

AUSTRALIA'S TERRESTRIAL ECOSYSTEM RESEARCH NETWORK

Strategic Framework 2016 – 2025



TERN

Terrestrial Ecosystem
Research Network





TERN – THE NATIONAL OBSERVATORY FOR AUSTRALIAN ECOSYSTEMS

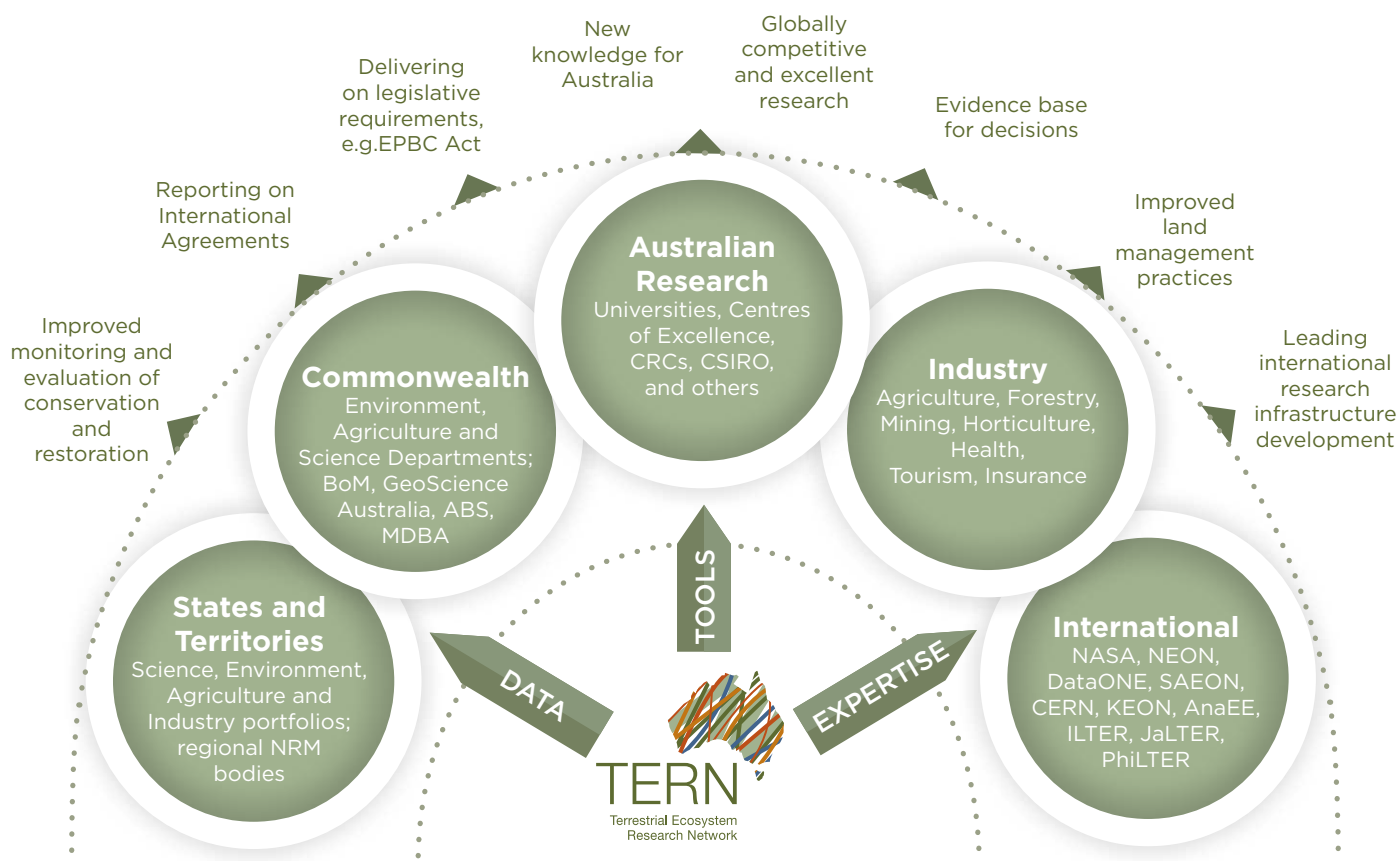
The world is experiencing an unprecedented era of rapid change as a result of human development. The future will require us to be smarter about how we manage, protect and use our environments to sustain our life and livelihoods. To do this, society must be equipped with the capability to understand the causes and the consequences of changing ecosystems.

