

National Collaborative Research Infrastructure Strategy

5.11 Terrestrial Ecosystem Research Network: Development and Investment Guidelines

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Purpose

This document is designed to provide guidance for the development of an Investment Plan for the Terrestrial Ecosystem Research Network. It builds upon the arguments and case put forward in the strategic planning paper “Development of the Terrestrial Ecosystem Research Network: Science Case and Next Steps” considered and agreed by the NCRIS Committee on 28th February 2008.

Conceptual Framework and Focus for TERN

The NCRIS Road Map for the Terrestrial Ecosystem Research Network (TERN) envisages a sea change in the way ecological research is conducted in Australia to address the long recognized need for research data, models and outcomes at a national scale to support decision-making in overcoming Australia’s myriad and developing environmental problems as follows:

The Vision for the Terrestrial Ecosystems Network (TERN) is a national collaborative infrastructure that promotes excellent ecosystems research and underpins productive and sustainable management of Australia’s terrestrial ecosystems.

The objective of the TERN is to invest in infrastructure that will mobilise the existing infrastructure investment in such a way that it will facilitate the development of an integrated approach to understanding Australia’s ecosystems.

The TERN infrastructure will provide the capability to collect and integrate data on key ecosystem components for a range of terrestrial ecosystems at different scales and in appropriate spatial and temporal configurations. This capability will enable researchers to conduct experiments, undertake analysis and construct models that would contribute to the development of a dynamic and holistic understanding of Australian ecosystems at both large (including national and regional) and small scales (such as catchments or habitat).

The TERN infrastructure will provide a platform for researchers to address key challenges and priorities to ensure Australia’s environmental sustainability. Examples include: understanding changes in water availability, responding to climate change and variability, managing and protecting biodiversity, assessing different impacts of land use, the sustainable utilisation of natural resources, and counteracting the impact of invasive species.

The TERN will need to be developed and operated in a manner consistent with the NCRIS principles which encourage research excellence, collaboration and accessibility

As a national infrastructure, the TERN will have to be widely accessible for use by researchers on the basis of merit and will include data management and accessibility frameworks that deliver a broadly available ecosystem research and management resource. Consistent and compatible data collections will be critical to the success of the TERN.

To achieve this, the TERN will need suitable governance and management arrangements that will encourage collaboration within the research community and with research users across all levels of government, regional natural resource management (NRM) bodies and the general public.

The TERN will need to add value to existing activities, particularly in the area of data integration and accessibility. For example, significant efforts to integrate existing data already underway include:

- *National Land and Water Resources Audit*
- *Environmental Resources Information Network (ERIN),*
- *Australian Soil Resource Information System (ASRIS);*
- *Australian Collaborative Rangelands Information System (ACRIS);*
- *National Vegetation Information System (NVIS);*
- *National Carbon Accounting System (NCAS)*
National Water Information Service
- *Water Resources Observation Network (WRON).*

The NCRIS aim, articulated in the TERN Roadmap, is to facilitate through infrastructure funding the development of a national perspective on ecological research to the long term benefit of the nation. In other words, it proposes to be a catalyst to change the planning and coordination of ecological research at a national level. To date the culture of long term strategic planning in ecological research in Australia has been weak. As a result there is no national framework whereby observations and measurements made at the local level can flow up to provide input to research and management questions at a regional or national level and there is no single agency that has the critical mass to address or have a perspective on ecological research questions nationally.

The TERN Roadmap also gives priority to ecosystem research directed at provision of ecosystem services to meet national needs

The US Decadal Plan for Long-term Ecological Research defines 'Ecosystem Services' as the *ecological foundations of society's wealth* comprising the following:

- *Provisioning ecosystem services are the products that people obtain from ecosystems, such as food, fuel, fibre, fresh water, natural biochemicals and genetic resources.*
- *Regulating services are benefits that people obtain from natural regulation of air quality, climate erosion, disease, soil and water quality.*
- *Cultural services are nonmaterial benefits that people obtain from aesthetic, educational, recreational and spiritual aspects of ecosystems.*

Ecosystem services directly support components of human well-being including security, basic material for a good life, health, good social relations, and freedom of choice and action.

Ecosystems services represent therefore the 'environmental capital' of the nation which, if not maintained through investment erodes the foundations of the society's wealth.

