Submission to the NCRIS exposure draft of the 2008 Roadmap for Australian Research Infrastructure

National Committee for Earth System Science

Concerning Terrestrial Ecosystems

The National Committee for Earth System Science, one of 22 National Committees under the auspices of the Australian Academy of Science, is developing a collegiate Decadal Strategic Plan for Earth System Science. A well-developed component of that community planning process is the part dealing with vegetation dynamics. The draft synthesis report on vegetation dynamics from the collegiate process makes 24 recommendations of which the first two are overarching enabling recommendations. The second enabling recommendation concerns the long-overdue requirement for the establishment of a national network of long term terrestrial ecosystem observation and research sites that would have a multiplicity of applications. It reads:

Recommendation 2.

> *A coordinated network of fixed, long term (multi-decadal) terrestrial ecological, eco-physiological and eco-hydrological observation areas, linked with underlying remote sensing data, should be established by governments as basic infrastructure for national reference stations for multiple time-series observation and analysis. Such an Integrated Terrestrial Observation System is to serve the needs of research into the land-based aspects of global environmental change, including tracking the impacts of climate change, land use change and management, and biosecurity on ecological and hydrological processes. Several hundred sites are needed within an hierarchical framework of varying observation intensity. The locations should be determined to cover the spectrum of Australian climates and ecosystems, including the range of management intensities imposed by humans and to provide information relevant to key natural resource management issues. In each area there should be several replicate routine sampling patches in order to be able to establish the statistical uncertainty of observations and conclusions.*

This recommendation and its associated discussion in the synthesis paper forms the backdrop to this submission to the Roadmap question relating to Terrestrial Ecosystems (p34), namely:

> *"Do you agree with the specific infrastructure needs listed here?*
> *What gaps need to be identified that have strategic importance to this research capability?*
> *What elements should be included in scoping out the detail of a sensor network capacity?"*

Preamble.

A landmark infrastructure. A comprehensive, integrated, nationwide terrestrial ecosystem observation network is needed to service the needs of many applications in policy development, natural resource management, and environmental reporting. The network should be compatible with international observation networks. Such international observation networks are critical for applications such as the development of digital global vegetation models coupled to global climate models, for tracking impacts of, responding to and adapting to climate change, for stewardship of continental ecosystem services, and for international collaboration in monitoring and managing the global spread of pests, weeds, exotic animals and diseases. With those characteristics, such a network should be treated, using Roadmap terminology, as "landmark infrastructure" embedded in the national infrastructure system, internationally linked, and having multi-institutional and multi-government involvement seeded by NCRIS planning and financial support.

Thus responding to the question on page 20 (*"In what ways could landmark infrastructure investments be integrated with strategic planning processes for research infrastructure?")*, we note that the existing body of uncoordinated, piecemeal and typically short-run environmental monitoring programs at federal, state and local levels should be drawn together and evaluated as a first step for coordinated planning of an integrated national network that is also integrated with networks in other countries. Additionally, the opportunities for integration with atmospheric, marine and geological monitoring should be examined. We stress that designing such an observing system is a major activity in itself that must involve a wide range of stakeholders and technical expertise, and may take 1-2 years to achieve. It is a critical first step that will establish the framework for all subsequent activities. We agree with the emphasis placed in the Exposure Draft on the need for integration of the observation and monitoring effort with the national data archiving, analysis and availability infrastructure ("eResearch").

Terrestrial site networks as a "collection". In addition to the biological, social and cultural collections mentioned in the Exposure Draft, Australia needs to view a network of terrestrial observation sites as ecological collections for study, analysis, and synthesis. Biological systems form an hierarchy spanning the full range of scales from nucleotide sequences, through genes and linked gene-groups, genotypes of species, species and higher taxonomic groupings, populations, communities, ecosystems, biomes and on to the whole biosphere. While emphasis is placed in the Roadmap on biological collections of individual examples of plant and animal species, and of genetic sequences (genomics) and physical measurements of individuals (phenomics) as items for collection and analysis, patches of the landscape representing communities of species, ecosystems are at least equally important in the national collections for systematic study of the biological hierarchy.

Thus in answer to the question on page 17 ("*What other broad cross-capability linkages need to be highlighted")* we highlight a nationally and internationally integrated network of terrestrial hydro-ecological sites for long term measurements (ranging from multi-decadal to permanent) as facilitating an important cross-capability linkage among many

groups of investigators having different perspectives on the ecosystem services provided concurrently and interactively by the land - both managed and unmanaged. These relate not only to the marine, continental and built-environment capabilities combined under "Environmentally Sustainable Australia" in the Exposure Draft, but also to biological discovery, sustainable energy, population health, biosecurity, and hazards and extreme events.

The questions on page 34

i) "Do you agree with the specific infrastructure needs listed here?"