TERN is a scientific facility that describes and monitors the condition of our land-based ecosystems and the vital processes within them. TERN enables Australians to track, understand and respond to change in ecosystems through time and across the breadth of the continent. It provides easy access for anyone – community members, policy-makers and industry leaders, as well as scientists – to national information about the ecosystems on which our livelihoods, lifestyles and identity depend.

THE NATIONAL NEED FOR TERN

In order to meet current and future challenges, questions that Australia needs to address include:

- How are our ecosystems responding to environmental pressures, and how might positive trends be enhanced and negative consequences managed?
- How is our environment likely to alter in the future, for example in relation to a changing climate?
- How are significant environmental assets – soils, carbon stocks, water, vegetation and biodiversity – responding to such changes and to their management?
- How resilient are the ecosystem services upon which our society and many of our industries depend, such as soil health, nutrient cycling, fire mitigation, provision of clean water, crop pollination and carbon sequestration?



NATIONAL AND INTERNATIONAL IMPACT

Figure 1: The comprehensive and co-ordinated approach adopted by TERN is an effective tool for delivering outcomes for researchers, government, industry and others, regardless of the scale or location of issues they are addressing.

Through the National Collaborative Research Infrastructure Strategy (NCRIS), TERN has become Australia's fundamental enabling infrastructure for long-term ecosystem observing, driving research that answers the above questions at local and national scales, for encouraging scientific collaboration and integration, and for guiding policy-makers as they respond to environmental opportunity and challenge.

TERN delivers quality data, tools and expertise to understand Australia's environment and so enable its management for sustainable social and economic benefit. TERN's work underpins the efforts of many individuals and organisations ranging from Universities, to all levels of Government, and industry (Figure 1), and it thereby provides a central underpinning to the nation's Science and Innovation Agenda. TERN supports Australia's progress towards the National

Science and Research Priorities, particularly the priorities of Environmental Change, Soil and Water, Food, and Resources. It is a foundation for delivery of numerous public science and environment programs, including meeting obligations under national and international legislative and treaty frameworks (such as the *Environmental Protection and Biodiversity Conservation Act 1999*, *Convention on Biological Diversity*, the *UN Sustainable Development Goals and Framework Convention on Climate Change*). It is also a key platform for sustaining Australia's globally recognised research excellence in the fields of environment and ecology.

In short, TERN provides the scientific underpinning to enable Australia's progress towards environmental sustainability on a continental scale.

These data from TERN will be vital in the process of validating the data we receive from SMAP (the Soil Moisture Active Passive satellite) and making sure the products delivered by JPL are as accurate as possible."

Andreas Colliander of NASA's Jet Propulsion Laboratory (JPL).



TERN'S IMPACT

Investment by NCRIS in establishing TERN has paid dividends for Australian ecosystem science. Before TERN, efforts in national ecosystem science, monitoring and modelling were often uncoordinated and disjointed. After six years of building and operation, TERN now delivers a nationally coherent and multidisciplinary framework for the collection and delivery of critical data, tools and expertise that address all aspects of our ecosystems (Table 1). Collectively, this infrastructure has acted as a catalyst for new exploration and understanding of Australia's diverse ecosystems and their dynamics, leading to novel outcomes such as:

- Significantly improved national carbon budget for Australia to inform the National Greenhouse Gas Accounts through use of field measurement of ecosystem processes from TERN including gas and energy fluxes, biomass and soil carbon, alongside remote-sensing products and modelled estimates of terrestrial ecosystem processes;
- The first risk assessment of a set of Australian ecosystems under the IUCN Red List of Ecosystems criteria, made possible by a synthesis working group established under TERN, and TERN's delivery of the ecosystem data required to undertake the assessment. This scientifically robust risk assessment provides an early warning system to help governments, industries and communities avoid radical ecosystem change and associated socio-economic impacts;
- Release of the first National Biomass Library and National Biomass Map, using world-leading analysis of satellite data products in conjunction with field measurements to show how vegetation height, structure and biomass varies across the Australian continent. This work includes data from State and Territory agencies, a myriad of research programs, and TERN's on-ground plots, demonstrating the value of TERN's ability to work across state and national agencies to integrate ecosystem data at continental scales; and