The modern management challenge is to take actions that enhance environmental capital – managing for the long term benefit derived from ecosystem services. This framework, suitably adapted for Australian circumstance, underpins the vision that TERN investment is trying to achieve through a higher level of integrative research. **However, science that informs management at a regional level is where most impact will be felt.**

Investment in infrastructure that enables high quality research against this national need has the potential to create considerable value to the Australian community. The inter connectedness of different scales of research into terrestrial ecosystems requires careful consideration of the type and distribution of infrastructure required. The Science Reference Group¹ in the initial facilitation process proposed that the infrastructure investment should be designed to help achieve the following driving question:

How and why are Australian terrestrial ecosystems changing, and what do these changes mean for the delivery of ecosystem services?"

This overarching question can be unpacked into three objectives:

- 1. Tracking vulnerability and resilience in ecosystem function (stocks and flows of key materials like water, carbon, nutrients and energy). Where are the key vulnerabilities? How have they changed over decades, and how will they shift in the future under growing pressures? What are the warning signs? What are the consequences?*
- 2. Tracking vulnerability and resilience in biodiversity ~how, where, when, why? With what consequences?*
- 3. Helping to manage production systems that depend on natural resources, and their tradeoffs with environment and biodiversity, through better information on state, trends and sudden shifts.*

In designing the overall TERN architecture, the SRG was also guided by some general principles:

- 1. TERN should include, in addition to a national observation system, much enhanced data management facilities.*
- 2. TERN must include observations of both ecosystem structure/composition and ecosystem physiology (e.g., fluxes, nutrient dynamics, hydrology etc.). Without both, and without having them*

¹ NCRIS. Platform 5.11 Australian Ecosystem Observation network (AEON) Facilitation Report, September 2007 Appendix A Science Plan for TERN (AEON)

co-located so far as possible, we will never be able to understand ecosystems as complex systems; there is a strong interaction between ecosystem structure and ecosystem functioning.

3. *TERN should be designed top-down from a national perspective. The architecture should be hierarchical (several levels) and prioritised (we can't measure everything everywhere). This means that not every research site can be included.*
4. *Existing long-term observation sites should be included, but only if they make sense in terms of the national-scale architecture. (Regional bodies and state agencies may want to support many additional observations for their purposes).*

The Science Reference Group defined two levels of science focus:

Level 1

There is the need for a set of activities focused at continental to regional scale, in the realm of what is called Earth System Science, to collect, analyse and disseminate syntheses of land use, water, climate and other data sets – and to examine and make predictions about interactions and interdependencies.

Level 2

There is a need for more detailed, finer grained regional studies of the interactions of ecosystem properties, ecosystem services, land use, climate change, fire regimes and invasive species – including the stocks and flow of materials, energy and information – in the context of pertinent national and regional issues. This is the level at which practical solutions for pressing national problems – urban and rural water pressures, for example –so it is here that TERN will link to regional and local management agencies. Based on national benefit, such regions and issues could include:

- *urban and peri-urban development and management in places such as SE Queensland;*
- *issues around forestry, land use, biodiversity and water management in Southern forests, including the effects of climate change on biodiversity, snow cover and run off from alpine areas;*
- *development of tropical resources in the North, and the climate gradient from the wet-dry tropics to the arid centre;*
 - *irrigation, water management and river restoration in the Murray-Darling Basin floodplain,*

Infrastructure investments are required to support both the regional scale analyses at Level 2 and the continental syntheses at Level 1. New sensors and systems are required to measure, gather together and curate nested sets of multi-disciplinary data. It will also be necessary to set meta-data standards, and provide infrastructure and facility management and expertise.

TERN Characteristics

Based on the above Conceptual Framework and Focus, TERN would therefore have the following characteristics:

- Facilitation of the establishment of priorities for national infrastructure investment in ecological research on an ongoing basis.
- Facilitation of a national ecological information, data and research base from which needed ecological information can be extracted or derived as required both for research and management.
 - it is necessarily a long term endeavour to follow the evolution of ecosystems and responses through time.
- Viability of this knowledge and resource base is maintained through long term data collection and research that transcends the political currency of particular environmental policy issues. Good strategic planning is crucial therefore to effective operation particularly in ensuring the appropriate focus and standards of data acquisition and quality are maintained and developed at a national scale in response to research outcomes and needs.
- Relevance is maintained by developing an a database and software environment for integrative research and decision support systems based on ecological principles to facilitate the provision of ecosystem input to management decisions at all levels throughout the nation.

