Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Environment and Natural Resource Management

In the next 50 years and beyond, unlike the decades prior, we anticipate increased ecosystem shifts (i.e. collapse of current functions, and localized extinctions), increased frequency of extreme events, island displacements, and sea incursions (among several other environmentally driven challenges). Research and policy advancement in the next 10 years will be critical to enable social and economic transitions and biodiversity adaptations through this period of change.

The 2016 Roadmap must clearly inform this pathway through dedicated and appropriate infrastructure investment. I trust that the evolution of the released Issues Paper into the 2016 Roadmap (and resultant funding profile) will demonstrate that our challenges and needs in Environment and Natural Resource Management are adequately recognized, understood, and ultimately funded by the Australian Government. Below I provide my individual views and responses to the questions asked to inform this process, however, these views have been informed through consultation with others within the biodiversity and ecosystem science community. Note that I have also participated in the drafting of submissions by the Terrestrial Ecosystem Research Network (TERN), the Ecosystem Science Council (ESC), and The Australian National University.

Question 18: Are the identified *emerging directions* and research infrastructures for Environment and Natural Resource Management right? Are there any *missing or additional* needed?

Item 6.1, Emerging Directions identifies two areas, titled: (1) Integration, and (2) Climate and water resources.

(1) Integration and *synthesis* is an emerging need and significant infrastructure investment is needed to enable scientists to integrate and examine *current data and modelling capability* to inform prediction and reduce uncertainty.

Integration refers to the adding together or amalgamation of data. Synthesis refers to the deriving meaning from the data to produce an outcome. Application, in this context, refers to using the data to answer specific questions. These components of synthesis and application require understanding of ecosystem processes *over time*, and are not just a generic technological capability.

To do this well, we need broad conceptual frameworks for the application and testing of 'data integration, synthesis and modelling capability'. Appropriate global application frameworks exist but there is currently very limited capability within Australia to adequate progress and apply these emergent policy frameworks. Pertinent examples include:

- **United Nations System of Environmental-Economic Accounting** (SEEA) (http://unstats.un.org/unsd/envaccounting/seea.asp)
- **IUCN Red List of Ecosystems** which is underpinned by an evidence-based, scientific assessments of the risk of ecosystem collapse (http://www.iucn.org/resources/conservation-tools/iucn-red-list-ecosystems)
- **Sustainable Development Goals** (http://www.un.org/sustainabledevelopment/sustainable-development-goals/)

Purely on the domestic front, research infrastructure investment is needed to enable repeated and reliable State of the Environment reporting in Australia, to adequately meet the intent of the Commonwealth *Environment Protection and Biodiversity Conservation Act*.

Research infrastructure to enable applications of the aforementioned frameworks, at a scale appropriate to meet the national need, is required. To achieve this, dedicated and reliable infrastructure investment in the form of people, site-based ecosystem data, and models is needed. This investment needs to *build from current long-term ecological research* networks and *existing landscape, water and climate* data and infrastructure assets. Investment and integration across people, networks and equipment is needed so that we can evolve current capabilities into long-term ecological-economic research and long-term ecosystem risk assessment networks, which can in turn, inform State of Environment reporting.

The Australian National University through its continued commitment to, and support of, *long-term ecological research* and *synthesis* has, in part, demonstrated the feasibility of these concepts. Refer for example to:

- Environmental Accounts: http://www.nespthreatenedspecies.edu.au/news/vic-forests-worth-more-as-national-park-than-timber
- Ecosystem collapse risk assessments: Assessment of mountain ash forest in the Central Highlands of Victoria, south-eastern Australia, http://iucnrle.org/assessments/
- Australia's Environment in 2015, http://wenfo.org/aus-env/#/

Essential foundational capabilities such as the Terrestrial Ecosystem Research Network, Atlas of living Australia, and the Integrated Marine Observing System have placed Australia in a position to now evolve our ecosystem research and forecasting capability. To harness this capability, we now need dedicated and aligned translational research infrastructure.

Climate and water resources.