- Access to Australia's ecosystem data in fresh ways thanks to TERN's ground-breaking eResearch infrastructure including: the Soil and Landscape Grid of Australia, which provides easy access to nationally-consistent and comprehensive soil and landscape attribute data at a finer resolution than ever before in Australia; and the Australian Ecological Knowledge and Observation System, a semantic data repository that for the first time permits integration of diverse ecological data across the country, and provides access to data from thousands of historical and current Australian research activities.

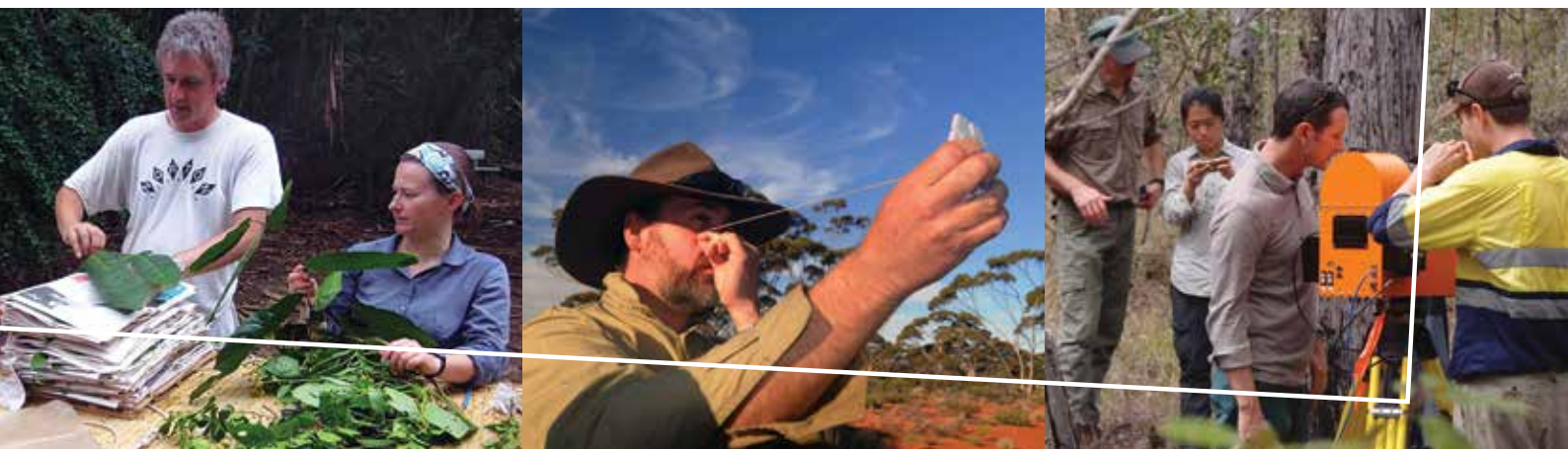
TERN has been able to achieve much in a short period of time thanks to its focus on collaboration, and its structure as a 'network of networks'. TERN's integrated approach is its great strength, enabling specialist groups to deliver fit-for-purpose infrastructure for their fields of expertise, and then connecting these efforts into a broader science framework that ensures delivery of coherent, national infrastructure. TERN's collaborative approach has broken down organisational silos, and attracted Australia's leading ecosystem scientists, thus capitalising on the existing strengths in Australian ecosystem science and leveraging these to deliver successfully.

This growing collaboration has led to scientific excellence and coherence within a rapidly maturing observing network – with the result that TERN's current stage of development represents an innovation platform for environmental management and an exciting springboard for fresh investment. The timeliness of further commitment through NCRIS is matched by TERN's record of successful implementation: it is cost-effective, focused on quality science and outcomes, used by a variety of groups nationwide, and possesses transparent governance and management.



Table 1: Snapshot of progress in Australian ecosystem science enabled by TERN, with future possibilities.

