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Book of Abstracts

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tern
Ecosystem Research Infrastructure

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Program 2025

Day 1

Day 2

We at TERN acknowledge the Traditional Custodians throughout Australia, New Zealand and all nations. We honour their profound connections to land, water, biodiversity and culture and pay our respects to their Elders past, present and emerging.

Speaker index

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Alphabetical

Online presentation

Opening Speakers

Dr Beryl Morris FRES, FIML, FAICD, MPRIA

Beryl has been Director of TERN, Australia's national ecosystem monitoring observatory, since 2016. TERN uses expertise, sensors, surveys & tools to produce long-term open access data, samples, models and analytics to enable research and prediction about change in climate, biodiversity and soils. Beryl has worked in executive roles in both the public and private sectors and has been the CEO of several companies in the life sciences area and a Director of listed companies and not for profits. Beryl has run national science communication programs, commercialised technology and authored books and papers on a range of topics in the fields of science, education and management. Beryl has an international reputation in forensic entomology.

Professor Emily Nicholson

Professor Emily Nicholson is a conservation scientist whose work has impacts on conservation policy and practice at global and local levels. Her research interests include biodiversity monitoring and risk assessment, conservation decision-making, and ecosystem science. She co-leads the IUCN Red List of Ecosystems thematic group in the Commission on Ecosystem Management, and is a member of the Ad Hoc Technical Expert Group on indicators for the Kunming-Montreal Global Biodiversity Framework under the UN Convention on Biological Diversity, and UN Statistics Division working groups on ecosystem accounting. She has >100 scientific publications, including in Nature and Science, cited over 8000 times, and has been awarded >$10M in external competitive grants, including an Australia Research Council Future Fellowship, two Discovery grants, and four Linkage grants.

Professor Andrew Campbell

Professor Andrew Campbell was the Inaugural Chair of the TERN Advisory Board from November 2009 to December 2016. Among influential roles in sustainable agriculture and research management in Australia for over thirty years, Andrew Campbell is Managing Director of Triple Helix Consulting Pty Ltd. He recently concluded a four-month role as Interim Executive Managing Director of the CGIAR (largest global agricultural innovation network), based in Montpellier, France. His 7-year term as Chief Executive of the Australian Centre for International Agricultural Research (ACIAR) concluded in July 2023. ACIAR is a Commonwealth agency in the Foreign Affairs portfolio that invests around $100m per year in research in developing countries to improve agricultural productivity and sustainability, and food system security and resilience. The ACIAR CEO reports directly to the Foreign Minister. Andrew Campbell was the 2021 chair of the Global Research Alliance on Agricultural Greenhouse Gases (64 member countries).

Andrew Campbell returned to Canberra in 2016 after 5 years in Darwin, where he led the Research Institute for Environment and Livelihoods, the School of Environment and the Centre for Renewable Energy at Charles Darwin University. He was Executive Director of Land & Water Australia 2000-07, and was instrumental in the development of Landcare in Australia as the first National Landcare Facilitator (1989-92). He has written widely on landcare and sustainability. He has professional training in forest science and agricultural knowledge systems from the University of Melbourne and Wageningen Agricultural University in The Netherlands.

Andrew was elected as a Fellow of the Australian Academy of Technology and Engineering (FTSE) in 2018. He is also a Board Director of AgriFutures Australia, a Professorial Fellow in the ANU Fenner School, Principal Fellow in the Faculty of Science at the University of Melbourne, Fellow of the Australian Institute for Company Directors (FAICD), Patron of Landcare in Victoria, and former Board Member of the Peter Cullen Trust and the Future Farm Industries CRC. His family has been farming in western Victoria since the 1860s. Andrew has been managing the family farm (farm forestry, prime lambs and wool) with the help of a neighbour since 1987.

Session 1

View recordings here

Session 1: **Biocomplexity**

Session 1 chair - Mike Grundy *University of Sydney*

Adjunct Professor, School of Agriculture, The University of Sydney; Member Wentworth Group of Concerned Scientists; Specialist Advisor TERN; Chair Independent Science Committee Accounting for Nature. Retired CSIRO Research Director, Soil and Landscapes.

Mike Grundy has a long-standing research interest in spatial soil and landscape science and its application to agricultural and forest production, environmental protection and systems approaches to complex problems – and has led major multi-disciplinary natural resource assessment activities for over 30 years.

He has had roles in Universities, State Agencies and most recently CSIRO where he was the Research Director – Soil and Landscapes. He was a foundation member of the global Knowledge Systems collaborative and held leadership roles in global initiatives in soil information and agricultural monitoring. He has recently retired from full time work but has continuing connections to the Terrestrial Ecosystem Research Network, the UN Office for Disaster Risk Reduction, the University of Sydney as well as the Wentworth Group of Concerned Scientists. Mike chairs the Independent Science Committee of Accounting for Nature Inc – following on from earlier collaboration with the Wentworth Group and NRM Australia in testing concepts of effective environmental accounting – as part of a continuing interest in understanding interconnection of our landscapes with the wider economy and environment.

Mike is a Fellow and Honorary Life Member of the Australian Institute of Agricultural Science and Technology.

He is also a proud grandfather of three and that role is becoming an increasing obsession!

