

Northern Australia Land and Water Science Review 2009

FULL REPORT



National Research
FLAGSHIPS
Sustainable Agriculture



Report coordinated by the Commonwealth Scientific and Industrial Research Organisation, October 2009



Photograph credits

[front page from top left to right]

1. Brahman Bull, Kimberley – Barry Traill, Pew Environment Group
2. Recreational fishing, Alligator river Northern Territory – Larelle McMillan
3. Garawa Ranger Coordinator Jack Green conducting early dry season burn, 2007 – Seán Kerins
4. Furrows in the Ord, Western Australia – Peter Thorburn CSIRO
5. Jabiru, wetland – Mat Gilfedder CSIRO
6. Ranger mine truck – Larissa Cordner
7. Kimberley landscape – Richard Mercer
8. Aerial view Century mine, Queensland – photographer unknown
9. Yellow crazy ants (*Anoplolepis gracilipes*) are recognised by the Global Invasive Species Programme as one of the world's worst invaders. They represent a major environmental and economic threat to northern Australia. Credit: CSIRO Darwin

Acknowledgements

The managing editor thanks all of the authors, and their supporting communities and institutions, for their contributions to the Review. John Ward, Richard Cresswell and Nick Abel coordinated much of their activity.

The staff of the Office of Northern Australia, Department of Infrastructure, Transport Regional Development and Local Government, provided invaluable assistance.

The Northern Australia Land and Water Taskforce and particularly its Chair, Joe Ross, provided valued guidance.

Econnect communication created the Review Summary, in collaboration with the authors.

Photographers are thanked for their contributions, and acknowledged individually in the text.

Financial support was provided by CSIRO; The Office of Northern Australia; National Water Commission; Department of Environment, Water, Heritage and the Arts.

Larelle McMillan is thanked for providing editorial assistance and expertly producing the Review.

Peter Stone
Managing Editor
CSIRO Sustainable Ecosystems

Copyright

Copyright is held by the specific author/s of each chapter.

CONTENTS

CONTENTS.....	3
CHAPTERS CONTAINED IN THE REVIEW	3
EXECUTIVE SUMMARY	5
PROLOGUE	7
INTRODUCTION.....	8
What makes Northern Australia special?	13

CHAPTERS CONTAINED IN THE REVIEW

- 01 Water resources of northern Australia**
Richard Cresswell, Cuan Petheram, Glenn Harrington, Heinz Buettikofer, Malcolm Hodgen, Phil Davies, Lingtao Li
- 02 Land and soil resources of northern Australia**
Peter L. Wilson, Anthony Ringrose-Voase, David Jacquier, Linda Gregory, Mike Webb, Mike T. F. Wong, Bernie Powell, Dan Brough, Jason Hill, Brian Lynch, Noel Schoknecht, Ted Griffin
- 03 Aquatic ecosystems of northern Australia**
Bradley J. Pusey, Mark J. Kennard
- 04 Terrestrial ecosystems of northern Australia**
Alex Kutt, Leasia Felderhof, Jeremy VanDerWal, Peter Stone, Genevieve Perkins
- 05 Sustaining growth of the northern beef industry**
Julian Cribb, Greg Harper, Peter Stone
- 06 Historical perspectives on land use development in northern Australia: *with emphasis on the Northern Territory***
Garry Cook
- 07 Indigenous interests in land and water**
Jon Altman, Kirrily Jordan, Seán Kerins, Geoff Buchanan, Nicholas Biddle, Emilie-Jane Ens & Katherine May
- 08 The minerals industry and land and water development in northern Australia**
David Brereton, Veronica Klimenko, Claire Cote, Robin Evans
- 09 Commercial fishing and aquaculture in northern Australia**
Elizabeth Clark, Nick Abel, Tom Measham, Julian Morison, Lisa Rippin
- 10 Irrigated agriculture: *development opportunities and implications for northern Australia***
Tony Webster, Lisa Rippin, Julian Morison, Alexander Herr, Nick Abel, Bruce Taylor, Elizabeth Clark, Peter Stone
- 11 Water-based tourism and recreation in northern Australia**
Elizabeth Clark, Nick Abel, Julian Morison, Lisa Rippin
- 12 Public and private conservation of aquatic systems in northern Australia: *threats and opportunities***
Nick Abel, John Rolfe