These characteristics in concert with the NCRIS principles, the TERN Roadmap lead to a suggested Purpose, Requirements and Principles to guide the development of TERN and its implementation.

Purpose: *Information and Research Capability for Sustainability of Ecosystem Services.* The real value of TERN will only emerge if systematic repeated data collection continues for a long time to see the full range of responses of ecosystems to natural and anthropogenic change. Sustained streams of data are integrally related to conservation and provision of ecosystem services.

Requirement: Within the landscape and climate context (geo-context), enable and encourage long term synoptic observations and their integration to the benefit of researchers and managers.

Principles:

- Service – TERN is a national system and will provide a service that strategically plans the infrastructure support for ecosystem research to maximize the contributions of R&D to the question “How and why are Australian terrestrial ecosystems changing, and what do these changes mean for the delivery of ecosystem services?”

- Focus – TERN will focus on infrastructure that facilitates integrative research supporting Australia's ability to manage ecosystem services – recognizing that science that informs management at a regional level is where most impact will be felt.
- Modeling Capability - TERN modeling capability will be provided as a test bed to facilitate collaborative and integrative research and management decisions at all scales of ecosystems
- Data Management Capability – TERN will provide a data management capability to facilitate access, integration and interoperability of ecosystem data, based on the Australian National Data Service (ANDS), following consideration of a National eResearch Architecture Taskforce (NeAT) Project in the NCRIS Platforms for Collaboration capability (PfC). For further details, refer to the Data Management System section in the Guidelines for NCRIS Investment below.
- Data-streams – Data provided through TERN will be delivered freely, openly in a timely manner. Where practical new and previously established data streams will be provided in near real time. Success will be measured in terms of the quality and quantity of research results produced with TERN data.
- Integration – where appropriate, TERN will deploy observing infrastructure and data management and modeling capabilities to take advantage of synergies with existing infrastructure in order to contribute to a comprehensive measurement of ecosystems of relevance to national and international programs

Guidelines for NCRIS Investment

Given these principles any TERN investment plan must cover 5 years in order to command the attention of potential participants. However the funds available to support infrastructure investment through NCRIS investment are relatively modest (~ \$20M provisionally allocated) and time limited – effectively there will be 3 years remaining of the NCRIS program from any decision to invest with the current NCRIS Program finishing June 2011. To achieve a 5 year planning period would require NCRIS investment to be predominant in the first 3 years with a co-investment being predominant in the last 2 years. **However, it will be essential to obtain Commonwealth /State/Territory buy-in early in the development of an investment plan to ensure institutional commitment for at least the first 5 years and with the intention of commitment for the longer term.**

The NCRIS Committee has therefore decided that in the first instance investment should be directed to promote the collaborative behaviours through national strategic planning and lever the formation of long lasting consortia of researchers and institutions implementation of data management, access and modeling capabilities as a service to the research community. In this way local and regional benefits which are so important to the stakeholders can accrue whilst national needs are met. Arrangements will have due regard for the cultural, institutional and governance arrangements that are extant in Australia. Development of a national site and observation network will ensue.

Sustaining and developing this system beyond 2011 will be dependent upon a longer term national commitment and will be a key requirement for any viable investment plan. It is also dependent upon having a concept of the eventual structure of TERN. The TERN Road Map envisaged mechanisms for national coordination of a small number of Hubs established to act as the foci for access to the infrastructure (and its products) and data integration. The proposed structure based on this concept is elaborated in the Attachment.

The NCRIS Committee has agreed to a process of engagement to progress the development of investment proposals for the following three priority areas of governance, modeling capability, a data management system; *and then* to engage with regard to the development of site and observation networks:

Stage 1

Specific investment proposals are required to address the following elements:

- **Governance arrangements operated by a Host Organisation** that:
 - undertakes long term planning for nationally significant infrastructure with an emphasis on integrative science that serves regional and national goals – this includes the necessary planning of site and observation networks.
 - promotes participation in acquisition and access to regionally and nationally significant data sets to appropriate standards
 - includes appropriate advisory arrangements involving key stakeholders at a State and Commonwealth level.