Before TERN	TERN 2016	2017 and beyond	
<ul style="list-style-type: none"> • Scattered environmental monitoring information • Little to no data-sharing • Limited coordination of research • Inconsistency across jurisdictions and institutions • Incoherent national picture of ecosystem processes 	<ul style="list-style-type: none"> • Multidisciplinary ecosystem data gathered in important biomes of Australia • Data collection and analysis is nationally coordinated • Data publishing and sharing is common practice • Data are free and easy to access • Strong partnerships and collaboration across institutions and agencies 	<p><i>Enhanced NCRIS investment for TERN</i></p> <p>▶</p>	<ul style="list-style-type: none"> • Expanded and integrated monitoring datasets allow improved ongoing analysis of ecosystem status and trend • Long-term capacity enables decision-makers to maximise benefits to human communities while minimising risks to ecosystems • Strong and cohesive national ecosystem science and management capability • Synthesis and modelling provide assessment of future opportunities and risks, allowing evaluation of management options for ecosystem assets • Contribution to global scientific synthesis <p><i>Australia a world leader in ecosystem science and information technology for environmental management</i></p>
<p><i>Cost inefficiencies and limited science outcomes</i></p>	<p><i>Delivered major national science infrastructure, leveraging existing investment</i></p>	<p><i>Insufficient investment</i></p> <p>▶</p>	<ul style="list-style-type: none"> • Loss of infrastructure, methods, and data for national benefit • Loss of collaborations, partnerships and momentum • Loss of ability to track and understand ecological processes affecting the continent and the economy <p><i>Riskier policy and management decisions, cost inefficiencies for science</i></p>



WHAT TERN DOES

TERN works across Australia providing critical infrastructure that allows researchers to collect and deliver data, information and knowledge about key elements of Australia's ecosystems from their physical characteristics, through to the interactions of the biodiversity that lives within them, to the way that these aspects change through time and across the country. No other national capability is able to deliver on this spectrum of information and knowledge, making TERN a cornerstone of Australia's capabilities in environmental management that enables researchers to:

- Describe the **past and present condition** of ecosystems and ecosystem processes, and
- Understand **how ecosystems respond to environmental drivers**, including anthropogenic pressures and management interventions.

While some of TERN's essential capabilities remain marginal because of recent severe financial constraints, TERN's national infrastructure (Figure 2) is designed to deliver information and tools that are meaningful at local, regional, continental, and global scales. This approach begins with TERN's on-ground work at individual plots to monitor and study soils, nutrients, energy, gases, plants, animals, and their interactions. Coupled with this national coverage of sites are remote sensing capabilities that draw in regional and continental perspectives gathered through airborne and satellite data collection. Underpinning all of these activities is eResearch-infrastructure that enables easy publication and access to data collected by TERN and others, including historical archives. In its brief history,

TERN has also demonstrated synthesis and modelling capabilities that draw full value from this assembled wealth of data, offering new insights into the function, condition, and likely future trajectories of Australian environments.

TERN's national infrastructure scope encompasses every major vegetation group, ecoregion and agro-climatic zone across the country ranging from deserts to coasts, rainforests, grasslands, and alpine regions. The network primarily focuses on natural and semi-natural ecosystems, while also offering insight into intensively-managed and peri-urban systems. Across the diversity of ecosystems where it works, TERN focuses on the key ecosystem attributes described below:

1. Land cover

- Vegetation type and biomass
- Ground cover

2. Biodiversity

- Composition and dynamics of flora and fauna

3. Carbon stocks and cycles

- Above-ground carbon including vegetation and atmospheric
- Soil carbon

4. Productivity

- Soil state and function
- Water and energy balances
- Vegetation condition and function



DATA INTEGRATION, ANALYSIS AND DELIVERY



NATIONAL DATA COLLECTION: FIELD, AIRBORNE, AND SATELLITE

Figure 2: TERN's national infrastructure includes on-ground, airborne and satellite data collection with data integration and delivery infrastructure that is designed to deliver information, knowledge, and tools that are meaningful at local, regional, continental and global scales.

