A national scientific reference site network within the Terrestrial Ecosystem Research Network, site stratification and establishment methods

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Abstract

The Australian rangelands cover around 80% of the continent yet, from a biodiversity perspective, probably constitutes the most understudied part. To further the understanding of these ecosystems and progress analytical and predictive modelling, the Terrestrial Ecosystem Research Network (TERN) through a collaboration between Adelaide University and the SA Department of Environment and Natural Resources, is in the initial stages of a process to establish a National Scientific Reference Site Network (NSRSN) across the rangelands. This paper describes the TERN setup.

Introduction

To further the understanding of these ecosystems and progress analytical and predictive modelling, the Terrestrial Ecosystem Research Network (TERN), through a collaboration between Adelaide University and the SA Dept of Environment and Natural Resources, is in the initial stages of a process to establish a National Scientific Reference Site Network (NSRSN) across the rangelands. (A reference site is defined as a benchmark area of land in 'best on offer' condition and characteristic of larger, significant areas across both widely distributed and restricted ecosystems).

Establishing the NSRSN will present challenges, but will also provide opportunities to:

- improve the knowledge and understanding of the dynamics of the most extensive and poorly understood Australian ecosystems, by providing quantitative information on the causal relationship between species and environmental variables;

- help progress the predictive analysis of species and ecosystems under environmental stressors, including climate change;

- provide the first major regional estimate of soil and vegetation carbon and nutrient stocks;

- provide a systematic baseline of reference areas that allow;

  - ongoing and future assessment of change in condition due to environmental and anthropogenic stressors, including drought, management and climate change,

  - directing restoration outcomes for large-scale development projects and offset schemes, and

  - a national integration of the extensive plot-based data undertaken by state and territory survey and monitoring efforts;

- significantly advance a new range of monitoring methods, including photo point based assessment of ecosystem change, integration and calibration of remote sensing methods and new DNA-based assessment of phylogenetic diversity, biogeographic structuring, connectivity and demographics.

The challenges of establishing the TERN NSRSN are considerable. Fundamental to the success of the NSRSN is the need to acknowledge the data that has been collected over decades across a variety of pastoral monitoring programs and other long-term scientific assessments. Where valuable and appropriate, this needs to be captured and used as an important foundation for locating sites for the proposed NSRSN and to direct monitoring methods. Supporting this will be effective relationships with the current custodians of this data. Notwithstanding these important background considerations, the establishment challenges include:

- developing a consistent monitoring method based upon appropriate ecological conceptual frameworks suitable for the rangelands region and extension into other regions;

- locating and establishing reference sites based on a logical stratification process to adequately represent the rangelands;

- collecting ecologically representative, site-based, baseline data and samples

Through plot-based methods, the NSRSN will seek to (see Table 1):

o quantify the diversity and abundance of perennial vegetation (trees, shrubs and grasses);

o assess the state, condition and structural complexity of vegetation, including demographic parameters of size and age class;

o derive soil carbon and nutrient stock estimations;

o establish and record photo point information;

o assess condition and landscape function parameters;

o record vegetation parameters that assist remote sensing interpretation (e.g. ground cover and leaf area index)

o collect species voucher specimens for taxonomic validation, and

o collect leaf and soil samples for establishment of an associated DNA bank and future assessment of biodiversity genetic parameters (including DNA barcoding and population genetic profiling)

The monitoring and assessment procedures will be flexible and adaptive to respond to stochastic events characteristic of the rangelands. Methods used will be consistent across the rangelands, repeatable, quantifiable and suitable for each broad vegetation community being studied. Data collection will be based on permanently marked plots to facilitate relocation and re-sampling. Up to 3,000 reference plots will be established, with 15 to 20 plots located within a 20 km^2 area constituting a reference site. All sites will have a minimum data collection set, but some sites may be sampled more intensively than others. Plot dimensions (i.e. hundreds of metres) will facilitate direct linking with remote sensing data.

Measurements at the establishment phase will include photographic descriptions and point based measurements of substrate type, perennial vegetation species (trees, shrubs and grasses) and vertical structure, to describe plant phrenology and cover (to calibrate remote sensing). Vegetation measurements at each plot will occur along 3 x 300 m transects (75 m apart) and soils will be collected from a minimum of 4 locations within the plot, from depths of 0-5 cm and 5-30 cm. Samples of soils and leaf material from each plant species will be collected for further analyses. Following calibrations, mid infrared spectrometry will be used to analyse the collected soils for carbon, nutrients, cation exchange capacity, moisture content, and DNA bar-coding of the leaf specimens will be used to assess biodiversity genetic parameters of the perennial plants and soil cryptogams. Rainfall timing and amount will be recorded (a major driver of rangelands systems). Collected data will initially be used to benchmark biodiversity in the bioregions of the rangelands. Collaboration with other monitoring groups will be encouraged to obtain the most complete inventories possible of flora and fauna at significant sites, and to value-add to the permanent sites.

The location of reference sites will involve negotiation with State and Territory agencies that will be undertaking the surveys for the project. Consideration will be given to location of current reference sites and location of proposed survey and monitoring efforts of partner organisations (e.g. Bush Blitz). The location of reference sites will then be determined using a hierarchical stratification process which includes: IBRA bioregions; land type; and disturbance regime. Reference sites will be replicated within and across the above levels.

The TERN NSRSN will also offer multiple use (non-destructive) opportunities and additional benefits including providing:

- the framework on which to base other research components (e.g. fauna monitoring);

- biological references to guide attainable targets for restoration projects;

- sites where other agencies can undertake monitoring using their jurisdictional methods to develop benchmarks/controls which have previously been beyond the logistical and financial resources of that jurisdiction; and

- opportunities for joint projects within TERN, such as locating additional flux towers within a TERN Scientific Reference Site Network site.

Table 1. Summary parameters, methods and applications relevant to the NSRSN

Parameter	Methodology	Application
Biodiversity discovery	- taxonomic ID - DNA barcoding	species knowledge
Species distribution - presence/absence	- plot based assessment	species distribution modelling (e.g. bioclimatic envelope prediction for present/future)
Demographic profile	- plot-based age profile - photo points - population genetic assessment of connectivity and diversity - demographic surrogates (e.g. dendrochronology)	modelling species dynamics, demographic processes
Condition assessment	- landscape function analysis - plot/photo based - productivity	change in condition, structure or invasive species composition over time
Remote sensing ground parameters	- plot-based assessment of ground cover (%, green fraction, non-green fraction, bare ground), vegetation structure categories (forb, grass, shrub, tree) and leaf area index, etc.	improved remote sensing accuracy and validation of derived products
Soil resources - soil crusts - microbiology - soil respiration	- C, N, P, K assessment - DNA barcoding/taxonomy	stocks and flows of soils and role in arid ecosystems
Climate/Moisture	- rainfall collection - soil moisture/temperature probes	water cycling in rangelands

The NSRSN in the rangelands will form the quantitative methodological framework for the TERN integration of plot-based ecosystem research in Australia. Being built on a sound conceptual framework will facilitate the extension of the NSRSN into mesic ecosystems through partnership with other survey efforts (state and federal, e.g. Bush Blitz). The advantage of such an extension will be to allow the co-analysis of a range of historical plot-based data using the quantitative base-line framework provided by the NSRSN. Temporal monitoring can be added to the spatial coverage of the NSRSN by combination with the Long Term Ecological Research (LTER) site network, and other long term monitoring sites.

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