- 13 The role of the Australian Defence Force in northern Australia's development**
Peter Stone
- 14 Palisades and pathways: Historical lessons from Australian water reform**
John Ward
- 15 Indigenous participation in water planning and management**
Sue Jackson, Cathy Robinson
- 16 Indigenous customary governance**
Cathy Robinson, Sue Jackson
- 17 A primer for water institutions and governance: *concepts, definitions and measures***
R. Quentin Grafton, John Ward, Sam McClennon, Jim McColl
- 18 Encouraging conformity with the principles of the National Water Initiative**
M Ejaz Qureshi, John Ward
- 19 The current status of water governance in northern Australia: *progress towards the goals of the National Water Initiative***
Kim Alexander, John Ward
- 20 The current status of water governance in northern Australia: *water management in the Northern Territory, Queensland and Western Australia***
Kim Alexander, John Ward
- 21 The current status of water governance in northern Australia: *audit and evaluation of northern Australia compliance***
Kim Alexander, John Ward
- 22 Experiences with integrated river basin management, international and Murray darling Basin: *lessons for northern Australia***
Erin Bohensky, Daniel Connell, Bruce Taylor
- 23 The case for a revised National Water Initiative for northern Australia**
Daniel Connell, Quentin Grafton, John Ward
- 24 Indigenous people and water management in northern Australia: *Kimberley Institute submission***
The Kimberley Institute Limited, Patrick Dodson
- 25 Northern savanna fire abatement and greenhouse gas offsets on Indigenous lands**
Scott Heckbert, Jocelyn Davies, Garry Cook, Adam Liedloff, Gary Bastin
- 26 Mitchell River catchment: *regional perspective***
Sarah Connor, Bill Sokolich, Tim Hoogwerf, John Mackenzie, James Butler
- 27 Daly River catchment: *regional perspective***
Daly River Management Advisory Committee
- 28 A robust framework for sharing water in northern Australia**
John Ward, Jim McColl, William Nikolakis, Bruce Taylor, Nick Abel, R. Quentin Grafton

EXECUTIVE SUMMARY

The Northern Australia Land and Water Taskforce has been charged with finding new opportunities for economic development in northern Australia based on water availability and sustainability. It is to report on the potential impact of new development on water balance and quality, the environment, existing water users and the broader community. It commissioned the *Northern Australia Land and Water Science Review 2009* to inform that report.

The Taskforce's five terms of reference and the *Review's* response to them are outlined below.

1. Identify, consistent with the provisions of the National Water Initiative (NWI), the sustainable capacity of the river systems and/or drainage basins to support increased consumptive water use

The *Review* has provided the best available quantitative estimate of the amount and distribution of water in the northern Australian landscape. The 1 million gigalitres of rainfall received each year supports a wide range of uses. These include unique aquatic and terrestrial ecosystems; recreational and commercial fisheries and tourism that are based upon them; a range of largely non-consumptive Indigenous uses; and consumptive use by irrigated agriculture, stock and domestic and mining. Water is critical to each of these uses, and increased consumptive use will involve a degree of trade-off between new uses and the range of existing consumptive and non-consumptive uses.

Surface and groundwaters are frequently highly connected. Consequently, groundwater abstraction from one point may influence surface water flow and function at another, and vice versa. Consequently, trade-offs between different water uses must take into account impacts on and responses to both ground and surface waters. These linkages are imperfectly quantified and specific abstractions require site-level assessment.

Conserving and accessing surface water for consumptive use is highly constrained by difficulties in impoundment. Groundwater therefore provides the best prospect to support new consumptive use. We estimate that there may be *ca* 600 GL, across northern Australia, that could support new consumptive use. This volume would be adequate, for example, to irrigate *ca* 40,000 to 60,000 ha of intensive agriculture. To be NWI compliant, this water would need to be assigned according to an agreed statutory water plan that takes into account diverse and competing water uses.