Given the complexity and the variety of research issues inherent in terrestrial ecosystems and their response to change, development and maintenance of plan of research priorities is a necessary pre-requisite to any on-ground infrastructure investment. To date there has been no national mechanism whereby the science community in conjunction with stakeholders can collectively develop the science plans required to inform the investments needed to support integrative research in the longer term.

However several mechanisms exist or have been recently developed for planning at the national scale:

- The Australian Academy of Sciences National Committee on Earth Systems Science have recently commenced development of decadal plans for research priorities as follows:
 - o Vegetation Dynamics and Global Environmental Change – at first draft stage.
 - o Climate – plans to utilize the output from the recent workshop “Future directions for Australian climate change science” 12-13 March Canberra sponsored jointly by the Dept of Climate Change, the Academy and CSIRO – an outline of a Terrestrial Observing Network was presented at this meeting.

- Soil and Land – future activity
- Water – future activity
- Long Term Ecological Research Australia is a network of sites for which coordination is currently under the auspices of the Bureau of Rural Sciences. This network currently comprising 6 sites has been established to follow the principles and protocols of International Long Term Ecological Research which in turn is based upon the corresponding US model. Although the principles and protocols for national coordination are well established they have not been successfully implemented in Australia on a significant scale. With an appropriate level of investment in national coordination, this model has the potential ‘capacity to collect share integrate, analyse and deliver ecological research at the national level’ and ‘national ecological research priority setting capacity for both science and public good outcomes.’

A major question is whether this model, given its history, is appropriate for Australian circumstances? and if appropriate, how it can best be invigorated adapted and operated?

- Government activities and processes at the nation scale have the potential to inform TERN investment particularly processes related to ‘State of the Environment Reporting’. There is currently a Commonwealth – State Joint Working Group on Improving Environmental Reporting Systems’ which has the responsibility to bring forward a plan to develop a National Environment Information System for consideration by the Standing Committees on Natural Resource Management and Environment Protection Heritage. In addition there are the government programs, collaborative networks and information systems summarized above.

The key issue here is the development of a mechanism which necessarily has to be ‘top down’ for reconciling the various priorities for infrastructure investment commencing with this program (NCRIS –TERN) and including the role of current and prospective programs, but leading logically to the roll out of the national infrastructure imagined in the TERN Roadmap in the longer term. For this mechanism to work there has to be coordination of groups of researchers and institutions with interests in particular regions and aspects of the ‘ecosystems and research agenda’. These are designated as HUBS (see TERN Roadmap) and will provide the science rationale and priorities for on ground investment. See attachment for possible operational description of the governance arrangements.

- **Modeling Capability** with fit for purpose models for addressing ‘integrative science’ questions and management scenarios **as a national service** to the ecosystem research and environmental management communities.
 - to provide a collaborative environment and infrastructure for modeling ecological systems at a range of scales including management

scenarios and cost benefit analysis including 'what-if' question and answer tools for the examination of long-term ecological research and management;

This is a key investment to promote collaborative and integrative research and to bring regional capabilities up to a common standard with benefit to regional and national reporting. There is an urgent need for a test environment to understand the data requirements for systems analysis and integrative research and to examine scenarios.

The concept is loosely based on the US National Centre for Ecological Analysis and Synthesis (NCEAS) but would clearly be need to adapted to Australian circumstances. The rationale is as valid to day as when the US system was conceived in the early nineties:

“ecological research problems are inherently multidisciplinary, requiring the efforts of biologists, engineers, social scientists and policy makers for their solution. Hence there is a need for sites where a longer term multidisciplinary analysis of environmental problems can be undertaken”, and

“Knowledge of ecological systems is growing at an accelerating rate. Progress is lagging in synthetic research to consolidate this knowledge base into general patterns and principles that advance the science and are useful for environmental decision making....Without such synthetic studies, it will be impossible for ecology to become a predictive science required by current and future environmental problems.”

The purpose of this investment is to provide mechanisms for inter-disciplinary integration and problem solving and provide the bridge between the various components of the ecosystem research community and natural resource managers to their mutual benefit and to longer term management outcomes.

The Modeling Capability can be envisaged as 'a virtual centre' with distributed nodes, perhaps utilizing the State partnerships for advanced computing as a structure to base such a centre around or alternatively a single site centre that serves as a national provider. Either centre would have a national manager and staff to develop the capability (identify the required models, build a test environment and then deliver it as a service.

