Submission Template
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Questions

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

It is surprising that Agricultural Sciences are not included as a distinct capability area – especially in relation to food production and security under rapid environmental change. We suggest that consultation with those currently developing the AAS Decadal Plan for Agriculture would be useful to ensure that this sector's needs are considered.

Our view is that research infrastructure for ecological and evolutionary sciences are inadequately represented in the Paper. The response from the Ecosystem Science Council, which we endorse identifies the opportunity for long-term investment in infrastructure that will enable "ecosystem forecasting", which will both advance ecological science and underpin management to increase resilience of environmental and agricultural systems.

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

Yes – in particular, there is room for improvement in interoperability and collaboration/networking across NCRIS and other national research infrastructure facilities and with the research community by sector. There is a potential role here for various peak bodies and/or AAS National Committees, depending on domain

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

Care is needed to avoid mission-creep of NCRIS, in relation to other Commonwealth schemes and research infrastructure. That said, there is high value overall in promoting access to international infrastructure to increase research impact and avoid duplication. Small grants to enable access to international infrastructure (and for international users to access Australian facilities) could be provided via an NCRIS-wide competitive process, focussing on strategic value and impact beyond a single research project.

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

Q3-4: Of course our research infrastructure should support global science. Priority for international over national investment depends on domain. For the biodiversity/environment

area, national infrastructure, connected to existing global facilities, is key, especially as Australian species and ecosystems are globally unique. Examples of major international infrastructure that are highly relevant include climate modelling, remotely sensed information, global data aggregators (e.g., GBIF).

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

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

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

Q5-7: Training of students and existing scientists in new technologies and quantitative/computational skills is vital, and is a primary function of universities. NCRIS responsibility is to identify specific training needs to ensure maximum impact of infrastructure investment, and to coordinate with universities to ensure delivery of such training. This could require specific partnerships and cost-sharing. This could include dedicated time on large facilities (e.g., National Marine Facility vessels) for such training. Beyond technical skills, it is important to maintain recent emphasis on expanding STEM skills, especially around computation and large-data capability in the research work force.

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

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

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

Q9-10: While co-investment in national research infrastructure from the non-government sector has worked well in some cases, it will not always be feasible; particularly for public-good and long-term strategic research. Recognising that effective co-investment is a priority for the roadmap, we recommend that any guidelines should be flexible and based on the principles of effectiveness and additionality, rather than minimum levels. Decisions around defunding/decommission of existing research infrastructure investments should be (i) transparent and (ii) given sufficient lead-time to explore alternatives and avoid disruption of long-term research.

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

This is clearly important for “production services”, especially to non-research users. However, care is needed to avoid constraining creativity of research and development users by invoking industry standards inappropriately.

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

One model that clearly does not work is to commit to development of infrastructure without considering how to sustain core elements into the future. This is exemplified by biodiversity informatics in the USA, where NSF, USGS and others have invested heavily in research to develop both standards and architectures for distributed databases, but without commitment from them or broader government to maintain the best of the systems developed. The Australian model, exemplified by ALA among others, is clearly superior.

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?

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

Health and Medical Sciences

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

The issues around Biobanking (5.2.4) resonate strongly with demonstrated capabilities and emerging needs of National Biological Research Collections around tissue banking for genomics. In both sectors, the physical objects (tissues, DNA samples etc.) need to be connected seamlessly to informatics infrastructure – e.g ALA for environment, and the proposed data systems for human health and biomedical research. This could therefore be considered as cross-cutting Underpinning Research Infrastructure. See further comments under Q 18 and 32.

Environment and Natural Resource Management

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

Research directions:

As given, section 6.1 fails to represent our research needs and outcomes across Biodiversity and Ecosystems. This is a major oversight.

Australia has unique biodiversity and our ecosystems exist in, and respond strongly to, our highly variable environment. Because of these features we cannot "borrow" biodiversity and ecological knowledge from elsewhere – it has to be home grown. Conversely, the combination of our dynamic biomes and long period of independent evolutionary history enables Australian researchers to contribute unique knowledge globally. Integration of biodiversity and ecological knowledge, as is becoming possible through integrated informatics across IMOS, ALA and TERN in particular, will sustain our strong global position in biodiversity and environmental science.