This 'direction' should be expanded to encompass sustainable use of natural resources under conditions of climate change and greater resource demand. The mentioned issues (relating to data requirements and scientific evidence to inform decisions about resource use) are common to many

resources: water, carbon, soil and biodiversity. Knowledge of these are equally important to meet the identified Science and Research priorities.

In my view, the 'emergent direction' should be whole-of-system thinking and reliable reporting. There is still a basic need for coordinated and coherent application through experimentation, adaptation, and mitigation strategies. Large-scale manipulative experiments in particular are needed. This type of research infrastructure, for example, is needed to drive breakthroughs in techniques for ecosystem restoration. This is important because the ecosystem services needed to maintain a prosperous Australia will depend, in-part, on *restoration* of ecological function. Embedded within this should be a focus on highly interactive species that help restore ecosystem function e.g. ecosystem engineers, and keystone species. These will be critical to soil health, carbon sequestration and the management of invasive species.

Missing or additional *emerging directions*

(1) Transdisciplinary and translational research (i.e. social, health and ecosystem scientists working together) and the infrastructure needed to enable this is an emergent direction.

Research infrastructure for measuring and managing uses of, and users of, environmental resources and social-ecological systems is needed. Investment in physical earth and planetary environmental infrastructure are important, and will produce large amounts of additional data, but it is also important for the research community to discover what data is most urgently needed for social and political purposes. This is important because only six out of 17 Sustainable Development Goals are physical, the rest are about people or societies.

(2) forecasting the sustainable limits of resource use to inform decisions about economic development versus sustainable environments is needed.

(3) quantifying ecosystem services to incorporate their value to human well-being into assessments of resource use trade-offs is needed.

(4) The importance of indigenous land and private lands in environmental and natural resource management research is missing. Access to, *and collaboration with*, indigenous people and farmers is essential to Australian research capability and to enabling sensible natural resource management to occur.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next 10 years and beyond?

Yes, below are some key examples

- United Nations System of Environmental-Economic Accounting (SEEA)
- IUCN Red List of Ecosystems
- Sustainable Development Goals
- The towards a global observatory network project. This is an emerging initiative being scoped and advanced in October 2016 in South Africa at the International Long Term Ecological Research Network Open Science Meeting.

- USA Long Term Ecological Research Network
- The German Biodiversity Exploratory concept
- Future Earth

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

What is needed most

An additional capability need is a system *to use* existing and future environmental data *to measure, synthesize and forecast* ecosystem change to drive research innovation but more importantly to support Australia's domestic needs under the *EPBC Act,* and meet international obligations through agreements, such as those under the UN Framework Convention on Climate Change, the Sustainable Development Goals and the Convention on Biological Diversity (to name a few).

Systems such as environmental accounts (eg United Nations System of Environmental-Economic Accounting) and the IUCN Red List of Ecosystems risk assessment process can be used as part of this to integrate and synthesize data and expert knowledge to identify the condition of ecosystems, their change over time, and quantify impacts from external factors. *We need a strong and coherent evidence-base to manage ecosystems for biodiversity, water, carbon, soil and air resources but also for human health and wellbeing.*

We have critical need for an enduring environmental *government-research* centre focused on designing and delivering public good initiatives addressing Australia's environmental challenges. We really need to re-think priorities and de-emphasize exploitative industries and commercial pathway research and *look equally to* enable research and create jobs and growth from our natural assets and natural sciences. We need to systematically value our ecosystems and look to address our environmental challenges *through appropriate experimentation and forecasting infrastructure*.

We can increase economic growth through a knowledge economy and *an environmental restoration economy*. In doing so, Australia can position itself as a central figure in the world's attempt to implement the Sustainable Development Goals by 2030. Meeting the 17 Sustainable Development Goals will require transformative change in energy, agriculture, *ecosystem management*, and urban development. These transformations are feasible, but not without significant research infrastructure investment to enable the best scientific *and policy minds* to be employed to make it happen. This will require leadership and stable policy settings to empower unprecedented problem solving on questions of science, implementation, financing, and monitoring.