Tracking invaders: an Invasive Species Index (ISX) to revolutionize biosecurity

Irene Martin Fores, *TERN University of Adelaide*, ***Ben Sparrow***

Invasive alien species are a major driver of global biodiversity loss, contributing to 60% of documented plant and animal extinctions and costing the global economy an estimated $423 billion annually. Despite their profound impacts, the absence of a standardized monitoring system limits our ability to track invasion trends, assess management effectiveness, and align biosecurity responses with conservation priorities.

Building on the success of the Threatened Species Index (TSX), which provides reliable measures of change in threatened species populations, we propose the development of an Invasive Species Index (ISX). The ISX will systematically track the prevalence and spread of invasive species across ecosystems, offering a powerful tool for policymakers, conservationists, and land managers. Importantly, by integrating ISX with TSX, we can create a complementary framework that strengthens the alignment between conservation priorities and biosecurity actions, enhancing both threat mitigation and biodiversity protection.

This presentation will outline the rationale, conceptual framework, and initial design of the ISX, highlighting its potential to transform invasive species monitoring and revolutionize biosecurity strategies at national and global scales.

10.5281/zenodo.15794963

Resolving soil microbiome responses to fire

Vilma Perez, *TERN University of Adelaide*, ***Ben Sparrow***

Soil microorganisms play a critical role in driving ecosystem recovery following fire. This project aims to reconstruct the short-term responses of soil microbial communities, including changes in taxonomic composition and metabolic function, to the 2019–2020 megafires on Kangaroo Island, South Australia. Using shotgun metagenomic sequencing of soil samples collected before and after the fires (available through the TERN repository), we applied a genome-resolved approach to identify the ‘functional toolbox’ of key soil microorganisms underpinning post-fire ecosystem processes and recovery pathways. These insights will significantly advance our understanding of how ecosystems respond to increasing fire activity under a changing climate in Australia.

10.5281/zenodo.15794954

Session 1

Assessing trends in threatened species and communities with ACT-specific indices

David Roberts, *Office of Nature Conservation, ACT Government*

This talk will present two indices derived from routine monitoring in the Australian Capital Territory (ACT) related to threatened species and ecological communities.

The ACT Threatened Species Index (ACT-TSX) applies the national TSX methodology to determine trends in the relative abundance of all threatened and potentially threatened species that are systematically monitored in the ACT. The ACT-TSX draws upon a wealth of citizen science, non-government, and government data for a suite of threatened species and taxa not currently represented in the national TSX. We will present initial results and show that temporal trends in the ACT-TSX follows a similar trajectory to the national TSX.

The ACT Woodlands Condition Index (ACT-WCI) is derived from systematic monitoring of the critically endangered Yellow Box - Blakely's Red Gum grassy woodland since 2009. The dataset has over 10,000 observations across 800 plots. The ACT-WCI draws together these data into an objective index of condition based on established benchmarks. The ACT-WCI can identify high-conservation value remnants from more degraded areas, and captures temporal trends in woodland condition that can be used to evaluate the efficacy of management actions in at-risk areas.

These two indices have practical applications for land managers, policy makers and restoration ecologists. They represent an efficient distillation of substantial long-term datasets that may have applications in other jurisdictions.

10.5281/zenodo.15794959

A Threatened Frog Index for Australia

Geoffrey Heard, *TERN Australia**, Sarah McGrath***

The Threatened Species Index (TSX) is a vital tool for tracking and reporting on changes in the abundance of Australia's imperilled species. Up to 2023, the Index reported on changes in the abundance of 286 species of birds, mammals and plants — derived from almost 23,000 monitoring time-series — providing a crucial update on the status of these species. Nevertheless, trends for other major species groups have remained undocumented. In this presentation, we will detail results of the first attempt to compile abundance trends for Australia's threatened and near-threatened amphibians. Australia has been a global hotspot of amphibian decline, with the impacts of amphibian chytrid fungus being particularly significant. Seven species of frogs were driven to extinction in Australia by this pathogen, and a further 36 suffered population declines. Here, we present preliminary abundance trends for Australia's threatened and near-threatened frogs over recent decades, based on extensive monitoring data collected by the Australian Government, State and Territory governments, natural resource management groups, NGOs, academics and citizen scientists. National and state-level trends will be presented, as will a comparison between key functional groups and chytrid-impacted and non-impacted taxa. We will close by describing future plans for filling taxonomic gaps in the TSX, including development of Australia's first Threatened Reptile Index in 2025.

10.5281/zenodo.16076894

Introducing the Blue Mountains Hub for Ecology and Conservation

Brendan Choat, *Western Sydney University*

Australia suffers from a paucity of comprehensive ecological datasets on forested ecosystems, particularly those relating to vegetation structure and function. The Greater Blue Mountain World Heritage Area constitutes one of largest tracts of protected bushland in Australia. However, it is directly adjacent to one of the largest and most rapidly growing urban areas in Australia and has recently seen the devastating consequences of natural disasters (bushfires, drought, flooding) related to climate change. This area is biologically and culturally unique, but also uniquely vulnerable. The Blue Mountains Hub for Ecology and Conservation has established a permanent network of ecological plots in the Greater Blue Mountains World Heritage Area (GBMWHA), where complex topography and disparate research foci have previously disadvantaged broad research coordination. The ecological monitoring network consists of 35 plots, covering all major ecosystem types found in the GBMWHA. In 10 plots, we will install instrumentation to facilitate real-time remote data collection: telemetry, weather station (temp, RH, rainfall, wind speed, light, soil moisture), dendrometers, sap flow gauges, micro-tensiometers, fuel moisture sensors, camera traps, acoustic monitoring, water quality and light traps. These sensors will allow for continuous and remote monitoring of plant growth, water use, soil moisture stress, bushfire risk, presence of wildlife, diversity of invertebrates, water quality and will form the basis for further on-site measurements and research. The measurements are crucial for achieving broad ecological understanding, development of predictive models, quantification of changes in carbon storage, and to conservation outcomes of international importance.