- **Data Management System** (including interoperability) for data and information management , discovery and access:
 - to provide systems and standards to allow integration and reporting of ecological data including quantitative and qualitative data at appropriate scales.
 - to provide mechanisms for access and brokering access to data for research . Could include elements of data management already proposed.

This is a key investment to facilitate collaborative and integrative research and management reporting. This issue should be addressed jointly with the Australian National Data System in the Platforms of Collaboration Capability and requires engagement with various national committees working in establishing standards for natural resources data management and state of the environment reporting. There are some synergies with the Integrated Marine Observing System in systems to manage remotely sensed data and the Atlas of Living Australia for management of biological data.

A key issue here is to reconcile the investment required to facilitate the access and flow of data for research with the requirements for management and environmental reporting. There are several potential investment elements to such a system.

Firstly, the proposed Data Management System could be the basis for an investment proposal along the lines of a National eResearch Architecture Taskforce (NeAT) project that seeks a 'management system for ecological data'. Refer to the NeAT website for examples of NeAT projects at: <http://plone.icu.edu.au/neat/meetings/meeting-3>; and www.pfc.org.au/twiki/pub/Main/AeRIC-5/Items5NeATSummary.pdf.

Under such a proposal NCRIS funds for TERN would be used to resource the development of the functional specifications of such a system under the auspices of the Australian National Data Service (ANDS) to ensure appropriate leverage of PfC concepts and investment. ANDS could provide assistance in the development and implementation of these specifications. This may be a 6-8 month design phase to allow for engagement of the stakeholders identified above and alignment/reference to current efforts in integrating existing data (i.e. NVIS or ACRIS etc see above). It would also then identify the initial investment to start implementation of the system.

Secondly, the proposed Data Management System could establish easy access to terrestrial remote sensing thematic products. This would build upon the program currently underway in the *Integrated Marine Observing System* for access to marine remotely sensed data. Although Australian agencies collectively operate several ground stations and currently acquire large volumes of a variety remotely sensed data (by agencies or groups such as Geoscience Australia, Bureau of Meteorology, Australian Institute of Marine Science, Tasmanian Earth Resources Satellite Station (TERSS) consortium and the Western Australian Satellite Technology Applications Consortium - WASTAC) as well as individual acquisitions by State agencies, these data are not readily available to users in a suitable form, thereby greatly limiting the potential benefits of these data sets.

Thirdly, the proposed capability could play a very useful role in brokering access to datasets for the purposes of research and management which currently are not available for a variety of reasons.

Stage 2

Subsequent to the above the following will be addressed

- **Site Network** focused on key regionally important ecosystems services as a framework for bring efforts together and facilitate integrative research and a basic set of integrated observations to nationally consistent standards
 - to provide an environment for integrative natural resources science at agreed nationally significant sites, both informing data needs and making use of data for research and reporting
 - Such a network of sites could comprise primary LTERs and secondary sites grouped into hubs and expand with time.

This is a key investment for establishment of a national framework of ecological research requiring ownership and a workable structure acceptable to the ecological research community. Such a network could include hubs identified in the earlier facilitation process, such as the Lower Murray- Soil, water; SE Queensland - Peri-Urban Pressure; SE Australia- Forests, clean water; SW Western Australia – farmed fragmented systems, salinity; Alice Springs Darwin Transect – a natural climatic gradient and incorporating existing Long Term Ecological Research Sites and others. The national purpose of such sites requires further debate. There will be a requirement to identify the necessary investment to ensure the flow of data from extant activities into the proposed ‘ecological data management system’ – data assembly, site integration and national support services. Funds perhaps could be set aside for these purposes with a view to work shopping the requirements say 6 months after the overarching governance arrangement and other investments are finalized.

- **Observation Network** comprising a modern national ecological observation network (Fig 1 for example) based on the sites outlined above :
 - the aim is to build on pre-existing capability to provide infrastructure for provision of data streams that facilitates integrative research and research outcomes at the regional and national scale in response to the national needs. The infrastructure is whatever is required to produce the data stream – hardware, software and operational support.
 - the focus should be on the elements that are common to all natural and production based ecosystems: climate and energy; water; nutrient; and soil, coupled with measurements of primary production due to its importance to ecosystem services. This is a connecting layer of infrastructure for the national system.
 - the design and resource requirements of individual observation sites will require extensive work.