A major research direction over the coming decade will have to be around impacts of climate change on our biodiversity and ecosystems. Changes in means and extremes of temperature and precipitation are already having observable effects on genes, species and ecosystems, including our World Heritage reefs and rainforests. Understanding how species and ecosystems respond will challenge current knowledge in ecology and evolution and is vital to conservation management, biosecurity and functional agro-ecosystems. Major questions include how climate change will interact with other stressors (habitat fragmentation, invasive species, disease), how we manage ecosystems as communities are reassembled, and how/when to intervene to sustain vulnerable species. In this context, the NCEEC notes and supports the emphasis in the submission from the Ecosystem Science Council on "ecosystem forecasting" and infrastructure required to meet this challenge. We also note that infrastructure support will be needed for both large-scale manipulative experiments and plot- and species- based monitoring across climatic gradients and in sensitive ecosystems - including aquatic and coastal, as well as terrestrial systems.

Australia is also a world-leader in restoration ecology, which seeks to recover ecosystem function in degraded systems. This expertise is vital in agro-ecosystems and production systems change over time, and also is a key requirement for the mining industry and regulators of that industry. Long-term studies of "restored systems" in production and mining sites can both increase understanding of non-equilibrium ecosystems and improve efficiency of often expensive restoration projects.

Research infrastructure capabilities:

The combination of new capabilities in genomics, remote sensing, informatics and modelling, when combined with on-ground ecological studies and analyses of specimens in collections, is revolutionising environmental and biodiversity science. Better climate and ecological models and remote sensing, while welcome and important, do not replace on-ground experiments and observations. Similarly, genomics, including environmental-DNA capability, can now be applied

broadly across the tree of life and diverse ecosystems, and will have maximum value when integrated with long-term ecological data from field sites and specimen-level information from collections. In this context, current investments in Bioplatforms Australia, TERN, IMOS and the ALA are crucial and must be sustained and enhanced via data integration. The success of these research infrastructure initiatives also serves to demonstrate that previously disparate communities of ecologists and evolutionary biologists are progressively coalescing around key infrastructure and common research challenges.

In the context of accelerating climate change, superimposed on an already variable environment, infrastructure to support long-term research on ecosystems, including manipulated or novel communities and both natural and agro-ecosystems, will be essential (see also Foundations of the Future: a long-term plan for Australian ecosystem science and the National Marine Science Plan, 2015-2025). "Long-term" here should be considered to mean >50 years, to encompass decadal-scale fluctuations and longer-term trends. Such infrastructure should span Australian biomes and the resulting data and knowledge should be highly connectable to enable modelling, visualisation and reporting. Some of this exists already through TERN and IMOS, which will be crucial to meeting ongoing needs of the ecological research community. In section 6.2, it is suggested that alpine, tropical and desert systems are clear gaps in existing coverage. This might be true in relation to the area covered by these biomes. But an even greater gap is in groundwater-dependent and aquatic systems – with obvious relevance to water quality, biosecurity and food security issues. In general, there is need for stakeholders to assess where and how to prioritise ongoing investment in long-term ecological sites.

The key role of our National Biological Research Collections (NBRCs) must be recognised here. These massive (~74M specimens) and irreplaceable historical records of Australia's biodiversity provide new and rich opportunities to understand how our current biodiversity came to be and how it responds to rapid environmental change. Our NRCs have traditionally been repositories and key infrastructure for discovery of Australia's biodiversity – an important and continuing role. But now these collections are enabling new questions and problems to be addressed, largely due to new capabilities in high-throughput imaging, isotope analysis, genomics and informatics. NBRCs are largely supported by a combination of CSIRO and State Government and represent a major co-investment in national research infrastructure. Our research museums and herbaria have invested heavily in development of on-line access to specimen data, leading to a world-leading resource in the ALA. But, despite this effort, a substantial proportion of the collections remain to be digitised. Further, it should be recognised that data quality, as well as accessibility, is crucial. Exposure of specimen-related data to the broad research community identifies errors which must be corrected at source – by the curators at the NBRCs – adding to the existing digitisation burden.

