

NATURAL RESOURCE MANAGEMENT QUEENSLAND 2020 RESEARCH PROSPECTUS



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Acknowledgement of Traditional Owners.

NRM Regions Queensland acknowledges the Traditional Owners of the land and waters on which our member bodies work and pays respect to their Elders, past, present and emerging. The term Traditional Owners is used in this document to mean Aboriginal and Torres Strait Island Peoples and is not intended to cause disrespect to people who may prefer terms such as Australian First Nations Peoples or Traditional Custodians.

Acknowledgement of contributions.

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Executive summary

Research partnerships deliver mutual benefits for research and regional natural resource management (NRM) bodies. Regional bodies depend on evidence-based knowledge to support their work and researchers' work can have greater impact when it is informed by local knowledge, practical experience and relationships with the people who ultimately apply the results of research to decision-making.

The *Natural Resource Management Queensland 2020 Research Prospectus* (hereafter 'the NRM Research Prospectus') collates NRM research needs across Queensland as a starting point for research partnerships that deliver mutual benefits for researchers, research investors, regional NRM bodies and their communities.

In addition to informing the direction of research, regional NRM bodies seek to take active, appropriate roles in research partnerships. Researchers identify many useful roles for regional bodies in research, including co-development of questions, design of project methods, data collection and management, and importantly, in engagement and communication with research end users

The NRM Research Prospectus identifies practical options for regional bodies, research organisations, NRM peak bodies, government and other investors to address major challenges to forming effective NRM research partnerships.

The NRM Research Prospectus also sets out 10 guiding principles for achieving mutual benefits through research partnerships within two overarching principles: *Start working together early* and *Engage intended users*.

This NRM Research Prospectus supports opportunities to align research with regional bodies' priority research needs in the emerging National Environmental Science Program (NESP 2) and Drought Resilience Research and Adoption Program, as well as in projects delivered through Cooperative Research Centres, Australian Research Council (ARC) Linkage projects, university and industry research facilities.

The NRM Research Prospectus can also be used to inform NRM investment through future iterations of the Regional Land Partnerships and National Landcare Program, Reef 2050 Water Quality Improvement Plan as well as the Queensland Natural Resource Investment Program.



Photo credit: Cathy Zwick



Photo credit: Southern Queensland Landscapes

Overcoming obstacles to forming NRM research partnerships

Despite the many perceived benefits of research partnerships, both Regional Bodies and researchers identify a range of challenges to forming NRM research partnerships, including:

- There is insufficient investment in both research and regional NRM bodies.
- Investment in research and regional NRM bodies has different purposes.
- The timing of investment in research and regional bodies is often mismatched.
- There is a lack of information about who to contact.
- Others' potential contributions and values may be misunderstood; &
- Organisational pressures can make it difficult to work collaboratively

People involved in research and in regional NRM both aspire to work together on NRM research and there are several examples of current and past successful NRM research partnerships.

Regional NRM bodies play important roles as facilitators between researchers and the users of research, although sometimes are themselves 'end users', depending on the nature of the research. Regional bodies can bring value to research partnerships through local knowledge and practical expertise, access to field sites and research participants, and skills in the application, translation and peer-to-peer sharing of results. There are also often people working in regional bodies with research experience or aspirations.

However, both researchers and regional bodies can identify examples of unsuccessful or unsatisfactory research partnerships arising from:

- unrealistic expectations about what research can deliver;
- complicated negotiation of Intellectual Property;
- delivery of information that is impractical to apply at the inappropriate spatial scale;
- results that don't align with the culture of intended users;
- damage to the trust between regional bodies and NRM partners and stakeholders;
- discounted local & traditional knowledge systems; &
- difficulties getting scientific publications from applied NRM research.

This work identifies 10 guiding principles to avoid or overcome such issues.

10 principles for NRM research partnerships

Start working together early

1. Gain a detailed understanding of **partners' objectives for the research** (e.g., the scientific knowledge to be generated, the management decision to be supported). Develop research questions to address these objectives and four cross-cutting topics.

2. Agree on the **form of the partnership**. This could range from consultation (e.g., providing feedback) to involvement (e.g., strategic input and advice) to collaboration (collaborative planning, design, delivery and communication).

3. Develop **fit-for-purpose research methods** that integrate local knowledge and experience, enable statistical analysis and address potential conflicts with aspirations of other NRM stakeholders.

4. Clearly define **partners' roles** based on the form of the partnership, partners' capacities and preferences.

5. Develop **research agreements** that set out details of the above, as well as in relation to Intellectual Property and data sharing. Identify, acknowledge and address power differentials in the partnership.



Engage intended users

6. **Identify the intended uses and users** of the knowledge that will be generated.

7. **Seek to understand intended users' values, priorities, needs and capacity** in relation to application of the knowledge (e.g., whether they are willing to adopt practice change, whether new technology be required).

8. **Seek opportunities to combine research with implementation** (e.g., action research) where appropriate. Consider realistic scope to adjust the project in response to users' perspectives on interim outcomes.

9. **Agree on whether and when intended users should be involved** in the research (e.g., defining objectives, project design, data collection, communication).

10. **Plan for two-way exchange of information** through trusted networks, using appropriate formats and forums to provide updates and interim findings and communicate results. Consider ways to release results as soon as possible (e.g., PhD by publication).



Synthesis of NRM research priorities across Queensland

This synthesis is based on a review of regional bodies’ most recent regional NRM plans and other relevant web-accessible documents, together with discussions with executive and staff. The work builds on Crowley *et al.* (2014)¹.

The NRM Research Prospectus recognises and respects researchers’ expertise and independence and does not specify research questions. Rather, this work identifies known gaps in the knowledge needed to address NRM challenges and scopes related research topics, as well as potential applications of related knowledge by regional NRM bodies.

It is appreciated that this process will not have identified all relevant knowledge needs. It is also recognised that results of research can have unexpected application to management and that basic and other research can have inherent value.