2. Identify, consistent with sustainable resource use principles and practices, economic development and diversification opportunities (including non-consumptive or in-stream uses) which rely on access to locally or regionally significant water resources

All of northern Australia's major economic development and diversification opportunities rely on access to water resources. This, along with their social and environmental importance, makes virtually all water resources locally or regionally significant.

Development need not be confined to deliberate modification of the landscape, or to extractive use of water or soil. Tourism, for example, contributes *ca* \$2,800 m p.a. to the northern Australian economy, and relies heavily on the largely pristine land and water of the north. Extractive industries such as commercial fishing (>\$160 m) are heavily water dependent non-consumptive uses of water. Opportunities available to these industries would be curtailed by significant consumptive water use or landscape modification.

Intensive irrigated agriculture (*ca* \$160 m) and beef production (*ca* \$1 b) are significant contributors to the northern Australia economy, the expansion of which is directly limited by access to water. Suitable (though not necessarily advantageous) agricultural soil is comparatively plentiful. Mining (>\$9,100 m)

may recycle more water than it consumes, but remains a large (and unspecified) consumer of water resources.

It is critical to understand that water dependent development need not imply monetised exchange. The hybrid economy that characterises many Indigenous livelihoods is heavily reliant on water-dependent natural resources, which intersect and support its customary, state and market sectors. Changes to the natural resource base impact the value of the Indigenous hybrid economy, upon which up to a third of the north's population may depend.

3. Identify the potential impact of such development opportunities on the natural environment and other users and the broader community

Pursuit of the diverse range of development opportunities detailed in the *Review* requires trade-offs amongst opportunities, especially where consumptive use is implicated. Key to development evaluation is how trade-offs are measured. Specific trade-offs are highly enterprise, site and activity dependent, and beyond the scope of the *Review*. Instead, we indicate the scale of opportunities available and their water requirements and impacts.

Cultural life in northern Australia is extraordinarily dependent on the region's high natural values. These, in turn, emanate from the intact landscapes and relatively undisturbed flows of the north's waterways. Development can directly reduce these values by depleting water, reducing water quality or by changing the natural flow of water in the landscape; all of which impact aquatic, marine and terrestrial environments. Development can also indirectly and inadvertently impact these. Roads, for example, can disturb the flow of water across the landscape, altering connections between waterways and floodplains that support communities of vegetation, fish, birds and mammals. The impacts of development on the natural environment are varied, and many are persistent and difficult to correct.

4. Identify incentive, market, regulatory or planning instruments that could be used to facilitate, control or influence development, such that it proceeds in a manner consistent with the principles of the National Water Initiative

A robust system of institutions and governance has been developed consistent with the principles of the NWI. It is applicable across the changing climatic and hydrologic realities of northern Australian basins and relevant to the various stages of development of water resources. The whole of basin approach accounts for neglected Indigenous rights and interests and aims to meet fairness and efficiency criteria. Robust design for northern Australia consists of independently managed instruments including a negotiated statutory water plan; access entitlements as secured, long term unit shares of the extractive pool; periodic allocation of water to each share and finally; a licence prescribing the obligations of water use.

These processes enable the systematic matching of instruments to northern basins, classified according to their current and potential cultural, ecological and development status. Included is a reserve pool which provides sufficient water to satisfy future unresolved Native Title claims and to buffer scientific uncertainty. The three classes are: Customary Management: with limited water extraction and co-management negotiated through a non-statutory water plan; Open: with a water sharing plan, some water extraction and a reserve pool and; Closed: with fully assigned environmental and extractive entitlements, no reserve pool, and opportunities to develop trading in entitlements and seasonal allocations. Entitlements assigned in this way indicate a potential role for water to promote and enable both water dependent enterprises and Indigenous autonomy. Compared to southern systems, it will be much easier to create the pre-conditions in northern Australia for NWI compliant and sustainable water management and avoid the costly retrofitting of unplanned water resources.

5. Recommend governance arrangements for the effective management of surface and groundwater resources that cross jurisdictional boundaries

There are three basins that cross state jurisdictional boundaries in northern Australia. This is unlikely to be of major concern. Potential exists for a closer working partnership between the Commonwealth and water managers in the Northern Territory. The relationship could be used to trial implementation ideas which could then be proposed to the states as evidence-based working models.