This investment commences the establishment and integration of national ecological observation sites (terrestrial observing) for Australia based on the concepts addressed in the TERN Facilitation Report. This will require detailed planning and reconciliation with other initiatives. The development of the design of an appropriate system and a full investment plan including the very complex issue of the role of various sources of funding in underwriting such a network will be the primary focus of this activity in the first instance. Funds perhaps could be set aside for these purposes with a view to work shopping the requirements say 6 months after the overarching governance arrangement and other investments are finalized.

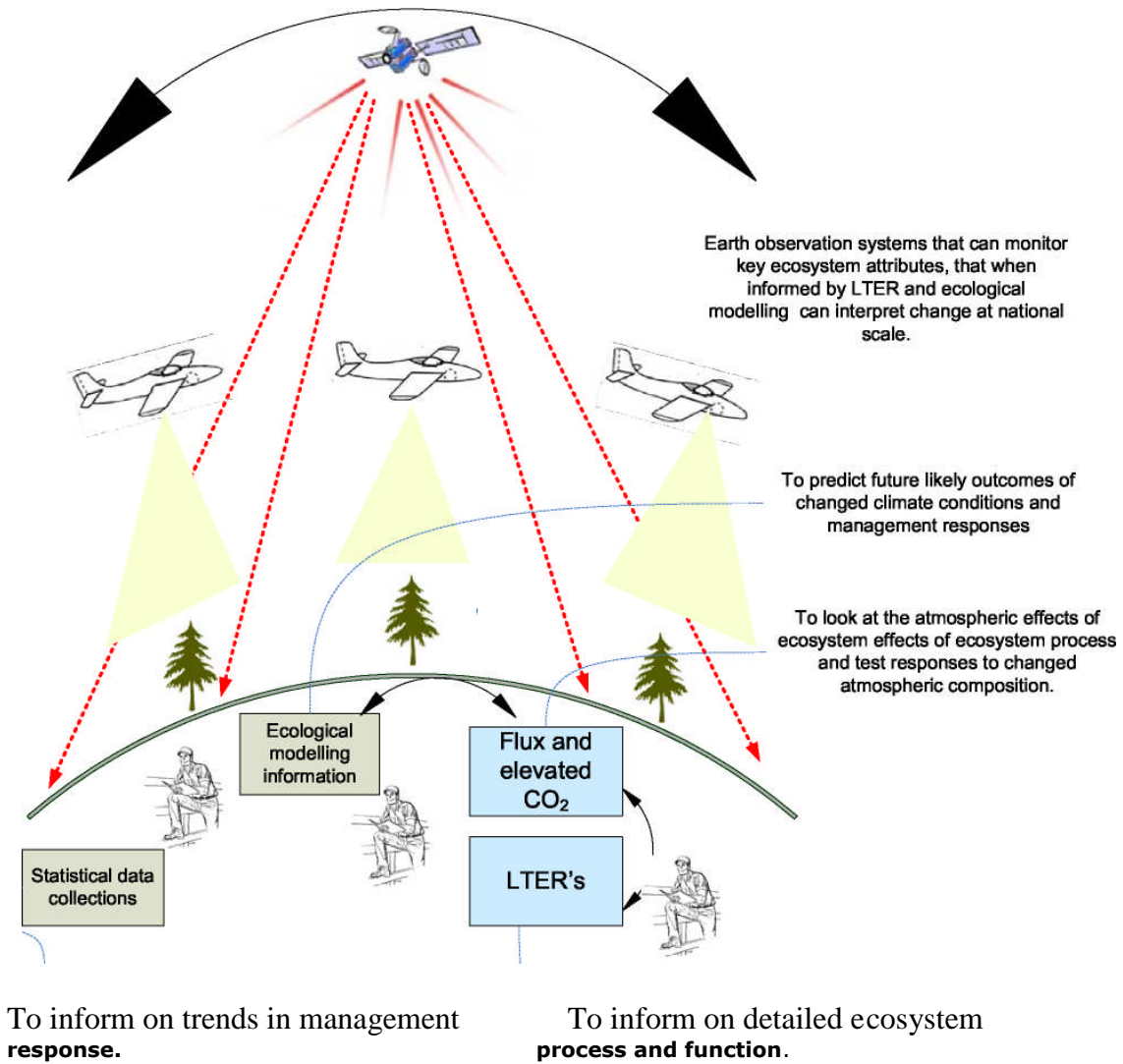


Figure 1. A schematic representation of the data sources that could be housed within TERN to position Australia to respond to climate change. (from comments on TERN Facilitation Report, January 2008, Department of Climate Change)