10.5281/zenodo.16077526

Session 1

The Wildlife Observatory of Australia empowers national wildlife camera monitoring

Zachary Amir, *TERN Australia*

The Wildlife Observatory of Australia (WildObs) is revolutionizing how Australia captures, manages, and uses wildlife camera data by building digital infrastructure for a continental-scale observatory to monitor and forecast trends in terrestrial vertebrate populations. WildObs aims to streamline biodiversity monitoring, dismantle data silos, and provide consistent, high-quality data for evidence-based conservation and policymaking. WildObs aims to deliver: (i) a national platform that leverages artificial intelligence (AI) to efficiently manage and classify wildlife in many millions of images, (ii) a repository of tagged wildlife images to support the development of novel AI computer vision models, and (iii) a curated, standardized database of analysis-ready data for researchers and biodiversity metric authorities (e.g., TSX, SoE). This work is made possible through the combined strengths of our broad partnership network. WildObs is collaborating with over 40 data providers and key infrastructure organizations including TERN, ARDC, ALA, and QCIF, to deliver purpose-built digital infrastructure. For example, QCIF is leading the development of computer vision applications, TERN will host systematic survey data, and ALA will provide access to images and species occurrence records. Together, these collaborations are enabling unprecedented insight into Australia's wildlife. One ongoing project integrates continental-scale data to investigate interactions among dingoes, foxes, and feral cats—three of Australia's most controversial carnivores—with the goal of informing threatened species management. WildObs demonstrates how shared infrastructure, open collaboration, and innovative technologies can unlock national-scale biodiversity insights—positioning Australia as a global leader in wildlife camera data use and reuse.

10.5281/zenodo.16077866

Session 2

View recordings here

Session 2: **Greenhouse Gases**

Session 2 chair - Dr Geoffrey Heard *TERN Australia*

I am a Science Advisor for the Threatened Species Index (TSX) at TERN and an Affiliated Researcher with the Centre for Biodiversity and Conservation Science. The TSX integrates long-term monitoring data for Australia's threatened and near-threatened species to estimate abundance trends. A key focus of my role is assisting to get the hard-won data of Australia's ecologists into the TSX, including working with data providers to generate reliable time-series of abundance or occurrence rate from their data. Ultimately, I help to ensure that the TSX continues to provide accurate and up-to-date information on population trends for Australia's imperilled species.

Outside of the TSX, I continue to pursue research on the spatial and temporal dynamics My projects usually lie at the intersection of applied ecology and herpetology, because I've been fascinated by reptiles and amphibians since I was a boy, and the obsession shows no sign of abating. Whatever the taxa, my aim is to provide insights and tools that can support practical, on-ground conservation decision-making.

Beyond Total Soil Organic Carbon: Operational Fractions for Australian Landscapes

Claudia Dămătîrcă, *CSIRO Agriculture and Food****, Ryan Farquharson, Phillip Ford, Tom Zhao, Christina Asanopoulos, Sheridan Morton, Mark Farrell, Ben Macdonald, Senani Karunaratne***

There is increasing interest in landscape-scale soil organic carbon (SOC) compositional datasets beyond total SOC. A practical approach to generating such data involves separating SOC into fractions with distinct turnover times using physical methods (e.g., size or density fractionation), and/or chemical characterisation. However, these methods might be costly and time- consuming. A reliable high-throughput, cost- and time-efficient method is needed, and the thermal approach could address these needs. This work uses nationally collected topsoil samples (0 – 30 cm) to develop a national-scale SOC fractionation dataset through physical and thermal separation methods. One hundred representative samples from 300 soil samples from diverse pedo-climatic conditions across Australia's agricultural regions were selected. Samples were first physically fractionated into coarse (>50 µm) and fine (<50 µm) fractions. The finely ground whole soils (<2 mm) and isolated fractions were then analysed using a three-step thermal ramping method. This method quantifies two oxidisable carbon pools with different thermal stabilities: thermally labile organic carbon (TOC400, <400°C) and residual oxidisable carbon (ROC, 400–600°C), as well as one inorganic carbon pool (TIC900, 600–900°C). The resulting dataset will be compared with the current national SOC fractionation scheme developed by CSIRO, to assess alignment and deviations. Once refined, the method will be scaled up to generate a broader dataset to support spatial modelling of SOC deficit (storage bucket) for stable carbon fractions and assess the ecosystem's resilience. Importantly, the dataset will inform soil monitoring, reporting, and verification frameworks, with thermal SOC fractions serving as measurable proxies for landscape-scale resilience.