PROLOGUE

Northern Australia has many thousands of stories.

It is vast; geographically diverse; alternately, and at times simultaneously, very wet and very dry. It accommodates great wealth and abject poverty. Extensive and extractive industries coexist with iconic environments. It is the cradle of Australia's human history and a crucible for an ingot of its future.

This report reflects on its past and considers its future. It doesn't attempt to tell a simple story. The north defies those. Its stories are contested; mutually incompatible; based on what are at once construed its triumphs and failures, and divergent hopes for its future.

This report reflects that diversity. The 71 contributing authors and their sources have brought with them their particular expertise and, as people are wont to, their partialities and peccadilloes. The editors have not sought to conceal these; they are safer when exposed to light. Where interpretation exists, it is accompanied with information or data gathered from cited and accessible literature. Drawing from this, readers can make their own, perhaps divergent, interpretations. Needless to say, the views of the authors are their own, and not those of their respective employers.

As a consequence of this pluralism, there will be something to dismay and delight all audiences - often concurrently. Everyone will, we hope, gain an improved appreciation of the challenges and complexities arising from the unusually high mutual inter-dependencies of the north's environments and peoples, and the processes that sustain them.

INTRODUCTION

The Taskforce: goals, initiation & activity

The large scale, comparative lack of development and apparent abundance of natural resources in northern Australia periodically stimulates enquiry as to its development potential. The recent and projected scarcity of water in the Murray-Darling basin has increased this interest and prompted the Australian Government in 2007 to convene the Northern Australia Land & Water Taskforce (the 'Taskforce'). Its role was to "examine the longer term, strategic potential for further land and water development in northern Australia, with particular emphasis on the identification of the capacity of the north to play a role in future agricultural development" (1).

Following a change of government the Taskforce was, in late 2008, overhauled and given a new direction. It was asked to broaden its enquiries to finding "new opportunities for economic development in the north based on water availability and sustainability...[and to report on]...the potential impact of new development on water balance and quality, the environment, existing water users and the broader community" (2). The Taskforce was asked to report to Government by December 2009.

Terms of reference

The Taskforce was instructed to address 5 terms of reference:

1. Identify, consistent with the provisions of the National Water Initiative, the sustainable capacity of the river systems and/or drainage basins to support increased consumptive water use
2. Identify, consistent with sustainable resource use principles and practices, economic development and diversification opportunities (including non-consumptive or in-stream uses) which rely on access to locally or regionally significant water resources
3. Identify the potential impact of such development opportunities on the natural environment and other users and the broader community
4. Identify incentive, market, regulatory or planning instruments that could be used to facilitate, control or influence development, such that it proceeds in a manner consistent with the principles of the National Water Initiative
5. Recommend governance arrangements for the effective management of surface and groundwater resources that cross jurisdictional boundaries

Undaunted by the requirements of this substantial and time-constrained undertaking, the Taskforce sought to gather the information required to support its deliberations via a commissioned project, the results of which are presented here as the Taskforce' *Northern Australia Land and Water Science Review*.

Northern Australia Land and Water Science Review 2009

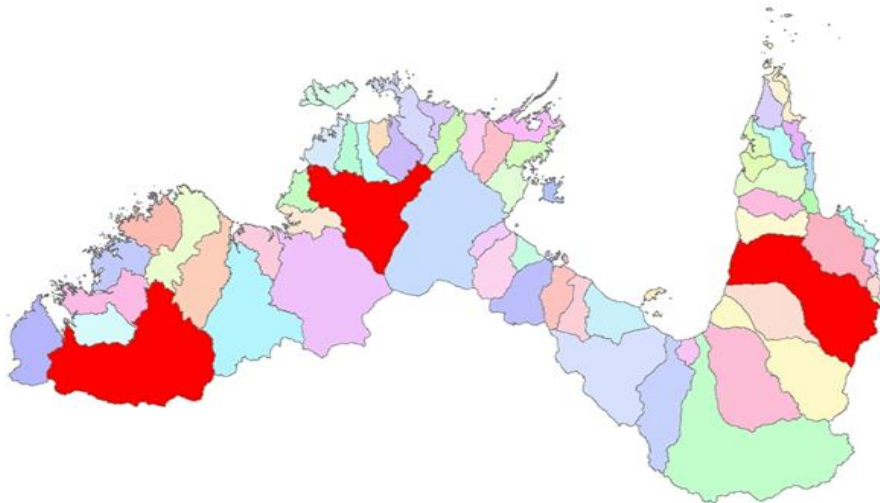
The *Northern Australia Land and Water Science Review* ('the Review') has been managed by CSIRO and draws on the contributions of over 80 technical specialists, community members and industry representatives from many institutions. It synthesises existing information to explore a range of development alternatives and land use change activities, and their impacts on a selection of critical sustainability factors. First amongst these factors is water, and its relationship with broader land