The knowledge needs identified in the NRM Research Prospectus may require new scientific research projects or synthesis of existing research that is not accessible to regional bodies, or a combination of both. Many of the research needs identified in the NRM Research Prospectus could be complemented by other types of knowledge, including traditional ecological knowledge,

practitioner expertise and local experience.

Many of the research needs identified in the NRM Research Prospectus are shared across most Queensland NRM regions. As a state-wide synthesis a high level of detail is presented, although successful NRM research projects would address region-specific needs and contexts.

This integrated research framework is organised into five focal research themes as well as four cross-cutting topics that apply across all themes (see page opposite). It is expected that all four cross-cutting topics will be addressed at the same time as knowledge gaps within a focal management challenge.

Framework for presentation of NRM research needs



¹ Crowley, G.M., 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*. NERP TE Project Final report. Report to the National Environmental Research Program. Cairns: Reef and Rainforest Research Centre.



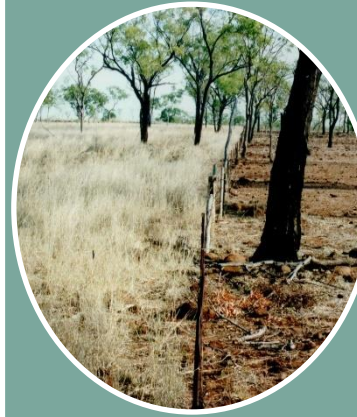
Sustaining human uses of natural resources



Supporting livelihoods



Understanding biodiversity



Implementing adaptive management



Improving organisational influence & practice

Cross-cutting topics

Adapting to climate change impacts
Respecting Traditional Owners' aspirations, rights & values
Fostering ecological resilience & sustainability
Protecting key societal values

Four cross-cutting topics meet the need for NRM research to address multiple, integrated objectives.

Every dimension of natural resource management is influenced by changing climatic conditions. Knowledge about NRM that doesn't address projected increased in temperatures, changes in rainfall patterns, higher sea levels and more frequent and intense extreme weather will have limited applied usefulness. Specific research topics address climate change impacts and adaptation are identified in the synthesis, but any NRM research topic must consider how projected climate changes interact with the sector's adaptive capacity. Developing adaptive NRM solutions involves climate system science as well as local understanding of potential impacts and adaptation options.

Adapting to climate change impacts

There are Traditional Owners for all the Land and Sea Country subject to natural resource management, but Traditional Owners' aspirations, rights and values are not equitably represented in NRM. However, even where NRM research is not explicitly aimed at addressing these equity issues, potential impacts on Traditional Owners' aspirations, rights and values are relevant. For example, in the same way that ecological information and legal frameworks would be considered in an evaluation of the options for translocating species at risk from climatic changes, Traditional Owners' perspectives must also be integrated into the research question. Culturally appropriate, participatory processes would be used, e.g., Threatened Species NESP Hub Indigenous Engagement Protocols.

Respecting Traditional Owners' aspirations, rights & values

It could reasonably be assumed that NRM is ultimately intended to foster ecological resilience and sustainability, but this imperative is explicitly articulated to reduce the risk of unintended or perverse consequences of NRM.

Fostering ecological resilience and sustainability

Consideration of key societal values is likely to influence uptake of NRM and is critical for organisations concerned with both environmental and community resilience. Societal values are likely to vary substantially between regions or even between communities within regions and are also likely to shift over time. For example, managing bushfire risk may have high societal value currently, but the value of managing flood risk may increase after some years of La Niña weather patterns.

Protecting key societal values



Photo credit: Reef Catchments

Theme 1. Sustaining human uses of natural resources

How can human activities be managed to avoid damage to the health and function of natural systems?

Management challenges in this theme require detailed understanding of large-scale ecological processes, interacting causes of significant damage to ecosystem functions, together with practical opportunities to minimise negative impacts of human activities on social, cultural and ecological values

