J.C.Z., Green, J., Fisher, A., Ensbey, M. & Mackey, B.G. (2013) The effectiveness of conservation reserves: Land tenure impacts upon biodiversity across extensive natural landscapes in the tropical savannahs of the Northern Territory, Australia. *Land*, 2, 20-36.
- 2 Woinarski, J.C.Z., Legge, S., Fitzsimons, J.A., Traill, B.J., Burbidge, A.A., Fisher, A., Firth, R.S.C., Gordon, I.J., Griffiths, A.D., Johnson, C.N., McKenzie, N.L., Palmer, C., Radford, I., Rankmore, B., Ritchie, E.G., Ward, S. & Ziembecki, M. (2011) The disappearing mammal fauna of northern Australia: context, cause, and response. *Conservation Letters*, 4, 192-201.
- 3 Woinarski, J.C.Z. (2015) Critical-weight-range marsupials in northern Australia are declining: a commentary on Fisher et al. (2014) 'The current decline of tropical marsupials in Australia: is history repeating?'. *Global Ecology and Biogeography*, 24, 118-122.

Table 3. Threatened species (check with latest lists)

	Top End		Gulf Savanna		Tablelands		Arid Lands	
	National	NT	National	NT	National	NT	National	NT
Critically Endangered	4	7	3	6	1	1	2	4
Endangered	24	24	14	9	5	3	3	6
Vulnerable	27	76	18	40	9	20	18	27

While each species is likely to have been affected by a different combination of factors, predation by feral cats, extensive and frequent fires, grazing pressure and poisoning by Cane Toads have been shown to be contributing factors. Experimental exclusion of cats and cattle has resulted in mammal recovery^{4,5}. Recovery plans are in place for 40 of the Northern Territory's threatened species and have been drafted for a further nineteen. However, further research is required to identify the actions required to secure the conservation of many species and to maintain broader biodiversity condition.

Rainbow Bee-eater (Source: Peter Donohoe)



Spinifex hopping mouse

- 4 Frank, A.S.K., Johnson, C.N., Potts, J.M., Fisher, A., Lawes, M.J., Woinarski, J.C.Z., Tuft, K., Radford, I.J., Gordon, I.J., Collis, M.-A. & Legge, S. (2014) Experimental evidence that feral cats cause local extirpation of small mammals in Australia's tropical savannas. *Journal of Applied Ecology*, 51, 1486-1493.
- 5 Legge, S.M., Kennedy, M.S., Lloyd, R.A.Y., Murphy, S.A. & Fisher, A. (2011) Rapid recovery of mammal fauna in the central Kimberley, northern Australia, following the removal of introduced herbivores. *Austral Ecology*, 36, 791-799.



BIODIVERSITY AND CONSERVATION SITES

Invasive plants

Exotic plants with the capacity to transform entire habitats pose the greatest threat to biodiversity⁶. This includes a number of grasses introduced for pastoralism, such as Gamba Grass, Para Grass and Buffel Grass, as well as several prickly bushes - such as Mimosa, Mesquite and Parkinsonia - that invade riparian areas and wetlands. These species also alter fire regimes, with fires fuelled by Gamba Grass eliminating canopy trees and by Buffel Grass killing threatened Red Cabbage Palms. Control of grasses is problematic, partly because of their value for pastoralism. However, concerted efforts have been made in recent years to contain Gamba Grass infestations and to reduce the impact of prickly bushes on wetlands. A Buffel Grass code of practice would be useful to guide management to minimise biodiversity impacts⁷.

- 6 Grice, A.C. (2006) The impacts of invasive plant species on the biodiversity of Australian rangelands. *Rangeland Journal*, 28, 27-35.
- SEWPaC (2012) Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses. Department of Sustainability, Environment, Water, Population and Communities.
- 7 Grice, A.C., Friedel, M.H., Marshall, N.A., and Van Klinken, R.D. (2012). Tackling contentious invasive plant species: A case study of buffel grass in Australia. *Environmental Management* 49, 285-294.

Feral animals

Feral pigs, cattle, camels, horses, donkeys and buffalo increase grazing pressure and exacerbate erosion, and can foul waterways⁸. Cats and foxes are present in large numbers across much of the Territory, and are implicated in the decline of small to medium sized marsupials, central Australian skinks. Effective control of feral animals requires strategic, sustained effort and monitoring to determine its effectiveness, such as has recently occurred in the feral camel control program⁹.