management. Water provides the lens through which other sustainability factors (such as terrestrial and aquatic ecosystems; employment & wellbeing) are viewed and analysed. By this means we have sought to establish and illustrate principles and guidelines for sustainable development of northern Australia, in accordance with the Taskforce terms of reference.

The geographic region of analysis

'Northern Australia' often refers to the land mass north of the Tropic of Capricorn. In accordance with its terms of reference, this report has defined 'northern Australia' as the basins within the Timor Sea and Gulf of Carpentaria drainage divisions, and that part of the North East Coast drainage division north of Cairns.

Figure 1 Geographic bounds of 'northern Australia' as defined in this report



This definition takes in the area north of Broome in the west and Port Douglas in the east. As a consequence, the northern Australia dealt with in this report is far less developed and populated than the northern Australia of common usage. For example, the population of the study region is *ca* 200,000, which is about 20% of the 'north of Capricorn' total, and < 1% of Australia's total. Excluding major northern centres of population and industry (such as Cairns and Townsville) substantially changes the level of development that currently exists and, as a consequence, future development trajectories and impacts in the study area.

Goals

The most immediate aim of this Review is to provide the Taskforce with the means to address its terms of reference.

We have also sought a more far-reaching goal: to provide data and principles that inform discussion and debate of sustainable development options for the north. What that doesn't mean is just as important as what it does mean.

What the Review doesn't seek to achieve

We don't try to provide sustainable development 'solutions'. Sustainability is a concept that involves values as well as objective data. Our role is to provide data and insights so that others might apply their values to the problems and opportunities of sustainability. In addition, the definition of sustainability varies with the emphasis placed on environmental, social and economic goals; it is a decision space, not a decision point, with boundaries that vary according to social preference and political criteria. A simplified (and somewhat simplistic) schema for sustainability illustrates the point. What is equitable, bearable or viable, and which mix of criteria give a sustainability 'sweet spot'? (Fig. 2). Such questions are correctly left in the political domain, and arise from and are informed by societal discourse.

Figure 2. Sustainability (S) occurs at the intersection of potentially competing socially-politically determined criteria. This schema of sustainability is somewhat simplistic but illustrative.



We don't try to prescribe or proscribe particular sustainable development activities. The range of potentially sustainable or unsustainable activities is almost limitless, and many have yet to be identified or invented. It is not our intention to privilege those of which we're aware over those of which we're not.

We do not undertake detailed regional case studies, designed to identify best-bet development or non-development options. Northern Australia comprises >1.2 million km² of highly variable landscape. Understanding its form and function at the scale required to identify the impacts of specific uses of land or water (i.e. certain types of development) is beyond the scope of this report. It is, as we show, also beyond the current capability of any report. Northern Australia cannot currently be understood at a detailed, site-specific scale – the raw observational data required for such understanding simply doesn't exist.

What the Review does seek to achieve

We have sought to broaden perspectives of development. Development needn't be confined to modification of the landscape, or to extractive use of water or soil. Development can be based on non-extractive use of resources, such as for artistic, aesthetic or recreational purposes. Development needn't imply simple economic activity, where money changes hands. It can include non-monetary activities such as the improvement of spiritual or physical wellbeing, or money-substituting activities such as the collection of food.