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>1. Reducing chemical and nutrient pollution and sediment loads in runoff</p> <p><i>Identification of the main sources of chemicals, nutrients and high sediment loads in runoff and information about methods for reducing contaminants and impacts on in-stream aquatic systems.</i></p>	<ul style="list-style-type: none"> • Spatial quantification of sources of contaminants in runoff, identifying variation between seasons, landscape features, land uses (e.g., primary production, urban, mining) and specific land practices (e.g., irrigated and dryland cropping, different fertiliser regimes). Consider climate change implications (e.g., more frequent and intense flooding; low ground cover during prolonged dry seasons). • Evaluation of existing (e.g., gully remediation, reduced nitrogen inputs; gross pollutant traps) and new (e.g., bioremediation on cane farms; denitrifying bioreactors in agricultural drainage channels; 'green engineering' in urban drainage) techniques for reducing or capturing contaminants in runoff. • Development of new methods or refinement of existing methods for measuring meaningful improvements in the health of in-stream aquatic systems, marine receiver environments, for farm and other infrastructure and water quality resulting from management measures. 	<ul style="list-style-type: none"> • Trials of emerging technologies for capture of contaminants. • Strategic, targeted chemical, nutrient and sediment reduction actions. • Informed discussions about unsustainable land uses for the region. • Best practice road drainage design to minimise soil erosion and heavy metal pollution. • Compliance reporting by partner organisations.
<p>2. Managing water use to minimise socio-ecological impacts</p> <p><i>Impacts of water use in the context of whole-of-system understanding of hydrological systems.</i></p>	<ul style="list-style-type: none"> • Understanding effects of water use across different sectors on wetlands, groundwater, springs, lakes and waterways, including seasonal variation. Develop scenarios in relation to changing patterns of average and seasonal rainfall, saltwater intrusion and evaporation from storage and supply infrastructure. • Understanding water use and management in relation to cultural values and aspirations of Traditional Owners. • Quantitative cost-benefit assessment of practical options for water treatment and use (e.g., extraction, waste-water management, crop diversification, new enterprises, irrigation techniques, efficiency technologies; storage; managing water supply catchments and water recycling opportunities) across sectors. 	<ul style="list-style-type: none"> • Support Traditional Owner led assessment of impacts on cultural water uses or values. • Advocate for appropriate water supply and distribution infrastructure, water resource allocation, water recycling and price scheduling. • Co-develop information about crops and cropping practices that align with sustainable water use. • Water recycling trials e.g., from sewage treatment to agriculture.
<p>3. Promoting soil health</p> <p><i>Understanding of methods to protect, restore and enhance soil health for many industries.</i></p>	<ul style="list-style-type: none"> • Develop mechanistic understanding of relationships between soil health and crop growth, pasture health etc. • Test effectiveness of various management options (e.g., inputs, tillage, crops, rotation, water use, fire) and soil characteristics. • Test outcomes of innovative management options e.g., microbial and fungal products, alternative fertiliser application, alternative crops at scales appropriate for commercial application. 	<ul style="list-style-type: none"> • Regional demonstration sites of the effects of different management interventions on farm productivity. • Soil health monitoring framework and programs.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>4. Addressing major ecosystem degradation issues</p> <p><i>Understanding of the specific causes of existing degradation and/or of the risk of future degradation and/or options for effective remediation.</i></p>	<ul style="list-style-type: none"> • Mechanistic understanding of links between management activities and dryland salinity, acid sulphate soils, gully erosion, beach and island erosion, soil degradation, woody thickening, marine debris, plastic pollution etc. • Modelling of potential land degradation issues under plausible scenarios of climate change. • Research and development into new technologies to address major land degradation. 	<ul style="list-style-type: none"> • Co-develop best practice protocols with regional industries. • Integrated planning with local government. • Develop operational management targets.
<p>5. Managing fire regimes in multiple use landscapes</p> <p><i>Integrated understanding of how different fire regimes impact different values in landscapes.</i></p>	<ul style="list-style-type: none"> • Develop understanding of how to implement integrated burning regimes to protect industries, Traditional Owner cultural values, protection of life and property, etc. • Develop understanding of the broader impacts of fires outside of burned areas (e.g., dispersal of plants and animals in human-dominated landscapes, scorching etc.). • Evaluate links between fire and erosion risk and groundwater infiltration capacity. 	<ul style="list-style-type: none"> • Integrate fire management planning and implementation into NRM program delivery. • Strengthen the role of regional bodies in fire management networks.
<p>6. Integrating sustainable uses of land and seascapes</p> <p><i>Understanding of the trade-offs arising from different uses of natural resources.</i></p>	<ul style="list-style-type: none"> • Integrated assessment of the environmental capabilities of different combinations of management activities in different ecosystems, identifying interactions, synergies, compatibilities, incompatibilities and cumulative impacts. • Robust and consistent system/systems for classifying ecosystems (e.g., Regional Ecosystems) at finer spatial scales. • Frameworks for assessing the condition of recovering systems. • Understanding of regional climate impacts on NRM using updated downscaled regional climate change projections, including likely secondary consequences (e.g., fire weather). 	<ul style="list-style-type: none"> • Integrated participatory pathway planning processes. • Work with Traditional Owners to prioritise locations for Indigenous cultural and natural resource management, including cultural landscapes and cultural heritage. • On-ground trials of new technologies for remote monitoring (e.g., using drones, artificial intelligence).
<p>7. Reducing risks from mining</p> <p><i>Effects of resources mining on regional socio-ecological values.</i></p>	<ul style="list-style-type: none"> • Integrated assessment of the benefits and risks to communities and industries (e.g., health, water availability, social aspects, education) during preopening stages, during operation and post operation of mining (e.g., coal, gas, nickel) • Identification of protocols for ethical good practice, including concepts of informed consent, social licence and community resilience. 	<ul style="list-style-type: none"> • Regional community responsibility protocols codeveloped with mining sector, state government. • Work with Traditional Owners to prioritise Indigenous cultural and natural resource management, including cultural landscapes and cultural heritage.



Photo credit: Fitzroy Basin Authority

Theme 2. Supporting livelihoods

What are realistic options for natural resource-based industries?