The comprehensive and co-ordinated approach adopted by TERN ensures that it is an effective tool for researchers, government, industry and others, regardless of the scale or location of issues they are addressing. It has also enabled TERN to create strong connections globally and offer leadership to the growing research infrastructure community, including ongoing collaborations with the US National Ecological Observatory Network (NEON), DataONE, the South African Environmental Observation

Network (SAEON), the Chinese Ecosystem Research Network (CERN), the Korean Ecological Observatory Network (KEON), the Analysis and Experimentation on Ecosystems Network in Europe (AnaEE), the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), the US/European Critical Zone Observatory Networks (CZOs), and the International Long-Term Ecological Research Network (ILTER).



CONSOLIDATION OF EXISTING INFRASTRUCTURE

TERN has achieved its present effective scope and success by leveraging in-kind support and co-investment to boost NCRIS' seed investments. TERN is now a truly national network of infrastructure and multidisciplinary capabilities, used by scientists, government, and industry to benefit the Australian community. However, resource limitations have confined its scope and left some gaps in coverage that must be addressed to ensure Australia has a complete ecosystem monitoring capability for the future.

Strategically, now is a significant and important time for an enhanced NCRIS investment to ensure a sustainable operational basis for TERN into the future that will safeguard the previous investment in this national research infrastructure, and will also ensure its continued delivery on national needs across the research, government, education, and industry sectors.

A priority for any increased investment is to expand TERN's capabilities at existing infrastructure sites to enable improved and coherent measurement of environmental parameters in priority ecosystems. One example of what could be achieved with increased investment is the expansion of TERN's nation-wide network of sensors and cameras that monitors the direction and magnitude of vegetation change due to climate change and extreme weather events.

Enhanced investment in NCRIS would also allow TERN to expand into regions of Australia currently deficient in environmental monitoring infrastructure. To fill this information gap, TERN will establish additional broad-scale ecosystem monitoring plots in both natural and managed landscapes—including in woodland bioregions as per TERN's collaborative pilot project with The National Environmental Service Program (NESP)—and establish an even more comprehensive ecosystem observatory for the Australian landscape.

“We collected data by climbing towers similar to TERN’s all around the world – from Hawaii, through continental U.S., to different corners of Europe. All the Australian sites we visited had superb equipment and infrastructure and were really professionally run by a great group of researchers. What impressed me the most though was the ease of obtaining the access to the infrastructure and the willingness to help in any way by all my Australian colleagues.” Jan Pisek of Estonia’s Tartu Observatory



FURTHER GROWTH OPPORTUNITIES

With increased investment, a further important priority is the establishment of a coherent national capability for monitoring freshwater ecosystems—something that has not been achieved in Australia to date. This is a troubling gap that leaves Australia vulnerable and without adequate information to manage these systems with any confidence. Not only are such environments particularly prized by Australians in our predominantly dry continent, but they are especially significant in the ecosystem services that they provide—notably clean water and transportation of waste. TERN is primed to provide the scientific basis for decision-making about our freshwater ecosystem assets, but to meet this ambition it is essential to boost investment so as to bring streams, rivers, lakes, waterholes, wetlands and groundwater into TERN’s infrastructure capabilities.

TERN is also the natural vehicle to establish a fully functional terrestrial monitoring capability for Australia’s coastal fringe. There is a great demand for scientific advice on options for better management in these areas due to growing human focus and residence on our coasts. TERN has already developed the Australian Coastal Ecosystem Facility to collate and publish key coastal datasets nationwide. The next step to expand this infrastructure is to implement land-based data collection activities in coastal areas. When integrated with the in-ocean data collection efforts of our sister NCRIS facility

the Integrated Marine Observing System (IMOS), such activities could deliver more effectively on Australia’s information needs for coastal environments.

The expansion of TERN’s integrative, synthetic capabilities also presents as a major opportunity for the Australian science community. The full value of TERN’s infrastructure network comes to life through integrative modelling and synthesis of complex information. Such activities draw the threads together to weave a national perspective on status and trend in Australia’s ecosystems, and enable prediction of how ecosystems may change in future. In addition, when environmental data are integrated with information from the social and economic domains, the degree of usefulness to decision-makers expands exponentially. TERN successfully demonstrated synthetic and modelling capabilities under the initial rounds of NCRIS investment. Now, expanded investment can allow for the full development and operation of this vital element of service to the Australian community.

With full NCRIS investment and commitment to TERN for the future, by 2025 Australia will have a better-connected, collaborative and inter-disciplinary community of ecosystem scientists with easier access to the data, procedures and infrastructure required to enable decision-makers to more effectively manage Australia’s environmental assets.