ATTACHMENT: TERN - Conceptual Organisational Arrangements

Relation of TERN to the Ecosystem Research Community and the Role of Hubs

TERN is conceived of eventually as a distributed set of equipment and data and information services which collectively contribute to meeting the needs for nationally significant ecosystem and terrestrial observing data. The infrastructure is best regarded as data streams, sets of data and modeling capability provided as a service to the research and management community. The investment is that which is required to maintain these services into the longer term – equipment, technologies and personnel.

The first stage is the establishment of the ‘national coordination mechanisms’ and address the national data needs. The initial TERN investments are proposed to be a means whereby the ecosystem research community can plan and develop the priorities including sites and coordinating arrangements, investment plans and infrastructure to meet the national requirements of ecosystem research and terrestrial observation on an ongoing basis and, also, to identify the national data management and modeling services required for the longer term.

The second stage is the establishment of the hubs which will as the foci for access to infrastructure (and its products) and data integration. The hubs would function as the main interface in the provision of the TERN supported infrastructure services to the research community. Hubs comprise the consortia of researchers and institutions with specific regional research interests. A designate institution or institutions within the hub will be the designated Operator (see below) for the TERN equipment or service.

Sites will be identified by the hubs and equipment will be deployed to make observations for defined periods of time or more or less permanently. Some equipment will be portable and deployed to meet the needs of particular studies. A characteristic feature is that priority for equipment deployment will be for the purposes of ecosystem and terrestrial observing in designated sites that have been defined of national significance in meeting the broad scientific objectives identified for TERN . In keeping with NCRIS objectives, the data obtained will be made freely available to the ecosystem research community. Access to the modeling and data management services will be low cost.

The client base for TERN is the terrestrial ecosystem community as a whole and the national and regional hubs of ecosystem researchers and institutions who have collaborated in the development of the the priorities for investment and deployment. They will continue to be involved in the strategic and operational planning for TERN through time.

Governance Framework

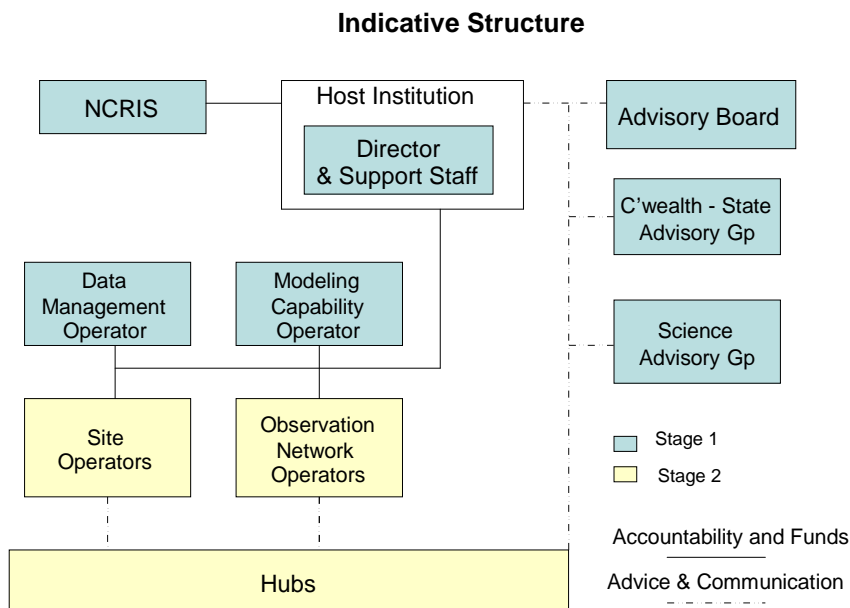
The Governance Framework for TERN is essentially a partnership between particular institutions for the delivery of ecosystem observing infrastructure and services on behalf of the ecosystem community with each institution agreeing to a particular role (see following figure – Indicative Structure).