We have sought to identify, by example, the consequences of undertaking a range of commonly and less-commonly considered development actions. We attempt to concentrate on the connections between action in one sphere (e.g. using water for irrigation) and impacts in another (e.g. river flows and aquatic fish stocks and, hence, tourism and fisheries). By this means we seek to inform debate and decision about what might be possible, who might benefit and who mightn't.

We have sought to identify the scale and threshold of connections and impacts. How much of a given activity can occur before it impacts on another, and what is the likely trade-off between the two? Reliable information on thresholds is scarce and highly location- and activity-specific. Nevertheless, we have attempted to inform debate over not only what, but how much, might be acceptable uses of land and water resources.

Translation of Terms of Reference and goals into research questions

The Taskforce' terms of reference, and our understanding of what the report should and shouldn't be, informed the formulation of this report's research questions. These were divided into three main categories: biophysical, economic-social-cultural and institutional-governance (below). Initially, we sought to answer these questions as simply and directly as possible by devoting a chapter to each. The clear inter-connectedness of land and water, social and economic systems and the institutions that seek to influence them, however, meant that we did not pass our own "one question, one chapter" test. Instead, each chapter's title indicates the questions that it addresses. More broadly, the questions and tasks were:

Water dependencies of biophysical systems, and their responses to development

- What is the sustainable capacity of rivers to support increased consumptive water use, for each drainage basin or part thereof?
- What is the impact on and of agricultural development of/on water availability?
- Assess land suitability for agricultural and other development opportunities
- What are the ecosystem needs of tropical water systems?
- What are the critical data and knowledge gaps regarding impacts of and on water?
- How can we use information on the water supply to promote the Government's water reform agenda, especially where water markets do not exist?

Water dependencies of eco-socio-cultural systems, and their responses to development

- Identify development and diversification opportunities, including non-consumptive or in-stream uses, that rely on access to significant water resources
- Identify the impact of those opportunities on the natural environment, other water uses, and the broader community
- What drives and limits economic development, including future infrastructure plans?

- What are the impacts of conservation based activities on financial returns and employment opportunities for the conservation and cultural economy?
- How do hard, soft and natural infrastructure contribute to economic development?
- What are the options and outcomes for indigenous employment, especially as related to conservation, mining, culture, irrigation/agriculture, manufacturing, services?
- What would a sustainable economic activity look like? How would you know in advance? What goes wrong/happens when a development is not sustainable? (Illustrative case studies would be helpful). What would best practice look like?
- What regulatory instruments or approaches would be useful to ensure that development is sustainable? What measures or attributes of sustainability could be used to rank/quantify development proposals?

Institutional and governance arrangements to inform water-dependent development

- Identify the incentive, market and regulatory approaches that would encourage development consistent with the principles of the National Water Initiative.
- Audit/catalogue the existing development incentives and controls in different jurisdictions. Compare and contrast these and highlight conflicts and problems
- Illustrate governance arrangements that help to effectively manage water across jurisdictional boundaries
- Provide case studies that illustrate the efficacy of jurisdictional planning and regulatory frameworks to ensure compliance with the National Water Initiative
- Illustrate improved systems of governance for effective management of northern waters
- Catalogue and describe Indigenous governance systems and approaches to cross-cultural legal and institutional arrangements, and the role of Indigenous Land Use Agreements in water development
- Examine international examples of integrated river basin initiatives, and assess their relevance to Northern Australia.

Focal regions - Mitchell, Qld; Douglas-Daly, NT and Fitzroy, WA

At the outset, we expected that the distillation of principles (to inform discussion and debate of sustainable development options for the north) would obviate useful and necessary links with 'real world' experience and practice. To overcome this, we intended to undertake detailed studies in three focal catchments, designed to provide a concrete context within which principles could be illustrated and their inter-relationships explored. It transpired that the chapters draw heavily upon and illustrate real events in real places across northern Australia. One of the impetuses for regional focal studies diminished.

Focal studies were also designed to capture community's development aspirations and concerns. After embarking on community consultations it became apparent that it would be difficult to uniformly gain representative community perspectives. In some cases, it became clear that achieving project goals in the time allowed would require the privileging of some views over others. Specifically, those with a high capacity for engagement (e.g. commercial interests) would be provided a platform denied to those with a lower capacity for engagement (e.g. Indigenous people). Presenting unrepresentative 'community' views

runs several major (and likely to be realised) risks that we have sought - by omitting focal catchment studies - to avoid. These include the risk of simply misrepresenting community views and the more serious risk of creating and supporting fracture lines within small and mutually dependent communities.