The management challenges in this theme will be supported by integrated understanding of the emerging and likely opportunities and risks associated with regional livelihoods, considering drivers at all scales, including global markets and trends.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>8. Reducing regional greenhouse gas emissions</p> <p><i>Regionally specific information about how to strategically reduce regional greenhouse gas emissions.</i></p>	<ul style="list-style-type: none"> • Audit of regional GHG emissions by specific activities in each NRM sector. Identify options for reducing regional emissions (e.g., solar powered pumps) or increasing capture (e.g., increasing soil carbon in agricultural systems) and conduct cost-benefit analysis of outcomes for existing or potential industries (e.g., productivity changes). • Assessment of opportunities for NRM industries in regional transition to renewable-based economy (e.g., branding, cost savings, new products, improved resilience in extreme weather events) and supporting structures and processes required (e.g., regional market development, distribution pathways, local energy generation and networks). 	<ul style="list-style-type: none"> • Co-develop business models for the region's communities that use or generate alternative and renewable electrical energy, fuel sources and consumable products e.g., hydro, solar, co-generation, waste. • Support work with regional industries to increase options, develop their profitability, resilience and sustainability.
<p>9. Securing payments for ecosystem services</p> <p><i>Quantitative value of different ecosystem services and understanding of current & emerging opportunities at the regional scale.</i></p>	<ul style="list-style-type: none"> • Quantification of regional carbon stocks in different ecosystems (e.g., soil, wetlands, saltmarsh, seagrass, mangroves) and potential for sequestration through practice change (e.g., in sugar industry). • Evaluate whether participation in current or emerging ecosystem services markets does/would be likely to achieve desired ecological, cultural and social outcomes in the region, e.g., compare ecological outcomes in areas burned using the savannah burning methodology with other approaches. • Feasibility assessments of opportunities for participation in existing and new (e.g., carbon grazing, whole-of-industry practice change in the sugar industry) markets, including economic cost-benefit analysis. • Develop advanced understanding of and methods for quantifying the value of desired management practices e.g., that maintain ground cover, buffer waterways, contribute to pest management, maintain soil fertility, protect hydrological cycles, protect water quality, prevent erosion, control pasture dieback, undertake ecological restoration, agroforestry, diversified production systems, grazing of native pastures. Include on and off-property productivity, cultural, social and ecological outcomes. 	<ul style="list-style-type: none"> • Work with industries and banks to develop commercially competitive renewable alternatives and business cases. • Work with Traditional Owners to develop opportunities in management of the Traditional Owner estate. • Advocate for the development of alternative ecosystem services market or accounting methods. • Use to quantify comprehensive cost of loss e.g., of infrastructure and other development.
<p>10. Building commercial opportunities in NRM</p> <p><i>Commercial opportunities associated with sustainable NRM activities.</i></p>	<ul style="list-style-type: none"> • Quantified relationships between economic viability (at the scale of paddock, farm, industry) and different options for diversification or switching of production. Identify optimal mixes of activities and the conditions needed to deliver benefits (e.g., shared processing, distribution infrastructure, market establishment). Consider different plausible scenarios of climate change. • Assessment of the options and feasibility of new commercial opportunities in pest management e.g., woody weeds as a resource, feedlots, camels; waste management (e.g., conversion to energy). 	<ul style="list-style-type: none"> • Promote and support development and adoption of viable new industries, profitable and sustainable mixes. • Business development for oyster regeneration, bees and pollination, eco-cultural tourism, sustainable NRM tourism.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
	<ul style="list-style-type: none"> • Feasibility of aquaculture to support regional food security and/or as a new regional industry, accounting for climate change and other impacts on fish stocks, cultural values and practices. 	
<p>11. Supporting sustainable primary production practice</p> <p><i>Systems-based understanding of primary production to support sustainable practices that account for cumulative impacts of human activities and human wellbeing.</i></p>	<ul style="list-style-type: none"> • Mechanistic understanding of the variation in NRM outcomes from different management regimes e.g., end-of-dry season groundcover in grazing systems, controlled burning start dates, effects of introduced pasture on native grasses. • Assessment of interactions between primary production and other threatening processes (e.g., occupancy, movement and hunting by feral species in relation to grazing regimes in different ecosystems). • Mechanistic understanding of regenerative agriculture for integration into different landscapes and agricultural sectors, together with wellbeing benefits. 	<ul style="list-style-type: none"> • Promote and support development and adoption of sustainable practices. • Co-develop business models for sustainable practices.
<p>12. Hunting & harvesting of native species</p> <p><i>Understanding of population dynamics of native species subject to commercial or traditional take in the context of interaction with pressures resulting from other activities, likely consequences of climate change and alternative livelihood and subsistence options.</i></p>	<ul style="list-style-type: none"> • Baseline understanding of extent and dynamics of significant fisheries species, including productive biology and flow-based cues for movement. • Population assessment of target species in in terms of pressures from other resource uses and climate change in interaction with e.g., commercial fishing, traditional hunting and harvesting practices, native forest logging, firewood collection. • Spatial audit and ecological understanding of old growth ecosystems in Queensland. 	<ul style="list-style-type: none"> • Traditional Owner led identification of target taxa (e.g., totemic species, traditionally hunted species) and co-designed population measurement and monitoring programs • Co-develop agreement on sustainable populations and practices. • Work across sectors to address interacting pressures.
<p>13. Anticipating emerging livelihood opportunities</p> <p><i>Systematic assessment of potential future shifts in global policies and markets and potential for uptake at regional scales.</i></p>	<ul style="list-style-type: none"> • Assess current and projected changes in policies and markets in relation to new regional economic opportunities in NRM. • Evaluate potential opportunities for regional industries in global markets e.g., shift toward plant-based diets • Develop understanding of additional complementary options for pastoral, horticultural, aquaculture, forestry and other primary production industries (as appropriate) at finer spatial scales (e.g., property level), including needs for supporting infrastructure, knowledge. 	<ul style="list-style-type: none"> • Work to prepare regional industries. • Promote opportunities to earn payments for ecosystem services. • Support communication of NRM activities as 'legitimate' economic pursuit. • Work with Traditional Owners to prioritise locations for Indigenous cultural and natural resource management, including cultural landscapes and cultural heritage.



Photo credit: Southern Gulf NRM

Theme 3. Understanding Biodiversity

What are the important factors underpinning regional biodiversity and ecosystem values?

Basic knowledge is lacking about the distribution, function and vulnerabilities of natural systems, dramatically limiting the ability to invest in strategic NRM interventions or to anticipate potential impacts of human activities.

Management challenge & research needs	Example research topics	Example of potential management applications by regional NRM bodies
<p>14. Protecting significant species</p> <p><i>Knowledge about the distribution and resource needs of threatened or regionally significant species and management of threatening processes.</i></p>	<ul style="list-style-type: none"> Spatial understanding of habitat areas for species listed as threatened, regionally significant taxa (e.g., critical weight range mammals), taxa with particular cultural significance, and those likely to be vulnerable to climate change (e.g., freshwater taxa, coastal birds, pelagic foragers, taxa at the limit of thermal tolerance). Spatially explicit understanding of threatening processes, including climate change (e.g., sea turtle rookeries, high altitude species), habitat loss and degradation, invasive species (especially cats). Metrics for identifying areas of species richness (the value of ecotones and diversity of ecosystems). 	<ul style="list-style-type: none"> Integrate into other regional planning processes e.g., Biodiversity Planning Assessments. Implement strategic engagement programs in key habitat areas.
<p>15. Protecting vulnerable ecosystems</p> <p><i>Information about the regional status and trajectory of natural systems.</i></p>	<ul style="list-style-type: none"> Benchmarks for the status and trajectory of natural systems, including those likely to be vulnerable to major threatening processes (e.g., climate change, land degradation, transformative invasive species such as crown of thorns starfish, yellow crazy ants). Advanced understanding of ecological function and relationships with characteristics (e.g., size, condition, connectivity, functional composition) of natural systems. Methods for detecting trends in condition (e.g., using drones, artificial intelligence, LIDaR). 	<ul style="list-style-type: none"> Targeted monitoring of change in the condition of natural systems. Strategic intervention programs to address key threats. Participatory development of practical management frameworks for ecological function.
<p>16. Supporting ecological burning</p> <p><i>Practical understanding of the outcomes of different fire management regimes for biodiversity, ecosystems and ecological health.</i></p>	<ul style="list-style-type: none"> Comparison of long-term outcomes for vegetation (e.g., tree cover, composition), target fauna and water quality of different fire regimes (e.g., different timing, frequency, extent, intensity and type) for different ecosystems. Understanding relationships between the outcomes of different fire regimes and ecosystem function. Specific understanding of different fire management practices (e.g., cool and hot burns) and ecological, carbon and other outcomes. 	<ul style="list-style-type: none"> Work with Traditional Owners to develop frameworks for decision making about ecological burning in different natural systems. Input to valuing ecosystem services.
<p>17. Maintaining freshwater systems</p> <p><i>Whole-of-system knowledge of freshwater ecosystems, especially groundwater systems and freshwater wetlands.</i></p>	<ul style="list-style-type: none"> Spatial and dynamic understanding of surface and groundwater systems, including source, quantity, flow, seasonality, chemistry, aquifer recharge rates, and associated groundwater dependent ecosystems and biodiversity. Inventory of the location and condition of freshwater wetland systems, together with assessment of likely climate change impacts. 	<ul style="list-style-type: none"> Inform regulatory frameworks (e.g., water resource allocation and price scheduling). Water Quality Improvement Plans. Input to statutory planning and industry discussions about potential impacts of different land uses.