Nationally the program is managed and coordinated by the *TERN Office* established and operated by the *Host Institution* which contracts with the Department of Innovation, Industry Science and Research (DIISR) for the implementation of TERN. In turn, the

Lead Institution through the TERN Office will enter into a TERN Funding Agreement with particular under the terms and conditions of the DIISR contract and the Investment Plan.

The TERN Office operates with the advice and agreement of an *Advisory Board* which has an Independent Chair appointed by the Lead Institution in consultation with the Operators and Members who are appointed for their skills and experience (relevant to their role) by the ecosystem research community operating through the hubs.

The equipment or services being delivered by Operators and meet that component of the data acquisition requirements of the Hubs that form part of the national TERN system



Specific Roles

Host Institution

The Host Institution will enter into a contract with DIISR for implementation of TERN, receive NCRIS funds and will be accountable to DIISR for execution and performance of TERN. It will establish, host and operate the TERN Office and appoint its staff. The Lead Institution will appoint the Independent Chair of the Advisory Board after consultation with the Operators.

TERN Office

Under the guidance and agreement of the Advisory Board, the TERN Office provides strategic leadership and management of the consortium of Operators for implementation and operation of TERN.

Under the terms of the DIISR agreement and the Investment Plan it would be responsible for coordination of the program, development of strategic and business plans, operation of the advisory system, communication and engagement with the ecosystem community at-large and through the hub structure, and planning and promotion. Development of new hubs to fill gaps in the scientific advisory framework will be encouraged by the TERN Office.

In turn, and on behalf of the Host Institution, the TERN Office will enter into agreements with the Operators for the operation of their part of the infrastructure and monitor the performance of the Operators under the terms of the DIISR agreement and the investment plan and initiate any actions as appropriate.

Advisory Arrangements

An Advisory Board will provide strategic guidance to the TERN Office, monitor the overall strategic direction, management and performance of the program in accordance with the DIISR Agreement. It would also provide a mechanism for resolution of issues that cannot be worked through the TERN Office. Business plans and budget allocations will require the concurrence of the Advisory Board.

The Advisory Board will comprise an Independent Chair, the Director TERN Office and 8 members nominated by the ecosystem community through the hubs collectively for their abilities to guide the program.

The TERN Office and Advisory Board would be supported in its work by a Science Advisory Committee drawn from the nodes and given the importance of Commonwealth and State agencies to ecosystem management issues a Commonwealth - State Advisory Group would provide a link to government management and policy processes and initiatives.

Operators

Operators are individual institutions (legal entities) which own and operate designated equipment in trust for the purposes of TERN or provide services under TERN. Services may be national level services (e.g. Data Management)

The Operators will enter into an agreement with the TERN Office for their role. This agreement would be the enabling agreement to allow funds to flow to the operator.

- an Operator may be responsible for a set of equipment in a particular hub
- an Operator may provide support service that is applicable to all hubs (eg Data Management)
- Operators will generally be a member of a hub and will have the competence to operate and maintain the equipment and/or provide the service as agreed.

The Operators agree to be responsible and accountable to the TERN Office for NCRIS funds and Facilities or Sub-Facilities deployed and operated under TERN terms and conditions as laid out in the DIISR Contract and the Investment Plan.

The Operators will be responsible for securing the co-investment and in-kind contributions for the operation of their equipment and services laid out in the Investment Plan and reporting on these arrangements

The Operators will also be responsible for reporting against the Performance Indicators pertinent to their responsibilities.

Each Operator will nominate a *Lead Scientist/Manager* for its area of responsibility.

Lead Scientist/Manager, Coordinator and User Groups

The Lead Scientist/Manager will be responsible under TERN for operation of the equipment and services for a particular hub and maintain and be responsible for the execution of the Operational Plan for equipment/service.

The TERN Office will appoint a *Coordinator* to work with the various Lead Scientist/Managers to ensure, where appropriate, they are operated according to a common set of standards and protocols and/or to coordinate overall planning.

Where appropriate, this activity will be supported by a User Group to work with the Lead Scientists/Managers in the development of operational plans and associated user protocols and relevant technical matters including training for users. Membership of the User Group will be drawn from interested personnel from the relevant hubs.