To implement the Sustainable Development Goals, better alignment through whole-of-government strategies are needed between health-social-employment-economic-environmental-and education policy positions. The time for piece meal, politicised and compartmentalized strategies must be brought to a decisive end. An era of long-term vision, intelligence, nuance, and integrated research and policy *by design and implementation* is needed. Central to this reform should be an agile and knowledgeable research workforce. One that is valued for its skills and an ability to work together and effectively apply their knowledge within appropriate policy frameworks.

If not done now, Australia risks being known for its missed opportunities rather than it's seized ones. To avoid this, we need research infrastructure investment that enables the transformative change needed to maintain our prosperity and current competitive advantage in environmental research.

Concerning emphasis and omissions

(1) In the Paper, 'gaps' are identified, which I don't think are gaps. I am not sure where these have come from but there is current TERN infrastructure in the mentioned alpine, tropical and desert ecosystems. In my view, the least-covered ecosystem types are actually freshwaters and coasts.

    However, to have 'gap' free monitoring data is likely not feasible at this time (for example at least $150M pa for TERN alone would be needed) so we need well designed, nested, and tailored capability. This should come from (at a minimum) continued funding of TERN and IMOS and both should be ***equally funded***. In my view to do otherwise is not justifiable.

    It is essential that at a minimum we maintain our current data streams, especially our existing long-term repeat-measure programs. The need for ***consistency over time*** from current capabilities surpasses other needs in this fiscally constrained times. The importance of, and need for, consistent long-term data is evident from the current climate debate and the role that existing long-term climatic data has played in completely preventing short-term vested interests preventing action for the public's wellbeing.

(2) In the Paper there is no mention of collections (eg herbaria, museum, and CSIRO collections) and how these are essential in enabling science, and education. These are critical infrastructure and must be funded appropriately.

(3) More generally, I thought there was a concerning 'extractive' and 'services' emphasis in the Paper, which may be an artifact of merging 'environment' and 'natural resource management'. The Paper, for example, doesn't really recognize the risks associated with ecosystem disturbance and potential loss of function from extractive pressures. It also generally doesn't recognize that ecosystems ***and biodiversity*** have intrinsic value and multiple benefits for human wellbeing—and the economy through such things as eco-tourism and ecosystem services (ie carbon sequestration, water, air etc). It also doesn't recognize ecology's track record in fostering innovation and invention. For centuries, environmental and life scientists have fostered innovation in societies. Their work inspires invention and technical advancements but equally importantly it provides foresight capability, which enables preparedness and adaption. This drives efficiency through avoided loss and arms industry with options and opportunities. Please refer to the Ecosystem Science Council submission for more detail and specific examples.

6.2.3 Terrestrial systems

The suggestion that 'essential environmental variables' need to be agreed to is, in-part, true but this needs to be approached with caution and grounded heavily with, why? For what purpose? For example, is it because TERN will have its budget expanded 10-fold? Or a new complimentary capability will be funded? To have this debate in the absence of a considerably expanded investment will be distracting at best, and at worst, potentially fractious to the ecosystem science community.

What is most essential, is to maintain and protect the data streams we already have established, *and to more adequately enable there use by the research community and the capabilities themselves*. There is certainly a need for expansion but if this were undertaken, it should be done with an appropriate budget and consultation process *and is must* not be approached under the

assumption that uniform data needs to be collected across the continent. Although convenient and easier to conceptualize and deploy, this approach won't meet our national needs. This approach is sensible for certain fields such as remote sensing but investment to meaningfully measure and forecast ecosystem change in *function and condition* needs to be tailored and primarily question driven. *Ecosystem specific investigations* of drivers of changes, and threat assessments are what is needed and the 'standards' and 'integration' needs to come from the supporting knowledge networking systems and overarching frameworks like the United Nations System of Environmental-Economic Accounting and the IUCN Red List of Ecosystems. These frameworks highlight what our data and modelling needs are. The research community needs to be enabled to produce a set of SEEA accounts and IUCN risk assessments for every ecosystem in Australia. This process will highlight where there are risks and current economic mismanagement, as well as highlight data gaps and modeling capability gaps to drive further innovation in research.