Management challenge & research needs	Example research topics	Example of potential management applications by regional NRM bodies
	<ul style="list-style-type: none"> Assessment of the role of wetlands and floodplains in filtering pollutants (e.g., those entering marine environments) and the factors or conditions related to function. 	<ul style="list-style-type: none"> Establish regional water quality and water quantity framework associated with monitoring groundwater bores and aquifers.
<p>18. Protecting soil biodiversity</p> <p><i>Understanding of natural variation or determinants of soil biodiversity and health.</i></p>	<ul style="list-style-type: none"> Understand the distribution of soil biota in different natural systems and across different management regimes in the region. Identify interactions between soil characteristics (e.g., structure, chemistry) and soil biodiversity and assess potential impacts of different land uses and specific land practices. 	<ul style="list-style-type: none"> Inform fire management frameworks. Co-develop best-practice with horticulture, grazing and other industries
<p>19. Protecting & supporting climate refugia</p> <p><i>How on-ground management of potential climate refugia could protect and develop their refugial potential.</i></p>	<ul style="list-style-type: none"> Spatially explicit assessment of potential climate refugia at regional and local scales (e.g., gullies, southern slopes, small rises in coastal plains), threatening processes and options for their protection. Operational understanding of micro-refugial characteristics (e.g., rocks and logs; tree hollows), including comparison of natural and artificial components, and options of enhancement (e.g., turtle rookeries). Identification of ecological processes required for the occupation of refugia (e.g., landward shift in coastal systems) and evaluate management options in terms of time scales involved, existing or future uses and technical capacity. 	<ul style="list-style-type: none"> Work with state and local governments to achieve practical protection for regional climate refugia. Target restoration to increasing amount of habitat adjoining or near refugia Develop intervention programs aimed at supplementing thermal microrefugia (logs).
<p>20. Effective & efficient ecological restoration</p> <p><i>Evaluation of the empirical outcomes of different restoration methods to identify optimal approaches for specific conditions.</i></p>	<ul style="list-style-type: none"> Analysis of key determinants of variation (e.g., local conditions, available resources and capacity) in approaches to revegetation, fire management, pest management, gully remediation, instream and riparian restoration, beach nourishment etc. Evaluation of medium-to-long term outcomes of different ecological restoration approaches for biodiversity and ecological function, together with a holistic cost analysis. Practical understanding of restoration options, on-ground methods and outcomes e.g., groundwater dependent ecosystems, in-stream systems. 	<ul style="list-style-type: none"> Support regional practitioners to improve restoration practice to minimise costs and maximise ecological outcomes. Achieve more widespread restoration. Seek increased investment for evidence-based intervention.
<p>21. Improving ecological connectivity</p> <p><i>Understanding of how practical interventions at different spatial scales can improve ecological</i></p>	<ul style="list-style-type: none"> Critical assessment of the role of connectivity in relation to Increasing the area of habitat by improving access and facilitating movement, including migration to & colonisation of climate refugia. 	<ul style="list-style-type: none"> Strategic, targeted interventions (e.g., habitat restoration, installation of fish passages, removal of physical and biological (e.g., predators) barriers.

Management challenge & research needs	Example research topics	Example of potential management applications by regional NRM bodies
<p><i>connectivity considering temporal dimensions of wildlife movement processes.</i></p>	<ul style="list-style-type: none"> • Evaluation of likely Impacts of climate change on existing connectivity (edge effects in ‘corridors’; climatic unsuitability (including seasonal). • Advanced understanding of the role of management in coastal, estuarine and marine connectivity dynamics. 	<ul style="list-style-type: none"> • Evidence-based investment in activities to improve connectivity and the amount of habitat for biodiversity.
<p>22. Managing invasive species</p> <p><i>Integrated, regional understanding of the impacts of invasive species on ecological function, economic productivity and cultural values. Strategic target areas and innovative control techniques.</i></p>	<ul style="list-style-type: none"> • Assessment of the impacts of invasive species on key ecological functions and associated management priorities and options. Evaluate likely impacts of climate change, including through processes such as shifting human populations. • Spatially explicit understanding of the priority areas for managing invasive species in order to have lasting effects on reducing pest populations and impact on natural systems. • Integrated understanding of effective methods of controlling invasive species (e.g., fire, fungal bioherbicide), including consideration of co-benefits (e.g., potential economic opportunities) and new methods (e.g., drones, biological control). 	<ul style="list-style-type: none"> • Integrated pest management strategy. • More efficient, targeted control of invasive species issues. • Ecological-based prioritisation of invasive species threats.



Photo credit: Cape York NRM



Photo credit: NQ Dry Tropics

Theme 4. Implementing Adaptive Management

How can the outcomes of management be measured and used to adapt future NRM?