10.5281/zenodo.16078042

Australian Long-Term Agroecosystems Research network (ALTAR) for industry natural capital

David Rowlings, Queensland University of Technology

Australia is unique within OECD countries in both its large areas of tropical climates and the paucity of data available for understanding agricultural management impacts on carbon and natural capital. As a result, there are limited known economically viable management strategies available to farmers to increase natural capital, poor understanding of current baselines, and no accurate measurement and verification tools that are economically viable at scale. Australian agricultural supply chains therefore face severe barriers to entry into global natural capital markets.

ALTAR was established to leverage TERN ecosystem processes capability to provide Australian agricultural industries a technological foundation to overcome these barriers. Here we present a framework to test the readiness level of this technology across northern Australian agricultural landscapes. Partnering with industry, we have deployed 18 eddy covariance towers in a paired agricultural management approach across Queensland and NSW. Towers are combined with phenocams, acoustic sensors, GHG chambers, drones, and remote sensing, and at some sites automated livestock weighing, GPS livestock tags and in-field enteric methane sensors. Data is not only testing specific management, but will form the basis of a regionally specific reference network to help set the reasonable bounds for low-carbon Australian agriculture.

10.5281/zenodo.16257820

Session 2

Integrated terrestrial ecosystem nutrient modeling for environmental applications

Chiara Pasut, *CSIRO*, ***Jacqui England, David Forrester, Sreekanth Janardhanan, Ben Macdonald***

Despite major scientific progress in recent decades, existing models still struggle to reliably represent complex biogeochemical cycles. A key limitation is their dependence on extensive physical, chemical, and biological datasets, which are often incomplete, inconsistent, or uncertain. These data limitations, combined with intricate feedback between systems, amplify uncertainty and reduce confidence in model outputs.

Here, we propose a modelling framework that integrates and builds upon existing approaches to address these key research gaps. The framework aims to improve tracking of carbon and nitrogen fluxes across the vegetation–soil–atmosphere continuum, while also accounting for lateral transfers from the surrounding landscape (e.g., streamflow and erosion), with applicability across regional to continental scales. Key features include a microbially driven biogeochemical model that replaces conventional approaches, deeper soil simulations beyond 30 cm, and a dynamic vegetation model linked to below-ground processes. A novel module will also capture the role of termites in nutrient turnover—an important but often overlooked factor in Australian ecosystems.

The framework is intended for landscape-to-regional scale assessments, supporting policy and planning rather than fine-scale, paddock-level decision-making. Initial testing, calibration, and validation will use data from the TERN Surveillance platform, before scaling up to the continental level using products from the Landscape platform. Early outputs will report on the development status of each sub-module, provide preliminary comparisons with existing national modelling platforms, and explore potential applications in natural resource management and Monitoring, Reporting, and Verification (MRV) of GHG emissions.

10.5281/zenodo.16258167

Beyond standard drivers: Enhancing TERN-OzFlux data products

Anne Griebel, *University of Technology Sydney*, ***Nicola Lieff, Peter Isaac, Ian McHugh, Daniel Metzen, Cacilia Ewenz***

Flux tower observations present our current best means to quantify carbon, water and energy cycling from the "bottom-up" at the ecosystem scale. Observations from individual sites are contributed to national and global networks that strongly enhance the value of single site data. While data quality control is often applied subjectively at individual sites, gap-filling of fluxes typically follows a standard community approach using a uniform set of drivers, regardless of ecosystem type or local conditions. Given the wide climatic variation across Australian flux sites, we investigated (i) how well a fixed set of drivers predicts CO_2, sensible and latent heat fluxes across climate zones, and (ii) whether site-specific driver selection improves model performance and representation of flux dynamics. We used supervised machine learning to assess driver importance and variables explaining up to 80% of flux variability at each site. These site-specific drivers were then used to reprocess fluxes across all sites with published data at the TERN OzFlux data portal. We compared the model skill (R^2, RMSE) and diurnal flux patterns to results obtained using the standard driver set. Driver importance varied with water availability and was broadly consistent within climate zones. Site-specific drivers significantly improved model skill and diurnal dynamics, particularly in very wet and very dry ecosystems. Our findings demonstrate the benefits of tailoring driver selection for flux gap-filling and underscore the limitations of a one-size-fits-all approach. We also identify key auxiliary variables for each climate zone, informing future observational priorities within flux networks.

10.5281/zenodo.16258216

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Session 3: **Monitoring Methods**

Session 3 chair - Alison Specht

Alison Specht is an environmental scientist currently assisting TERN as an Ecosystem Research Analyst. Alison has broad expertise in research, teaching, and community engagement. In the past 13 years she has focussed on facilitating interdisciplinary and multinational groups to tackle complex environmental problems using existing data. Her major interests, apart from her domain activities, are to enhance collaboration between scientists, policy-makers and managers to improve environmental outcomes, and improve data management and preservation, data sharing and re-use. Collaboration across boundaries, conservation of data for appropriate re-use, among other factors, she feels are essential for effective management of our biodiversity and the future of our environment. Following a career as an academic at two universities, she joined the Terrestrial Ecosystem Research Network (www.tern.org.au) in 2009, where she established the Australian Centre for Ecological Analysis and Synthesis, the first synthesis centre in the Southern Hemisphere. From 2015 to 2019 she was Director of CESAB, in France. She was a member of a DataONE (www.dataone.org) Working Group from 2010-2019. She is co-leader of a Belmont Forum funded project PARSEC (www.parsecproject.org), a multi-national project funded under the Belmont Forum CRA for Science-Driven e-Infrastructures Innovation (SEI) for the enhancement of transnational, interdisciplinary and transdisciplinary data use in environmental change research.