We agree that the initial TERN funding of $20M should be seen as being for first stage establishment of a system. But what should be the nature of the first stage? Given the shocking deficiency of integrated environmental monitoring in Australia[1], one could argue that establishing the design and methodology for a national network of sites, making a start in setting up such sites, and commencing time series acquisition of core data is the critical first step. A subsequent step is the setting up computer infrastructure for managing, analyzing, synthesizing and modelling data when it eventually comes available. Until the scope and precise objectives of the site network has been settled, and some data has started to flow, there is not much archiving, synthesis, analysis and modeling that can be done. Thus, we believe that establishing the nature and scope of the network, the standard methodologies to be adopted for each measurement type, and commencing rolling them out across the country is a clear initial priority. The network design stage may take several years involving many workshops, working groups and manuals, and requires a guiding strategic plan of its own with a strong and knowledgeable Director. This would be a valuable use of the TERN start-up fund under discussion. Only after that is taking shape can in-depth planning of the IT hardware and software to deal with the data be cost effectively commenced.

A fourth activity in the start-up years, which should go on concurrently alongside the above-mentioned 3 areas of a) site network design and establishment, b) measurement protocol development, and c) data management infrastructure, is the identification, location, gaining permission to use, collection, and compilation of past and present geo-referenced environmental data streams of diverse, uncoordinated, piecemeal and variable-duration nature that should be brought together to complement and help inform the acquisition of new continuous continent-wide time series of information.

The National Committee for Earth System Science and its Carbon Task Force envisions that a sensible network of terrestrial observations would have a structure of tiered sites having a range of continental coverage and measurement intensity.

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[1] It has been noted in the supporting documentation (Gleeson and Dalley 2006) to "*Australia: State of the Environment 2006*" that:

> *"Effective national state-of-the-environment reporting on land condition is now not possible [in Australia] because of the paucity of relevant time-series datasets"* .

At the largest scale of coverage would be remotely sensed attributes of the land. On the ground, the most important tier of observation should comprise hundreds of sites (eg 1 hectare or less) across the nation, stratified according to key policy and natural resource management questions, bioregions, soil types, topography, aspect and management regimes to obtain balanced coverage of the whole continental land mass. The kinds of observations at these sites are ones needed to monitor ecosystem and soil condition (including such measures as C stocks above and below ground, leaf area index, soil pH, salinity), episodic disturbance events and impact, and biodiversity surveys. Sampling at perhaps 5 year intervals and after major disturbance events, complemented by continuous satellite imagery and on-site automatic weather station data, would suffice.

A third tier of intensity at perhaps 50 sites across the nation should be established for more frequent or continuous monitoring of key components of attributes like net primary production and soil water status. They would involve repeat visits perhaps 4 times per year for collection of material from litter traps, soil water readings down the soil profile, dendrometer readings, ground vegetation sampling, etc. The measurements at Tier 2 sites would also be made at Tier 3 sites.

The fourth tier should be at about 20 targeted sites for detailed process studies. These sites would involve continuous staffing. They would include existing larger area Long Term Ecological Reserves in iconic ecosystems, and experimental sites such as Free Air CO_2 Enrichment sites in forests (Raison et al 2007) and other ecosystems. As well as contributing to the minimal data sets to the Tier 2 and 3 ensembles, these sites would also provide the opportunity for targeted limited duration projects to study ecological and biogeochemical processes.

At the highest intensity there should be several flux tower sites that continuously track the fluxes of gases, energy, water vapour and momentum into and out of the vegetated land surface. For the carbon cycle objectives, these sites measure annual Net Ecosystem Exchange which corresponds to ascertaining whether the vegetated land in the footprint of a flux tower is a net sink or a net source of CO_2 over the year. These sites would also contribute to data for the Tier 2, 3 & 4 objectives.

A key point is that these tiered sites having different levels of observation intensity are linked within the coordinated observational framework, and provide a basis for making estimates across spatial and temporal scales. Thus, they will provide data relevant to informing wide-ranging questions being asked at local, regional and national scales.

ii) "What gaps need to be identified that have strategic importance to this research capability?"

Not clearly and explicitly mentioned in the Exposure Draft is the paramount topic of tracking the change in vegetation dynamics as a function of environmental change notably change in atmospheric composition and climate. This is the critical area both for

understanding and predicting the impacts of atmospheric composition and climatic changes (and of associated disturbances such as fire) on vegetation, and for coupling land surface properties into global climate models for improved climate prediction globally and in the Australian region.

iii) "What elements should be included in scoping out the detail of a sensor network capacity?"
The most critical element, and one not addressed in the Exposure Draft", is developing a stakeholder communal synthesis of the land attributes that are most in need of long term systematic monitoring for both urgent and foreseeable research and end-user applications. Only after these have been established and prioritised can the subject of what sensors to use be usefully addressed. Importantly, it should be recognized that "sensors" (*sensu strictu*) are not the only means of data acquisition. Often only sample collection by humans followed by laboratory procedures can provide the necessary data. Consider, for example, the needs of vegetation sampling and analysis, soil sampling and analysis, and species or genotypic frequency observations - all require manual effort on site and in the laboratory. In those circumstances the technical staffing needs of routine measurements should be viewed as infrastructure, just as the staffing needs for operation and maintenance of ICT equipment should be classified as infrastructure. In short, the needs of clearly identified critical questions or applications should drive the scoping out of infrastructure, not the latest techniques or sensors that a vocal advocate may want to deploy somehow somewhere.

24 July 2008.
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