An early recommendation of this report is therefore that those seeking specific 'regional' views on development in the north devote defined and significant resources to community consultation. This would need to include time, money and Indigenous language translators.

What makes Northern Australia special?

A recurring theme of this report is that the north is a different country from the south. Some contributors commented that it might even be a different planet.

What makes the north so different? Need that distinctiveness inform decisions about development of the north and, if so, how? Some preliminary observations will help to answer these questions and interpret the findings of this report.

The north is different from the south

The north is in good condition

The north comprises the world's largest intact tropical savanna, which is uniquely contiguous and in good condition across much of its extent. This is the source of its iconic status to many Australians, its attraction to overseas tourists, and its ability to support about 50% of Australia's animal species [calculated from (3)]. This contrasts with much of the south, in which the environment is highly fragmented and often substantially degraded. The north presents an irreversible opportunity to retain a largely unmodified landscape.

The north is very wet, then very dry, every year

Almost 90% of the rain falls in less than 50% of the year (4), so the north alternates between very wet and very dry. In full wet season flow, the Fitzroy River's discharge could fill Sydney Harbour from empty while you were sleeping. During the dry, you can sleep on its sandy bed. The north's annual floods make people and places inaccessible, render much of the landscape unsuitable for development, and are responsible for the teeming fish stocks of the north's rivers and oceans. The north's annual droughts make large parts of the landscape unattractive to humans, inhospitable for animals and present a considerable impediment to development. Millennia of flood-drought cycles have shaped the environment: plants and animals need it to survive. The north's flood-drought cycle remains largely untamed. By contrast, the natural rhythms and functions of water in south have been significantly and irreversibly altered by interruptions to flow and consumptive use.

The north is hot, most of the year, every year

The north is almost always, by southern standards, very hot. The average daily maximum temperature for Fitzroy Crossing, for example, falls below 35°C for only four months each year (during which it averages 32°C) (5). It often exceeds 40°C for more than 70 consecutive days. Climatic discomfort indices indicate that much of the north is "nearly always oppressive" or "often to usually uncomfortable" for 10 months of the year (6). Even a "hot" southern capital such as Perth remains "comfortable" during all but

the summer months. Almost 200 separate cyclones made northern landfall from 1970-2007, an average of five per year (7). In addition to the heat and humidity that can test human comfort, floods and cyclones can lead to isolation and property damage or, on occasions, loss of life. In many respects the north isn't for the faint of heart.

The north is sparsely populated

The direct and indirect impacts on humans of the north's harsh climate help to explain the low population of the north. The north of the study area comprises *ca* 17% of Australia's land mass yet contributes less than 1% of its population. That population is clustered into a number of small centres surrounded by very large areas of sparse population (8). Darwin (pop. 66,290) is the largest population centre. The second largest, Mt Isa, is less than one-third that size (pop. 18,857) and the third largest, Broome, is about one-sixth that size (pop. 11,546). The fifth largest population centre in the north has only 3,748 people (Kununurra) (9).

The north has sparse infrastructure

The north's small population reduces the extent to which industries, and society more broadly, can build a critical mass of soft (skills, networks, labour, etc) and hard (transport, communications, hospitals, schools, etc.) infrastructure. Northern Australia's low rates of internet connection and power generation based mainly on local generators (10) are tangible indicators of infrastructure-related isolation that impede development. The dearth of hard infrastructure is amplified by access that can be seasonally interrupted by floods or cyclones.

The impacts of sparse soft infrastructure are exacerbated by the very high rates of population turnover in much of the north. Four of the nation's ten highest population turnover rates occur in statistical local areas (SLAs) in northern Australia (8). Attracting and retaining skilled and experienced people is a persistent challenge in the north, and one that limits development.

Infrastructure may present something of a vicious circle for northern Australia, in which a lack of such resources prejudices against the accumulation of more resources.