Dronescape: UAV Observations of TERN Surveillance Monitoring Plots

Juan Carlos Montes-Herrera, *University of Tasmania*, ***Arko Lucieer, Ben Sparrow***

Dronescape is a research infrastructure initiative within TERN that incorporates uncrewed aerial vehicle (UAV) remote sensing into Australia's terrestrial ecosystem monitoring framework.

The project aims to bridge spatial and temporal gaps between ground-based observations and satellite data by deploying UAVs equipped with RGB cameras, 10-band multispectral imaging, and LiDAR sensors across TERN's national surveillance plot network. The project aims to enable standardized data collection protocols and automated processing workflows to produce open-access analysis-ready outputs such as orthomosaics, reflectance maps, vegetation indices, and 3D point clouds.

As of 2025, over 120 plots have been surveyed across multiple bioregions, with continued expansion underway. Each flight survey covers approximately 90,000 m^2, contributing to a growing archive of high-resolution spatial data. This presentation will focus on the operational aspects of implementing UAV monitoring at scale, including field deployment, data standardization, and initial outputs. It will outline how these workflows support the broader goal of enhancing long-term, repeatable monitoring within Australia's terrestrial ecosystems.

10.5281/zenodo.16258565

Seasonal drought alters avian soundscape in Taiwan's mountain tea–forest mosaic

Cho-Ying Huang, *National Taiwan University*, ***Kuei-Han Chiu, Mao-Ning Tuanmu***

We investigate the responses of the avian soundscape to environmental variation, particularly the interaction between seasonal drought and vegetation complexity in a tea plantation-forest mosaic landscape in the Alishan high mountain region of central Taiwan. We installed 15 passive acoustic recorders along an elevation gradient of 810–1463 m a.s.l. We calculated five soundscape indices (data recorded two hours after sunrise): Acoustic Complexity Index (ACI), Acoustic Diversity Index (ADI), Acoustic Evenness Index, Bioacoustic Index (BI) and Normalized Difference Soundscape Index of February of 2022–2025 to assess the ramification of severe spring drought in 2023 on biodiversity. For landscape complexity, we acquired high point-cloud density (≤ 161 pts/m^2) light detection and ranging (lidar) data in 2022 and 2023 and calculated a vegetation complexity metric, the Vertical Connectivity Index (VCI). We also collected field meteorological data including air temperatures, relative humidity and solar radiation. Linear mixed-effects models were used to assess the main and interactive effects of meteorological and landscape variables. Results showed that air temperatures and relative humidity consistently had positive effects across all indices ($p < 0.001$), underscoring the sensitivity of bird vocal activity to microclimatic conditions. Drought significantly ($p < 0.001$) altered BI compared to non-drought periods. Although lidar-derived VCI alone was not a salient predictor, its interaction with drought was significant ($p < 0.005$) with ACI, ADI and BI, suppressing frequency diversity while enhancing energy evenness. We conclude that seasonal drought may affect avian vocal activity, with additional complexity introduced by the surrounding forest canopy structure.

10.5281/zenodo.16258734

Session 3

How exploding stars help us measure soil moisture across Australia

David McJannet, *CSIRO*

Earth is continually bombarded with energised particles, or cosmic rays, which likely originate from exploding stars. When these particles penetrate the earth's magnetic field they interact with the atmosphere and form cascades of neutrons and other secondary particles. Luckily for us, neutrons of a certain energy characteristic are particularly sensitive to water (or more specifically hydrogen) in the near surface environment. This means we can measure changes in the intensity of these neutrons to infer soil moisture changes. The key feature of the cosmic-ray soil moisture observations is the sheer size of their large measurement footprint which covers an area of around 12 hectares. Recognising the potential benefits of this novel approach, the Australian cosmic-ray soil moisture monitoring network (CosmOz) was established by CSIRO in 2010 with a handful of sensors deployed at locations around Australia. With continuing funding from TERN, the network has since evolved to include 28 sites across Australia with 23 of these sites continuing to produce data and new installations planned. This presentation will give a brief overview of the measurement method, the evolution of CosmOz and will discuss how the data being provided by TERN is being used. In addition, it will provide an overview of some recent advancements in the field and provide an update on global collaborations around consistent data delivery from the growing number of similar networks around the world.

10.5281/zenodo.16258928

National ecosystem integrity mapping using a flexible 'best-on-offer' reference approach

Matthew Gale, *Australian National University*

Ecosystem integrity, which refers to the intactness of biotic and abiotic components of ecosystems and their processes and interactions, varies across landscapes in response to anthropogenic and environmental processes. Remote sensing supports broad-scale estimation of ecosystem integrity indicators (e.g., forest height, leaf area index), but does not distinguish degradation from natural variability within and between ecosystems. We developed and tested an Australia-wide method to estimate ecosystem integrity by measuring how far current integrity indicator values depart from ecologically plausible reference values. Suitable reference areas were identified using spatial information describing land use and management, and were classified based on the level of confidence that they represented high integrity. Reference sites were allocated within these areas using an iterative technique that placed sites in a multi-dimensional environmental space, gradually including lower-confidence sites only if they expanded the multi-dimensional environmental envelope. By training machine learning models on these reference sites, we predicted 'best-on-offer' reference maps for several remote sensing indicators. For each indicator, the departure between current and reference values was compared to a dataset of site vegetation integrity assessments in NSW. The strongest correlations were observed for departure of forest height, above-ground biomass, annual reflectance variation, and soil organic carbon content. By modelling different ecosystem integrity indicators relative to plausible contemporary reference values, our method offers a flexible and scalable approach to ecosystem integrity assessment. It may support environmental monitoring, markets, impact assessment and restoration planning. The data will be publicly available and used as part of TERN's Australia's Environment report.