“The delivery of TERN’s nationally collaborative infrastructure is one of the most important developments in ecosystem sciences for decades. Supporting TERN is strategic for us as a higher education institution because it positions our students and researchers well to take advantage of new opportunities, maintaining our lead in these fields.”

Professor Ian Gentle, Associate Dean (Research) of the Faculty of Science, UQ.

TERN’S 2025 VISION

TERN’s vision for the future is that: *by 2025, Australia will possess a continuously growing time-series of environmental measurements for land-based ecosystems that enable science for decision-making about our valuable ecosystem assets and foster targeted research on emerging challenges.*

This vision is supported by three objectives:

Objective 1. Terrestrial ecosystem information to enable scientific research and monitoring: TERN will enhance access to data by collecting, modelling, curating and publishing national datasets and data products required by the ecosystem science and management communities to assess long-term change. In addition, TERN will provide tools and services to enable improved management, use and re-use of data, thus enabling more effective and efficient utilisation of fundamental environmental information.

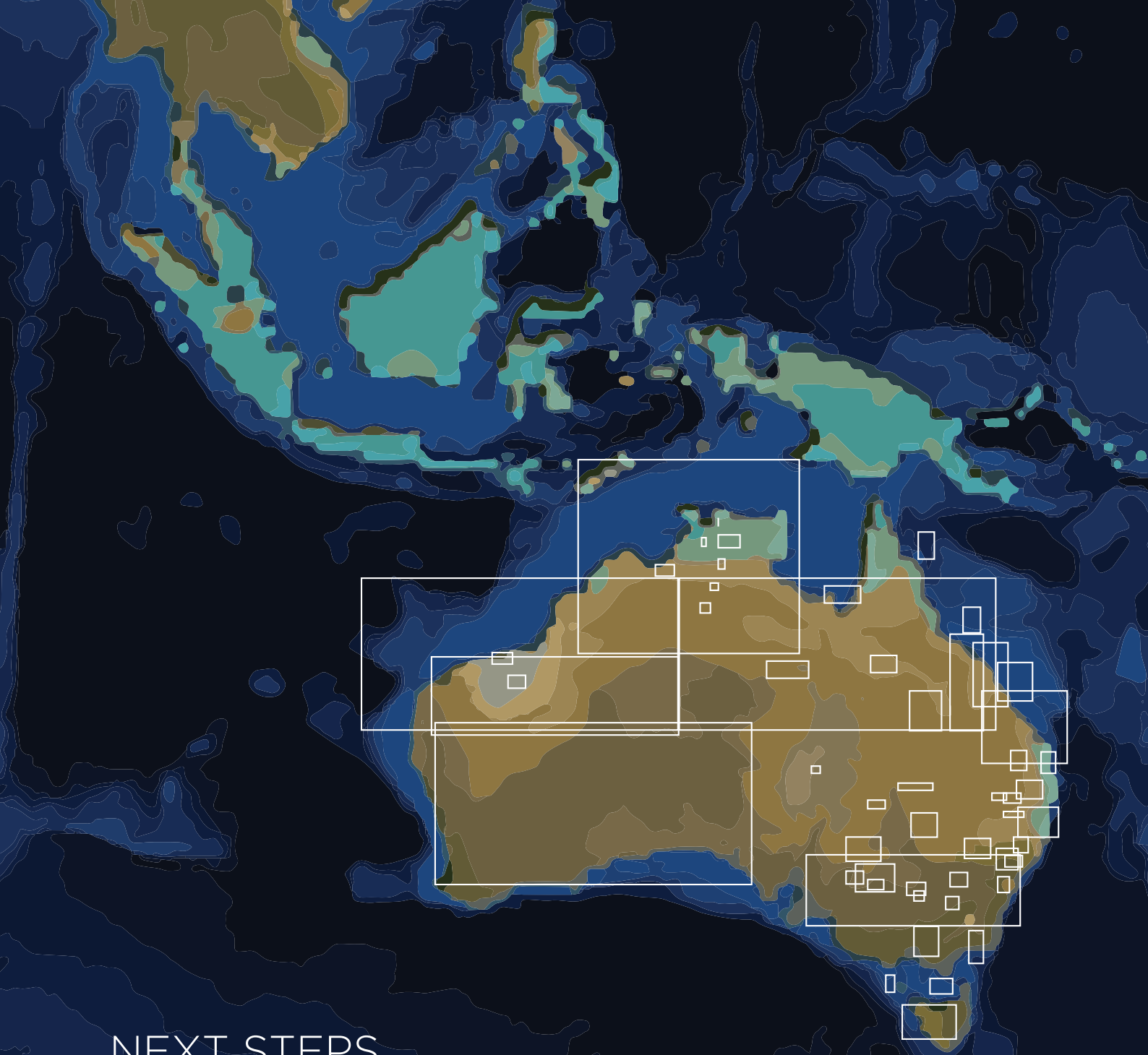
Objective 2. A knowledge base for decision-making and management: TERN will deliver the evidence-base to support decision-making about ecosystems nationwide by government, business, not-for-profits and the community. This will be enabled through the ongoing and stable provision of data and knowledge about significant ecosystem processes, and options for managing them better. This activity will support major national programs such as the National Environmental Science Programme, the National Environmental Information Initiative, and State of Environment Reporting, and enhance Australia’s capacity to meet obligations under national and international legislative and treaty frameworks. TERN will also support sustainable and enhanced productivity of our natural resource industries in food, fibre and fuel, together with greater effectiveness of the environmental assessment and management associated with them. Finally, TERN will provide the opportunity to harness community ingenuity and citizen science to generate new understanding and knowledge of Australian ecosystems.