6.3 Desirable new capabilities

(i) Workforce skills require good understanding of ecosystem processes and the Australian environment to interpret and make use of the data. It is not only skills in data analysis and technology that are required, *field skills are essential*.

(ii) Research infrastructure should be aligned to applications, such as informing current or potential problems, or testing theoretical hypotheses.

6.3.1 Automation is not the only solution to data collection, particularly on the ground. Understanding of field situations, differences between environments, and ecological processes are critical for collecting and interpreting high quality data. There is value in automation but it should not be invested in at the expense of more holistic survey data (which employs people).

6.3.2 National model systems – one of the national systems required is that of environmental accounting that will link environmental benefits into economic analysis to assess benefits for human well-being. This is a general system that can be adapted to a suit of specific natural resources, regions and issues. A system of environmental accounting will contribute to decision-making about conflicting land uses; an issue that will become increasingly important with greater demand for resources and greater impacts from global change coupled with population growth.

The other critical national system required is the deployment of the IUCN Red List of Ecosystems. This risk assessment protocol requires ecosystems to be defined, conceptualized and risk assessed. Based on the conceptual diagram of the ecosystem, the framework requires key biotic and abiotic variable to be specified for that system, as well as key threats. Change then needs to be quantified since settlement and separately for the last 50 years. Models are then required to *forecast* the state of the ecosystem within the next 50 years. Operationalization and deployment of this framework should be a high priority for Australia. It would have numerous benefits if linked to adaptive experimentation/interventions, and government reporting. In my view, the IUCN Red List of Ecosystems criteria and protocol — demonstrates what sort of data and models are needed.

NCRIS POLICY LEVEL QUESTIONS

Question 1: Are there other capability areas that should be considered?

An additional capability need is an independent and overarching national Environment and NRM assessment, forecasting and reporting centre/institute/bureau (something akin to BoM, ABS, MDBA, GA, GBRMPA etc). This capability would *use* and *synthesise* existing data from NCRIS investment (and other sources) and inform future environmental data needs from NCRIS investment (and other sources) to assess and monitor the state of the environment and support Australia's international obligations.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.

Governance systems and performance metrics need to be designed appropriately for the nature of the infrastructure, to account for the differences in managing, for example, an instrument at one location compared with a network of nested initiatives at different locations across the continent. The current 'champagne' tower contracting is inefficient and results in highly skilled personnel not using their skills but instead undertaking protracted administrative functions. In recent years, this has been particularly the case due to annual contracting arrangements.

Another issue is that national needs will be difficult to meet if there is an ongoing inherent dependency on ARC funding to deliver on the 'science' aspirations of NCRIS investment. That is, national need research infrastructure should include the complete supply chain of information, including data collection, storage, integration and utilization, and the workforce skills to implement all these components. A distinction between 'infrastructure' vs 'research' can be unnecessarily problematic and potentially undermine our national capacity to address our challenges. The value of the NCRIS investment will be greatly enhanced when all these components are supported so that a capability can deliver all outcomes rather than rely on third parties that may or may not have capacity to utilise, for example, published data. Attracting, maintaining and enhancing workforce skills is also a critical issue.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Yes.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

Where they have clear domestic application to enable the identified national needs to be met and/or maintain competitive advantages to certain disciplines in a more cost effective manner. That is, don't duplicate international infrastructure unless of a cost-benefit.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes. People, networks and knowledge are critical infrastructure and need to be reliably and meaningfully invested in for us to be able to address the identified national needs. In essence, maintaining a skilled workforce with long-term continuity of skills and projects is the greatest issue for Australian research.

Question 6: How can national research infrastructure assist in training and skills development?

Yes. In part, this could be achieved by allocating a set proportion of grants to training and development for employed staff. This is a particular issue for university led capabilities which have compartmentalized processes for staff development. For example, 'project staff', that is staff employed relative to a particular grant, do not readily have access to funds to maintain their technical skills and knowledge base. A 10-year allocation will necessarily need to accommodate for skills maintenance and development.