10.5281/zenodo.16259044

OzSET: aligning coastal Research Infrastructure to monitor tidal wetlands

Madeline Goddard, *TERN Australia*, ***Catherine Lovelock, Vicki Bennion***

Tidal wetlands, mangroves and saltmarsh along with their upland counterparts, supratidal forests, are important social and economic ecosystems. Yet they are increasingly threatened by sea-level rise due to their low coastal elevation. Surface Elevation Tables (SETs) are mechanical levelling devices used in tandem with benchmarks that measure the relative elevation change of wetland sediments (Cahoon et al., 2000) and are considered the global standard for assessing the vulnerability of tidal wetlands to sea-level rise (Webb et al. 2013). The existing SET network across Australia consists of over 300 SETs at over 30 sites (Saintilan et al., 2023) contributing long term data sets. A collaborative approach to ensuring the existing and expanding network is monitored using the same standard methodology allows for comparison and better management outcomes. The Terrestrial Ecosystem Research Network (TERN) are running a 3-year National Collaborative Research Infrastructure Strategy (NCRIS) enabled project to bring the SET network from discrete projects to a recognisable community of practice around Australia to a network contributing to and recognised as National Research Infrastructure (NRI).

10.5281/zenodo.16259212

Boosting Ecosystem Monitoring in WA's Climate-Sensitive Landscapes

Caitlin Moore, *University of Western Australia****, Jason Beringer, Suzanne Prober, Craig Macfarlane, Margaret Byrne, Richard Silberstein***

Australia's ecosystems are facing increasing pressure from climate change, and long-term monitoring is essential to understand how they my respond. The Terrestrial Ecosystem Research Network (TERN) plays a key role in collecting vital data on ecosystem processes through its observatories that track how carbon, water, and energy flow between the land and the atmosphere. While these sites offer valuable insights, there are still important gaps in monitoring, such as detecting early signs of plant stress, tracking vegetation structure more frequently, and improving biodiversity monitoring. To address these challenges, new instruments upgrades have been installed at three SuperSites in Western Australia thanks to support from the WA State Government. These instruments provide daily data on how plants grow and respond to light and climate, using tools like laser scanners, hyperspectral sensors, and quantum light sensors. This talk will discuss some of the key findings and lessons learned from implementing this new equipment to understand ecosystem-climate interactions in more detail.

10.5281/zenodo.16259374

Automated on-farm biodiversity assessment using combined remote technologies

David Tucker, *Queensland University of Technology*

Traditional on-farm biodiversity assessments can be costly and labour-intensive, creating barriers for widespread ecological monitoring. To address this challenge, an automated monitoring approach was developed that leverages recent advances in hardware and software technologies.

The approach combines three complementary remote sensing technologies: passive acoustic monitoring (PAM), camera trap deployments, and satellite-derived environmental data for landscape-level analysis. These technologies were integrated into a single modular package specifically designed for farm-scale biodiversity measurement, offering a comprehensive alternative to traditional survey methods.

The approach was tested on multiple grazed properties within the Brigalow Belt South bioregion of Queensland, Australia, generating ecological integrity scores at both individual survey points and at property levels. A key innovation included in the output was a novel predictive model that quantifies ecological condition by synthesising acoustic and satellite-based indicators.

The practical design allows landowners and farm managers to independently deploy the monitoring equipment, and for specialists to analyse data and generate ecological assessments post survey. This approach may significantly reduce costs while maintaining scientific rigour, making routine biodiversity monitoring accessible to a broader range of agricultural operations.

10.5281/zenodo.16297750

Long-term ecological monitoring using the Australian Acoustic Observatory

Paul Roe, *James Cook University****, Slade Allen-Ankins, Lin Schwarzkopf, Robert Clemens, Nelli Holopainen, Anthony Truskinger***

The Australian Acoustic Observatory provides continental-scale environmental monitoring of enormous spatial extent and temporal resolution, having collected over 2.5 million hours of audio since its inception in 2019. The vast data collected from these recordings can be analysed to identify patterns in animal vocalisations, facilitating the detection of temporal and spatial trends in biodiversity. Furthermore, the acoustic data provides a non-invasive, cost-effective, and scalable approach to long-term ecological monitoring. To highlight its potential, we present results from a recent project targeting threatened vocal vertebrates across the entire network using deep-learning models. A total of 43 of the 76 targeted species were detected across the network, with some species occurring at up 10 locations. These data can help inform conservation efforts and contribute to existing initiatives such as the Threatened Species Index. We also discuss the open-access tools available through the Open Ecoacoustics platform that enable ecologists to upload, store, analyse and verify Ecoacoustic data in a standardised way.