Management actions are necessarily based on assumed links between on-ground intervention and strategic objectives. Setting appropriate objectives requires critical assessment in the context of anthropogenic climate change, as well as other overarching drivers of natural resource distribution, extent, condition and use. Evaluating whether and why actions are (or are not) achieving intended outcomes depends on improved monitoring design, as well as clearer understanding of baseline conditions and of change that is occurring independently of management.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>23. Setting realistic goals for regional biodiversity</p> <p><i>Understanding of whether and how NRM objectives based on current distributions and compositions of ecosystems need to adjust to current large scale and rapid climatic changes and climate instability.</i></p>	<ul style="list-style-type: none"> Refined understanding of the regional consequences of climate change, including both primary (e.g., exceeding temperature thresholds of high-altitude fauna) and secondary (e.g., reduction in dugong and turtle feeding opportunities) consequences. Understanding the potential for <i>in situ</i> autonomous adaptation in regional biodiversity and ecosystems, including using micro-refugia. Understanding likely changes in the composition and structure of regional ecosystems, including changes resulting from adaptive responses (e.g., immigration by species currently living outside the region). 	<ul style="list-style-type: none"> Regional NRM planning Co-develop implications for management practice by NRM industries e.g., adaptive provenancing for revegetation. Communication with the broader community about likely changes. Targeted monitoring programs aimed at picking up triggers for changing management.
<p>24. Measuring outcomes of NRM</p> <p><i>Practical frameworks for monitoring meaningful change and outcomes of management at realistic time scales.</i></p>	<ul style="list-style-type: none"> Practical monitoring frameworks including indicators of the desired ecological outcomes of management that can be applied at appropriate spatial and temporal scales and require appropriate skills and effort. Technological innovation in monitoring, including automated monitoring (e.g., drones, satellite imagery, ground sensors, artificial intelligence) and improved internal digital systems (architecture, inputs, outputs and processing). Appropriate roles for citizen science in monitoring projects, considering issues relating to capacity, accuracy, reliability and engagement, including potential trade-offs between maximising participation and data quality. 	<ul style="list-style-type: none"> Co-development and implementation by Traditional Owners of monitoring using integrated Traditional and western science frameworks. Advocate for consistent reporting across state and national programs. Develop consistent citizen science monitoring programs that complement other data collection on pastures, wetlands, rivers, coastal and marine systems. Design and/or improve appropriate data management systems. Implement recommendations from previous program evaluations.
<p>25. Detecting underlying responses to climate change</p> <p><i>Targeted real-time monitoring of autonomous responses in biodiversity and ecosystems to ongoing climate change.</i></p>	<ul style="list-style-type: none"> Predictive understanding of likely changes in natural systems as a result of the cumulative effects of changing average climates, as well as extreme events, and secondary impacts (e.g., through processes such as fire). Practical monitoring frameworks to detect actual responses of regional biodiversity and ecosystems to changing climatic conditions. 	<ul style="list-style-type: none"> Dynamic management and planning. Processes for regional communities to provide input into adaptive management. Forums for exchanging information about regional changes in natural systems.
<p>26. Supporting adaptive communities</p> <p><i>Understanding of the structures and processes that enable community adaptation to</i></p>	<ul style="list-style-type: none"> Evaluation of appropriate roles for regional NRM bodies in supporting and/or contributing to community resilience structures and processes (e.g., co-ordinate decision-making forum, empower local groups, engage government, deliver information). 	<ul style="list-style-type: none"> Support regional communities to access, share and consider information to make decisions that optimise benefits across sectors.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p><i>changes in climate, the condition of natural resources, global markets etc.</i></p>	<ul style="list-style-type: none"> • Collaboratively scope options based on adaptation experiences in Traditional Owner communities. 	<ul style="list-style-type: none"> • Build regional capacity for disaster management and recovery (e.g., energy micro-grids, local goods and services networks, green infrastructure).
<p>27. Adapting NRM strategies</p> <p><i>Practical understanding of how to build in response to the results of monitoring to operationalise flexible NRM planning and investment processes.</i></p>	<ul style="list-style-type: none"> • Evaluation framework that links monitoring to decision-making and planning, including identification of risks and specific thresholds as triggers for management. • Operational understanding of regional goals and targets at finer spatial scales (e.g., catchment, local landscape, industry). 	<ul style="list-style-type: none"> • Adjust cycles of NRM planning linked to regional monitoring and reporting programs • Keep regional Water Quality Improvement Plans current and up to date. • Developing leading and lagging indicators for monitoring programs that stem from regional NRM plans (consistent approach across NRM).
<p>28. Planning for future uses of natural resources</p> <p><i>Information about how patterns in regional demands for and management of natural resources are likely to change in the future.</i></p>	<ul style="list-style-type: none"> • Plausible scenarios of demand for regional natural resources, considering major drivers of natural resource use and management, e.g., demographic projections, foreign ownership laws, aging farmers, changes in the Traditional Owner estate, major infrastructure plans, as well drivers of resource availability (including primary and secondary impacts of climate change; marginal land). • Proactive understanding of the policy and planning pathways needed to support ecologically sustainable human communities (e.g., One Planet Living®) • Refined understanding of agricultural land suitability (e.g., Queensland Agricultural Land Assessment) to property level. 	<ul style="list-style-type: none"> • Integrated regional participatory planning processes that assess whether and how future options may be affected by current decisions about the management and use of natural resources (i.e., path dependency). • Support for uptake of innovative practices through discussion of the cost/risk of not changing. • Support for succession planning.



Photo credit: Southern Gulf NRM

Theme 5. Improving organisational influence & practice

How regional bodies advance positive change in the NRM sector?