The north embodies Indigenous interests

Northern Australia differs from the more populated regions of southern Australia in having both a much larger Indigenous proportion of the population (over 30 per cent) and a much larger proportion of the Indigenous-owned estate (around 30 per cent of the region is Indigenous-owned). The rapidly growing Indigenous population means that economic futures in northern Australia will be increasingly interdependent with Indigenous people's livelihoods (11).

This interdependence and the growing attention being paid to setting and more completely realising Indigenous aspirations – especially in northern Australia – places particular demands on governance structures and processes that are required to ensure that allocation and access to resources is equitable.

Most of these governance arrangements have been developed for and in the south. Their suitability for use in the north – and its different people, climate, environment and industries – has not been established.

Why that difference matters

The north's relative lack of development means that the footprint of the past is smaller than in the south. This is most obvious in the north's biodiversity values. On the other hand, the north has been denied the many benefits of development, such as the 'hard' and 'soft' infrastructure required to support public amenities that are taken for granted southern communities. The north is in many senses much more a 'blank slate' than the south.

This means that the landscape is more intact and, in a broad sense, 'pristine'. For many, this implies a high intrinsic value that warrants preservation. For those who draw a different inference it presents a rare opportunity: to pursue development based on the values and knowledge of today's society rather than those of the Georgian, Victorian and Edwardian eras that have so pervasively influenced the south.

The Northern Australia Land and Water Science Review 2009 seeks to inform discussion of these varying perspectives and preferred trajectories.

References [Introduction]

1. Northern Australia Land & Water Taskforce. Northern Australia Land & Water Taskforce, background. *Northern Australia Land & Water Taskforce*. [Online] Northern Australia Land & Water Taskforce, 31 August 2009. [Cited: 25 September 2009.] <http://www.nalwt.gov.au/index.aspx>.
2. Gray, Gary. Rudd Government Overhauls Northern Australia Taskforce. *Northern Australia Land & Water Taskforce, media releases*. [Online] 26 September 2008. [Cited: 25 September 2009.] http://www.minister.infrastructure.gov.au/gg/releases/2008/September/GG013_2008.htm.
3. Woinarski, J, et al. *The Nature of Northern Australia: natural values, ecological processes and future prospects*. Canberra : ANU E Press, 2007. ISBN 9781921313318 (online).
4. Australian Bureau of Meteorology. Monthly rainfall - Darwin Airport. *Weather station data*. [Online] 15 October 2009. [Cited: 15 October 2009.] http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_stn_num=014015.
5. —. Monthly mean maximum temperature - Fitzroy Crossing Aero. *Weather Station Data*. [Online] 15 October 2009. [Cited: 15 October 2009.] http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=36&p_display_type=dataFile&p_startYear=&p_stn_num=003093.
6. Gaffney, D. Climatic discomfort in the Kimberleys. *Bureau of Meteorology*. [Online] August 1959. [Cited: 15 October 2009.] <http://bom.gov.au/amm/docs/1959/gaffney.pdf>.
7. Bureau of Infrastructure, Transport and Regional Economics. Table 8.4.1. *Northern Australia Statistical Compendium*. [Online] May 2009. [Cited: 15 October 2009.] <http://www.bitre.gov.au/publications/07/Files/BITRE%20Northern%20Australia%20Statistical%20Compendium%20Data%20290509.zip>.

8. —. Chapter 2: Population. *Northern Australia Statistical Compendium*. [Online] 17 August 2009. [Cited: 15 October 2009.] http://www.bitre.gov.au/publications/07/Files/Chapter_2.pdf.
9. —. Chapter 2, additional data, Table 2.1(a). *Northern Australia Statistical Compendium Data*. [Online] May 2009. [Cited: 12 October 2009.] <http://www.bitre.gov.au/publications/07/Files/BITRE%20Northern%20Australia%20Statistical%20Compendium%20Data%20290509.zip>.
10. —. Chapter 7: Infrastructure. *Northern Australia Statistical Compendium*. [Online] May 2009. [Cited: 10 October 2009.] http://www.bitre.gov.au/publications/07/Files/Chapter_7.pdf.
11. Altman, JC, et al. *Chapter10: Indigenous interests in land & water; this report*. 2009.