10.5281/zenodo.16297891

A deep dive into TERN Australia Soil and Herbarium Collection

Donna Lewis, TERN Australia, Carly Steen

The TERN Ecosystem Surveillance program is a unique national long-term ecological monitoring initiative that supplements the collection of vegetation, landscape and soil attributes with various types of vascular plant voucher specimens and soil samples. The TERN Australia Soil and Herbarium Collection, Adelaide University houses six sample types, including: plant voucher specimens, plant tissue samples, soil pit samples, soil subsite samples, soil metagenomic samples and more recently, ant samples.

Plant voucher specimens representing all vascular plant species are collected at every plot. Plant specimens can be used for taxonomic revision, phylogenetic studies, plant traits. Plant tissue samples are sampled from each plant voucher specimen, and additional samples are collected for four dominant species. Tissue samples can be used for genetic, population genetics, molecular, and isotopic analyses.

Soil pit samples are collected at intervals down the soil profile (~1m), within horizons at one location in the south-west corner at a plot. For each horizon, a sample is collected (~500g). Soil subsite samples are collected from 9 subsites within each plot, with pits to a depth of 30 cm and samples collected at 10 cm intervals (~500g). Soil pit and subsite samples can be used for physical and chemical analyses. Soil metagenomic samples are collected from the top layer of soil at each of the 9 subsites (~200g). Samples can be used for biological analyses.

The collections and associated data are available for researchers to visualise and submit an expression of interest via TERN EcoPlots Samples and the ausplotsR package.

10.5281/zenodo.16298070

Engineering Monitor: an extensible tool for EMSA field-data collection

Andrew Tokmakoff, TERN University of Adelaide, Luke Derby, Walid al Naim, Jin Zhou, Huy H H Vo, Ashley Leedman, Ben Sparrow

Monitor is an information system developed by TERN as part of the Ecological Monitoring System Australia (EMSA) initiative to enable standardised ecological field data collection, addressing the technical challenges of robust, offline-capable data collection in remote field environments.

The system architecture employs several key innovations. An offline-first design with local storage ensures data integrity in areas with poor connectivity. The modular protocol engine dynamically renders survey forms based on configurable JSON schemas, enabling rapid deployment of new methodologies without large application updates. Submission-time validation against data schemas and subsequent mapping to the Australian Biodiversity Information Standard (ABIS) enable data to be delivered into Australia's national biodiversity information repository (the BDR).

Development has focused on three key areas: extensibility enabling new protocols to be rapidly deployed; integration through separation of organisational configuration from core functionality; and data quality assurance ensuring completeness (all required data collected) and correctness (only valid values accepted). The system's extensibility to support new protocols has been demonstrated through expansion beyond the original 24 EMSA modules across diverse terrestrial ecosystems to include Grassy Weeds Aerial surveys and UAV data management. Technical features include DGPS integration with accuracy thresholds, automatic photo geotagging and compression, and opportunistic background synchronisation.

Initially targeted at tablets, the responsive interface also operates on smartphones and desktops, maintaining usability in field conditions. Data flows seamlessly from collection and submission through validation to the Biodiversity Data Repository. Monitor integrates with MERIT, adding a field data collection function through the implementation of the "Org" integration interface.

This presentation will provide a technical overview of Monitor's architecture, demonstrate key innovations addressing field data collection challenges, and discuss lessons learned from approximately one year in production. We'll examine how engineering and design decisions enable scalable, reliable ecological data collection while maintaining flexibility for diverse research applications.

10.5281/zenodo.16298223

Uncovering the Hidden Links Between Rock and Root

Brady Flinchum, University of Newcastle

Outcrop islands are intact rock exposures embedded within deeply weathered landscapes. They present a paradox in hot, humid climates where chemical weathering typically produces thick regolith and minimal exposed bedrock. These cryptic landscapes host rare plant species and exhibit stark ecological and subsurface gradients, offering a unique perspective into the initiation and evolution of regolith that forms Earth's critical zone (CZ). This study introduces the Biotite and Biocrust Conceptual Model (BBCM), which hypothesizes that initial resistance to weathering is driven by steep slopes, low fracture density, and low biotite and phosphorus concentrations. These conditions create a nutrient-limited environments that can be colonized by biocrusts and lichen, which help initiate regolith and ecosystem development. I explore two key questions: (1) What attributes make outcrop islands resistant to weathering, and how do these influence ecosystem development? (2) Do ecosystems preferentially establish in areas with pre-existing CZ structure, or do they actively shape the CZ to meet their needs? This is ongoing work. Seismic refraction and ground-penetrating radar (GPR) data reveal that spatial gradients in regolith thickness are as extreme as the vegetation contrasts visible at the surface. Furthermore, the data show strong correlations between vegetation height and composition and the underlying subsurface structure. Preliminary soil geochemistry shows large spatial gradients in nitrogen and phosphorus, suggesting that biocrusts play a foundational role in nutrient cycling, enabling the establishment of vascular plants and the initiation of CZ development. The data presented here are preliminary and form the basis of a hypothesis I aim to explore further in Australia. This interdisciplinary research requires collaboration across geology, ecology, and biogeochemistry. I welcome discussions to explore comparative studies, data integration, and future partnerships.