Increasing uptake of NRM on the ground requires better understanding of the drivers and motivators of change. Fostering investment, policy and other support for NRM depends on clearer evidence about the value of Regional Bodies and the broader NRM sector. Continuous improvement in Regional Bodies depends on critical evaluation of and innovation in NRM practice.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>29. Motivating adoption of sustainable NRM practices</p> <p><i>Understanding of the tools available to regional bodies to generate actual shifts in NRM practice through their influence on the behaviour of individuals, groups and communities.</i></p>	<ul style="list-style-type: none"> Evaluation of the relative roles of information (e.g., financial argument), delivery (e.g., through trusted networks) and other factors (e.g., cultural identity, social services, community perspectives) in adoption of new NRM practices. Framework for understanding the scale (e.g., incremental or transformational) of change required to achieve regional NRM goals. 	<ul style="list-style-type: none"> Work with industry bodies to co-develop stewardship frameworks, information kits or extension programs. Better support for online tools and services to support stakeholders. Support for and co-development with Traditional Owners of strategies for youth engagement in NRM.
<p>30. Adapting to global drivers of NRM</p> <p><i>Understanding of external circumstances that influence the perception of and engagement with NRM by regional communities.</i></p>	<ul style="list-style-type: none"> Evaluation of the tools available to regional NRM bodies in the context of global drivers (e.g., prolonged drought, global pandemic, government politics, population shifts in response to climate change) influencing NRM practice (e.g., appetite for risk, community willingness to volunteer). Understanding critical dependencies between the regional distribution of power, influence and vested interests and NRM outcomes. 	<ul style="list-style-type: none"> Flexible and adaptive use of NRM strategies that adapt to global drivers and achieve desired NRM outcomes. Strategic partnerships to address power imbalances.
<p>31. Influencing programs, policies and plans</p> <p><i>Understanding of practical pathways for integrating regional NRM priorities (including research needs) into decision-making at local, state and Commonwealth levels.</i></p>	<ul style="list-style-type: none"> Holistic analysis of the science investment system in Australia and identification of options for regional bodies' entry and influence. Critical analysis of the need for and reforms or pathways needed to integrate regional priorities in NRM policies and programs at local, state and Commonwealth levels. Assessment of factors related to outcomes of laws and policies, especially unintended outcomes (e.g., drought relief funding perpetuating unsustainable practices). 	<ul style="list-style-type: none"> Regional bodies organise appropriate information-sharing forums (e.g., Communities of Practice) to develop relationships and inform the science agenda. NRM regional bodies' participation in integrated planning processes.
<p>32. Supporting NRM careers</p> <p><i>Understanding of the policy and programmatic reform required to improve employment opportunities and conditions in the NRM sector.</i></p>	<ul style="list-style-type: none"> Develop understanding of the expertise, skills, experience and training required by professional NRM practitioners and critically evaluate the relationships with a reliance on volunteers or jobs programs to deliver on ground works. Assess potential pathways for increasing understanding of the value of NRM practitioners, including through formal recognition of skills and experience (e.g., micro-credentialing). Evaluate the risks to human health of NRM-related practices such as the use of herbicides. 	<ul style="list-style-type: none"> Support viable industries for workers in sustainable NRM operations. Improve cultural security in regional bodies to enhance career paths and employment opportunities for Traditional Owners. Work with universities and TAFE to develop links across graduate programs.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>33. Improving regional bodies' work with Traditional Owners²</p> <p><i>Understanding opportunities and regional bodies' responsibilities in relation to cultural heritage, Traditional Owner governance and management to support equitable, culturally appropriate and effective ways of integrating Traditional Owners aspirations, values and knowledge into NRM regional planning and delivery.</i></p>	<ul style="list-style-type: none"> • Co-develop applied understanding of Regional Bodies' roles and responsibilities in relation to native title and cultural heritage, as well as Traditional Owner sovereignty and self-determination. • Co-develop fit-for-purpose guidelines for partnerships with Free, Prior and Informed Consent, protocols around data sharing that recognises data sovereignty for Traditional Owners (e.g., cultural knowledge governance, appropriate data collection, storage, management, ownership and access). • Co-develop framework for Traditional Owner participation in regional bodies' processes to influence programs, policies and plans. 	<ul style="list-style-type: none"> • Brokerage by regional bodies of ILUAs and other access agreements in relation to NRM activities in places or concerning species with special cultural value for Traditional Owners. • Collaborative incorporation of Healthy Country Plans into regional NRM planning and implementation. • Appropriate engagement with and support for Traditional Owner alliances (including traditional cultural networks and/or Indigenous Advisory Groups). • Participatory approaches for co-design and co-delivery with Traditional Custodians
<p>34. Quantifying the value of regional NRM bodies as regional service providers</p> <p><i>Quantitative understanding of the cumulative social, economic, cultural and environmental value of the services provided by regional NRM bodies.</i></p>	<ul style="list-style-type: none"> • Develop meaningful, measurable indicators of the economic (e.g., primary productivity), cultural (e.g., healthy Country, healthy people) and social (e.g., wellbeing) values of regional NRM bodies, including co-benefits and both up-front and longer-term costs and savings of NRM activities at relevant scales (e.g., paddock, farm, industry, region, state, Australia). • Detailed regional economic analyses of benefits to broader economy of investment in NRM. • Quantify realistic options for sustained investment in NRM, including philanthropic and other opportunities, and understand key enabling factors (e.g., marketing). 	<ul style="list-style-type: none"> • Development of a value proposition for sustained investment to address uncertain and discontinuous project funding. • Motivate engagement with regional NRM bodies. • Improve the influence and uptake of practices promoted by regional bodies.

² Example research topics are identified for this management challenge, although it may be more appropriately addressed through Traditional Owner led processes rather than research *per se*. They are included here on the understanding that it may otherwise be excluded from consideration. It is also understood that a contemporaneous process of identifying Traditional Owners' research priorities is being implemented through the Northern Australia NESP Hub and readers are referred to its outputs.