Looking to the future, our NBRCs could expand their role beyond taxonomic research and specimens of plants and animals in order to curate, protect and share information about, environmental samples (e.g. as used for geochemical and e-DNA analysis) and tissue samples for genomic/metabolomic research. As such the NBRCs would be a key element of any ecological observatory. This places additional burdens on already tight budgets and it is not an option to abandon essential curation of the specimens in their care. It follows that NCRIS should consider

targeted investment in NBRCs to (i) enable these new functions, and (ii) to enhance the rate of digitisation and of data correction for already digitised material. In this context, the NCEEC notes and supports the submission from the peak bodies representing NBRCs (i.e CHAFC and CHAR).

Finally past experience demonstrates the value of synthesis working groups, who tackle questions beyond the scope of any one research project, and often span discipline areas. Examples include the highly successful synthesis centres supported by the National Science Foundation in the USA (NCEAS and NESCent in ecology and evolution, respectively, and various Mathematical Biology institutes), and the TERN-funded Australian Centre for Ecological Analysis and Synthesis. These networking and synthesis centres add value to existing data and could well play a role in enhancing synergy across different NCRIS platforms. We suggest that NCRIS discuss with ARC and NHMRC how to support such Centres into the future. This could include partnerships with Universities, CSIRO and industry.

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

Australia is already a key player in many global initiatives (see examples below; also the Ecosystem Science Council submission). In the environment and biodiversity space, our needs are primarily national, though connections with international efforts, our research enhances global understanding of biodiversity and how it is changing. Indeed, Australia's scientific infrastructure and knowledge is arguably the most advanced in the southern hemisphere, and so is all the more important globally. Some relevant global initiatives include:

- The Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES)
- Future Earth and Future Australia
- The Global Biological Informatics Facility (GBIF)
- European Molecular Biology Laboratory (EMBL)
- Group on Earth Observation Biodiversity Observation Network. (GEOBON)

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?

See response to Q18 concerning National Biological Research Collections

Finally, we note that continuing investment in research infrastructure, including NCRIS, should be seen in context of an apparent decline in government support of environmental research. For ecosystem sciences, the picture is increasingly bleak. The CRC program, which previously delivered key research for management of the arid zone, rainforests and the reef, has explicitly moved away from such "public good" research in favour of industry-focused outcomes. The most recent round of cuts to CSIRO have substantially diminished that institution's capabilities in ecosystem science. Applied ecosystem research in Universities is often supported through ARC Linkage projects and these too have increasing emphasis on industry engagement with economic return. The Commonwealth Department of Environment supports research through the National Environmental Science Program, but emphasis here has shifted to threatened species over ecosystems. Overall, the assessment of the NCEEC is that our science-base for

understanding and protecting our unique ecosystems is itself threatened. In this rather bleak context, NCRIS investment in support of our world-class ecological and evolutionary scientists has been, and will continue to be, crucial, as is rebuilding support for long-term research across government and industry.

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

Understanding Cultures and Communities

Question 24: Are the identified emerging directions and research infrastructure capabilities for Understanding Cultures and Communities right? Are there any missing or additional needed?

Question 25: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 26: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Understanding Cultures and Communities capability area?

National Security

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

The attention to national digitisation infrastructure is commended. This is highly relevant to opportunities to leverage our National Biological Research Collections (see response to Q18).

But is should be noted that (i) the physical specimens themselves must continue to be curated in perpetuity, and (ii) centralization of digitization infrastructure will not work for NBRCs as the specimens themselves are frequently fragile and not able to be loaned for this purpose. In this context, development of, and access to, mobile imaging systems, including micro-CT scanning, would be of immense value.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Digitisation of environmental, ecological, genomic and specimen-related data is a global enterprise with well defined and embedded standards and interoperability. For example the informatics platforms developed by IMOS, TERN and ALA are widely regarded and increasingly be adopted by other countries.

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

See comments on National Biological Research Collections under Q18. As NBRCs are used extensively in biosecurity (9.3.1) and identifying novel disease vectors for public health intervention (8) as well as environmental research, these could be considered as Underpinning Research Infrastructure

Data for Research and Discoverability

Question 33 Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

The aims presented here a lofty and welcome. There is no doubt the cross-platform computing environments will be essential to collaboration and extracting knowledge from the ever increasing data deluge. While computing hardware and environments might be generic, how best to serve each research domain will be a challenge to determine. This will require extensive and continuing dialog and experimentation between computer scientists and each research community. Caution is also needed to avoid monolithic approaches that are less effective than distributed efforts at dealing with domain-specific needs.

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.