Objective 3. Fostering excellent research to address emerging domestic and global challenges: TERN’s national observing system will help Australia prepare for the future. It will do so by enabling deeper exploration of Australian ecosystems and their long-term dynamics to address future national challenges, by stimulating research to determine emerging ecosystem thresholds, and by facilitating connections with the international research community to support Australian leadership of international efforts in ecosystem science. TERN is able to do so because Australian ecosystem science is demonstrably among the world’s best.

Several elements are essential to ensure delivery of these objectives.

- Measurement of core ecosystem characteristics across the continent – because Australia’s ecosystems range extraordinarily widely across a spectrum from rainforest to desert;
- Long-term monitoring of core ecosystem characteristics through time – to create the potential for adaptive management based upon evidence of responses to change, given that many significant aspects of ecosystems respond slowly to external forces;
- Understanding of ecosystem behaviour and function – because decision-makers need to be able to separate human-induced change from natural change;
- Operation of tailored data infrastructure – to collate and curate the treasure-trove of data collected, and ensure easy access by all; and
- Synthesis and modelling to integrate data from a range of disciplines –to allow evaluation of likely impacts of various management options, and capacity to predict future trajectories for human and ecosystem health.

Through these activities, and for the betterment of the Australian landscape and its people, TERN will deliver quantitative, integrated, synthesised and reliable information from the scientific leading-edge.



NEXT STEPS

TERN is now poised to deliver on future national needs for important environmental information through a re-commitment of NCRIS investment. With expanded investment TERN can enhance capabilities at existing sites, expand into areas currently lacking environmental monitoring infrastructure and establish new capabilities such as for freshwater ecosystems, coasts, and data integration and synthesis. This will allow TERN to become increasingly trans-disciplinary in the range of its capabilities as it reaches out to wider groups of researchers and users of its infrastructure.

Long-term investment in TERN will ensure the delivery of enduring benefits for decision-makers from government, industry and the community as well as for research. Simultaneously, TERN will ensure that the record of Australia's terrestrial

ecosystems grows exponentially into an information-base of inestimable long-term value equivalent to that of our climate and weather data. Ecosystem science will be in a better position than ever before to contribute towards effective use, management and protection of the Australian ecosystems that sustain our life and livelihoods.

To ensure TERN is in the best position to make this a reality, the strategic framework outlined in this document is being further developed into a detailed 10-year science plan. TERN is currently seeking input from stakeholders in the ecosystem science community, government and industry to guide its future activities. If you have any feedback on TERN's vision, future plans, or what data, services or tools would most benefit your work in ecosystem science or management, please contact tern@uq.edu.au

IMAGE CREDITS

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