Management challenge & research need	Example research topics	Example of potential management applications by regional NRM bodies
<p>35. Undertaking effective regional NRM planning</p> <p><i>Understanding of variation in NRM planning approaches to investment and the delivery of NRM outcomes across regions.</i></p>	<ul style="list-style-type: none"> • Evaluation of different regional NRM planning approaches (e.g., participatory processes, delivery formats) and impact (e.g., uptake of priority actions). • Operational understanding of consultation, engagement and co-development processes that avoid engagement fatigue among stakeholders. • Comparative analysis of the effectiveness of statutory and non-statutory NRM planning in Australia. 	<ul style="list-style-type: none"> • Align planning approaches to achieve organisational strategic objectives. • Co-develop with Indigenous Advisory Groups effective participation in planning processes.
<p>36. Supporting local NRM stakeholder groups</p> <p><i>Understanding options for supporting local NRM stakeholder groups to overcome challenges to practical governance and participation.</i></p>	<ul style="list-style-type: none"> • Develop understanding of the options for - and appropriate roles of regional NRM bodies in supporting – effective and enduring governance of delivery groups (e.g., local Landcare groups, industry bodies, Traditional Owner groups). • Critically evaluate barriers to participation (e.g., time, remuneration, culture) by local organisations. • Social network analysis and social audits of partner groups. 	<ul style="list-style-type: none"> • Support work with regional delivery groups. • Sharing resources and celebrating local examples of good governance • Offer appropriate remuneration for time and expertise (including reporting, etc.). • Develop protocols around sharing and protecting Intellectual Property of partner organisations.



Priority research needs

Each of the 36 management challenges in the synthesis table above is associated with research needs that are priorities in at least one NRM region; most are priorities in multiple regions. Based on five prioritisation criteria³, research needs associated with the following management challenges are indicative priorities⁴, commonly shared across most Queensland NRM regions⁵. Most are in the theme *Understanding biodiversity*. Numbers correspond with numbers in the synthesis table.

5. Managing fire regimes in multiple use landscapes
9. Securing payments for ecosystem services (not in SEQ)
14. Protecting significant species
15. Protecting vulnerable ecosystems
16. Supporting ecological burning
17. Maintaining freshwater systems
18. Protecting soil biodiversity
19. Protecting and supporting climate refugia
24. Measuring outcomes of NRM
33. Improving Regional Bodies' work with Traditional Owners
34. Quantifying the value of regional NRM bodies as regional service providers

Naturally, there is variation between NRM regions in their research priorities, depending on the nature of the region, organisation and past research activity⁶. Regional bodies in similar bioregions⁷ often share several research priorities. Regional patterns in indicative priorities are summarised in the following map.



³ Systematic prioritisation considered 5 criteria: Urgency; ii) Foundational; iii) Risk of not knowing; iv) Impact; Strategic value

⁴ Scored for at least one of the criteria across all NRM regions or scored for at least 3 across most regions.

⁵ Systematic prioritisation of research needs was done directly by participants in a workshop involving representatives from all regional NRM bodies except Desert Channels and Reef Catchments which are in the Rangelands and Wet Tropics NRM clusters, respectively.

⁶ The perspectives of the individual(s) completing the prioritisation for each region also potentially account for some variation. The prioritisation framework would ideally be completed by multiple people across each organisation to get more objective regional perspectives.

⁷ E.g., the NRM clusters used in the [NRM Planning for Climate Change programme](#), i.e., Rangelands (Desert Channels, Southern Queensland Landscapes), East Coast (Fitzroy Basin Authority, Healthy Land & Water, Burnett-Mary Regional Group), Monsoonal North (Northern Gulf Resource Management Group, Southern Gulf NRM, North Queensland Dry Tropics) and Wet Tropics (Cape York NRM, Terrain NRM and Torres Strait Regional Authority).

Research priorities in the Torres Strait region overlap with those from other regions, especially the Wet Tropics NRM cluster, but research to support 1. *Reducing chemical and nutrient pollution and sediment loads in runoff* remains a priority in the Torres Strait region. In addition, 32. *Supporting NRM careers* is a priority for the region.

Priority research needs across the Wet Tropics NRM cluster include those that support the management challenges of 8. *Reducing regional greenhouse gas emissions*, and 10. *Building commercial opportunities in NRM*, as well as several in the Adaptive management theme, i.e., 23. *Setting realistic goals for regional biodiversity*, 25. *Detecting responses to climate change*, 27. *Adapting NRM strategies*. Additional research priorities for the Wet Tropics and Cape York regions include 21. *Improving ecological connectivity*, 31. *Influencing programs, policies and plans*, 35. *Undertaking effective regional NRM planning* and 28. *Planning for future uses of natural resources*.

Research to support 6. *Integrating sustainable uses of land and seascapes* is identified as a priority across northern regions of Queensland in the Wet Tropics and Monsoonal North NRM clusters. More remote regions (e.g., the Gulf regions and Torres Strait) tend to priorities research associated with supporting regional communities i.e., 26. *Supporting adaptive communities* and 36. *Supporting local NRM stakeholder groups*.

Across the Monsoonal North regions, research priorities include those addressing the management challenges of 20. *Effective and efficient ecological restoration* and 22. *Managing invasive species*. 2. *Managing water use to minimise socio-ecological impacts* is important for the Gulf regions.

As predominantly agricultural regions, Monsoonal North and Rangelands prioritise research to support 3. *Promoting soil health*, 11. *Supporting sustainable primary production practice* and 29. *Motivating adoption of sustainable NRM practice*.

Research priorities for the East Coast NRM cluster include 2. *Managing water use to minimise socio-ecological impacts*, 3. *Promoting soil health*, 13. *Anticipating emerging livelihood opportunities*, 21 *Improving ecological connectivity* and 22. *Managing invasive species*. There is considerable diversity among the three regional groups, for example the more rural regions prioritise 34. *Quantifying the value of regional NRM bodies as regional service providers* while research to support 29. *Motivating adoption of sustainable NRM practice* is a high priority in some regions but not others.

In the Rangelands, research to support 2. *Managing water use to minimise socio-ecological impacts* is a priority reflecting the semi-arid nature of the regions. In addition, research priorities relate to 10. *Building commercial opportunities in NRM*, 13. *Anticipating emerging livelihood opportunities*, 21 *Improving ecological connectivity*, 23. *Setting realistic goals for regional biodiversity*, 26. *Supporting adaptive communities*, 27. *Adapting NRM strategies* and 30. *Adapting to global drivers of NRM*.



Further information

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