Primary industries

Best practice management of pastoral lands, particularly using moderate stocking rates and wet season spelling, can also benefit biodiversity¹⁰. However, increasing livestock numbers in the Northern Territory may reduce biodiversity habitat if not managed well. Moreover, the establishment of new water points to spread grazing pressure can reduce the population of grazing-sensitive plants and animals¹¹ and aid the spread of Cane Toads¹². These issues can be managed by pastoralists entering into conservation agreements.

- 8 Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A. & Watson, I. (2004) Review of total grazing pressure management issues and priorities for biodiversity conservation in rangelands: A resource to aid NRM planning. Desert Knowledge CRC, Alice Springs, and Tropical Savannas Management CRC., Darwin.
- 9 McGregor, M., Hart, Q., Bubb, A. & Davies, R. (eds) (2013) Managing the impacts of feral camels across remote Australia – final report of the Australian Feral Camel Management Project. Ninti One Limited.
- 10 Fisher, A. & Kutt, A.S. (2006) Biodiversity and land condition in tropical savanna rangelands: summary report. Tropical Savannas CRC, Darwin.
- 11 James, C.D., Landsberg, J. & Morton, S.R. (1999) Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments*, 41, 87-121.
- 12 Letnic, M., Webb, J.K., Jessop, T.S., Florance, D. & Dempster, T. (2014) Artificial water points facilitate the spread of an invasive vertebrate in arid Australia. *Journal of Applied Ecology*, 51, 795-803.

Fire

Inappropriate fire regimes have been implicated in the loss of species and habitats as well as in general biodiversity decline. Efforts have been made to reinstate fire management across large areas of the Territory, such as through the Central Land Council's Warlu fire committees and Top End fire abatement projects aided by funding obtained for greenhouse gas emission abatement.

Management capacity

Fire, weed and feral animal control needs people on country. The number of people managing country is aided by Indigenous ranger programs, which require on-going financial support from programs such as Working on Country and the North Australian Quarantine Strategy.

Climate Change

Temperature rises; an increased frequency of cyclones, droughts and floods; increased fire intensity; as yet unknown changes in average annual rainfall; and sea level rise as a result of climate change¹³ are all expected to adversely affect the Northern Territory's biodiversity¹⁴. How species and communities will respond and which are most vulnerable is still uncertain. However, modelling of species distributions under future climates has identified birds restricted to the Top End (including seven Tiwi

- 13 Ekström, M., Whetton, P., Gerbing, C., Grose, M., Webb, L. & Risbey, J. (2015) Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports. CSIRO and Bureau of Meteorology, Australia.
- 14 Steffen, W., Burbidge, A.A., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Smith, M.S. & Werner, P.A. (2009) Australia's biodiversity and climate change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change. A report to the Natural Resource Management Ministerial Council commissioned by the Australian Government. CSIRO Publishing.



BIODIVERSITY AND CONSERVATION SITES

Islands endemics) as among the species considered most at risk¹⁵. Concrete evidence of changes that can be attributed to climate change is difficult to obtain, but increased frequency of coral bleaching is one such example¹². Recommended management to address climate change include the current priority activities of fire, weed and feral animal management.

Knowledge gaps

The biggest challenge in managing biodiversity is to know which actions will be most effective at addressing threats. We still don't have enough information to determine the current extent of species and which ones are in decline¹⁶. Research is needed to establish the causes of biodiversity decline and how best to address them. Monitoring is required to determine whether management is being undertaken as intended and to understand whether these efforts are being effective.

Indicators

- Conservation status of Northern Territory species
- Number of threatened species for which conservation actions have been identified and implemented
- Number of Sites of Conservation Significance being managed for conservation values
- Number of Indigenous Protected Areas being managed for conservation values
- Number of Indigenous ranger groups actively managing for conservation values
- Number of conservation agreements on pastoral lands that include
 - livestock exclusion from high conservation value areas
 - retention of water in remote areas
- Control of grazing pressure through moderate stocking rates and/or wet season spelling
- Patterns of fire seasonality and extent
- Number of active weed management plans and codes of practice
- Number of active feral animal management plans



15 Garnett, S.T., Franklin, D.C., Ehmke, G., VanDerWal, J.J., Hodgson, L., Pavey, C., Reside, A.E., Welbergen, J.A., Butchart, S.H.M., Perkins, G.C. & Williams, S.E. (2013) Climate change adaptation strategies for Australian birds. In, p. 109. National Climate Change Adaptation Research Facility, Gold Coast.

16 House of Representatives Standing Committee on Climate Change; Environment and the Arts (2013) Managing Australia's biodiversity in a changing climate: the way forward. Final report of the inquiry into Australia's biodiversity in a changing climate. In. Commonwealth of Australia