Infrastructure should also be 'used' in education and skills development more generally, especially though undergraduate programs.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

Limited based on current funding levels and profiles. The primary responsibly should reside with government. That said, feedbacks and consultations between NCRIS facilities and government with educational institutions should enable curriculum adaptation to provide a workforce with technical skills which appropriately meet the needs of society. In many respects this is a duty-of-care issue for research/education institutions to their students as many will work outside traditional academic roles.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

Open access is a good general principle. That said, if open access will undermine the scientific integrity of an experiment then exceptions are needed. Access management is also an issue for host institutions, and one that current funding levels might not easily accommodate/permit.

In relation to data (as infrastructure), data should be accessible and published open-source to provide the highest ease of access and value to researchers. However, sensitive data, such as threatened species data, needs to be accommodated. There have been significant advances in how to treat these matters through NCRIS to date but there remains room for improvement and greater consistency across current capabilities.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

Defunding or decommissioning should only occur if there is clearly no longer a need for the capability. If appropriate governance has been implemented and the capability has development strategically in agreement with the Government (as evidenced through previous reports, reviews and consultations) — then a capability should have the capacity to evolve with changing needs *and should be afforded the opportunity to respond to changing requirements*.

To minimizes losses and reduce impacts, a 12-18 month time frame and appropriate budget should be provided to enable the closure/archiving/transitional arrangements for current capabilities. There are, for example, liabilities and risks to host institutions currently under enterprise agreements. Not to mention the economic and mental health impacts on individuals employed through this investment.

It must be recognised that most NCRIS capabilities have taken a significant time to build to the point where they can attract critical mass trust and usage levels. This is particularly the case with data based infrastructure because data providers gradually gain trust in the systems and subsequently users gain trust in the data and tools. Each stage can take some years and could be lost if transitions are not managed sensitively through an adequate change management approach.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

A shift from a traditional grant arrangement is worth considering. Seed funding arrangements could be more appropriate. That or the establishment of corporations. This, however, can be problematic if politicking occurs as per previous years, where considerable delays in access to funding have occurred. This may result in insolvency. Other arrangements for environmental research and monitoring such as a statutory authority could be a viable option.

The current and previous reliance on co-funding (at times greater than 70%) presents challenges regarding appropriate and robust financing models. This needs to be recognized and managed as it is not sensible nor sustainable. It also need to be recognized that certain capabilities require a flat operating funding profile as their expenses relate to salaries and other ongoing costs more than equipment maintenance.

A greater whole-of-government approach is needed regarding financing and governance. For example, funding bodies such as the ARC, NHMRC and RDCs should be encouraged to support the NCRIS facilities and there should be sufficient funding in their grants for infrastructure access, use and reporting. It is important to recognize the competitive environments being fostered by the Government through NCRIS and ARC to date. In essence, competition kills collaboration and fosters a culture unattractive to younger generations and women in science.

Question 11: When should capabilities be expected to address standard and accreditation requirements?

Where it impacts on international uptake, and productivity. This is particularly important in data management and sharing.

Question 12: Are there international or global models that represent *best practice for national research infrastructure* that could be considered?

The USA Long Term Ecological Research Network is a model worth emulating in Australia. This initiative was created by the National Science Foundation (NSF) in 1980. It has been maintained since that time and conducts research on ecological issues that can last decades and span huge geographical areas.

Question 13: In considering whole of life investment including *decommissioning or defunding* for national research infrastructure are there examples domestic or international that should be examined?

Lessons have most likely been learnt from recent experiences in the USA from structural and management changes to NEON (National Ecological Observatory Network).

Question 14: Are there alternative financing options*, including international models* that the Government could consider to support investment in national research infrastructure?

The USA National Science Foundation funding of the USA Long Term Ecological Research Network is a model worth investigating.

Financing options which do not *overly* rely on multi-party in-kind and co-contributions are most appropriate. Capabilities established with multiple 'owners' can lead to a split focus, be administratively burdensome, and result diluted productivity. This can be avoided through prudent management and standards, which allow for flexibility whilst preventing unsustainable and 'extractive' cultures and models. Transparent and robust co-investment arrangements are needed, potentially within minimum and maximum thresholds, and specific articulation of expectations and requirements through the upfront contracting arrangements.