10.5281/zenodo.16301268

Sustaining Gondwana Rainforest: A Collaborative Critical Zone Observatory at Springbrook

Lucy Reading, Queensland University of Technology

Australia's Gondwana Rainforests contain globally significant subtropical cloud forests uniquely sensitive to climate and hydrological changes. To provide integrated long-term ecosystem monitoring, we are developing Australia's first mountainous Critical Zone Observatory (CZO) at Springbrook Plateau (700–1000 m elevation). This initiative is co-designed with the Kombumerri Indigenous community to incorporate Indigenous water lore and culturally significant site stewardship, alongside key collaborators: Queensland University of Technology (QUT), TERN, CSIRO, Seqwater, City of Gold Coast, Queensland State Government (QPWS, DETSI, DLGWV), Tweed Shire Council, and the Australian Rainforest Conservation Society.

Currently, ecohydrological instrumentation—including soil moisture arrays, weather stations and sap-flow sensors—is fully operational, supplemented by groundwater and surface water data from the completed Springbrook Groundwater Investigation (SGI). The next phase (subject to funding) involves deploying a smart-sensor network for enhanced groundwater and surface water monitoring, as well as integrating environmental DNA (eDNA) monitoring and eco-acoustic sensors to assess ecological health and biodiversity indicators.

Anticipated outcomes include:

Comprehensive protocols for ecohydrological and biodiversity monitoring transferable to other Gondwana rainforest ecosystems; Robust, data-driven guidance for groundwater extraction policy; and Enhanced community engagement and Indigenous storytelling through interactive data visualisation tools.

By blending scientific, cultural, and policy dimensions, the Springbrook CZO serves as a scalable model for integrated ecosystem monitoring and collaborative stewardship.

10.5281/zenodo.16301359

Unlocking TERN collected material samples: Discoverability and Accessibility

Siddeswara Guru, *TERN Australia****, Javier Sanchez Gonzalaz, Avinash Chandra, Enzhen Luo, Arun Singh Ramesh, Guohualing Huang, Gerhard Weis, Megan Edward, Donna Lewis, Carly Steen, Sally O'Neill, Ben Sparrow***

TERN, as part of the site-based systematic survey monitoring program, collects observation data on vegetation and soil characteristics. In addition, field campaigns collect physical samples from Australia's diverse landscape, including plant tissue, plant specimens, soil samples and metagenomics. Typically, Specimen samples, once collected, will be curated in the lab, catalogued and archived. Often, their visibility is limited, hindering their usage. These samples are critical for understanding natural phenomena and providing context to observational data. Hence, it is essential to make these samples widely discoverable and accessible. However, Significant effort is required for the digitisation of specimens and making them discoverable through digital means.

The samples repository is created as part of TERN EcoPlots, a systematic survey data integration platform, to publish all samples collected by TERN. Just like observational data, samples can be searched by region, site, and sample type. Each material sample is assigned a globally unique identifier (IGSN) that links to its sampling context, site information, and digital artefacts.

Through EcoPlots, users can select samples of interest, review their details, and then choose and complete a form to express their interest in accessing the samples. Once the expression of interest is submitted, the samples' curating team will get in touch with users to discuss further access methods. EcoPlots bridges the gap between physical collection and digital infrastructure. We envisage publishing more than 130,000 samples once the digitisation is complete.

10.5281/zenodo.16301370

Naturescan: Drone Remote Sensing for Comprehensive Biodiversity Monitoring

Alice Robbins, *University of Tasmania****, Arko Lucieer, Ben Sparrow***

NatureScan aims to advance biodiversity monitoring in Australia by leveraging consumer grade drones, advanced remote sensing analysis and expertise in field ecology. Funded by the Department of Climate Change, Energy, the Environment and Water, NatureScan aims to develop innovative monitoring techniques to support the Nature Repair Market. The project will develop robust and scientifically sound techniques to inform biodiversity across diverse ecosystems, validated with field data, and aims to place drone remote sensing technology for national-scale monitoring in the hands of land managers.

To ensure the analysis-ready data products (a RGB and 4-band multispectral orthomosaic, and Structure-from Motion 3D point cloud) are representative of the vegetation condition across a range of ecosystems, to date the project has focused on the development of user-friendly collection and processing protocols for the DJI Mavic 3 Multispectral drone. These were tested across a diverse array of ecosystems nationally including Eucalypt woodlands, Acacia shrubland, mallee woodlands and tidal wetlands, to ensure robust, reliable and accurate results across vegetation communities. This research has included developing clear, easily accessible standards for data collection, and has defined processing parameters that return analysis-ready data products that best represent ecosystem condition. This has included testing the impact of orthorectification surfaces, to ensure the processing of raw drone imagery returns results that are representative of the on-ground vegetation – essential for on-going monitoring of ecosystem condition. This presentation will focus on the development of the collection and processing protocols, with an emphasis on testing photogrammetric parameters for reliable analysis-ready data products.

10.5281/zenodo.16301572

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Session 4: **About Data**

Session 4 chair - A/Professor Ben Sparrow *TERN Australia*

Ben leads the Ecosystem Surveillance team within TERN Australia to deliver the best ecosystem science infrastructure available to meet Australia's environmental monitoring needs. Ben's team delivers data and samples, and creates tools and strategies that are scientifically sound, pragmatic, practical, and can be implemented operationally.

Previously Ben held numerous positions including conducting and leading biological surveys, selling and analysing imagery, and conducting extensive vegetation mapping in South Australia and the Northern Territory. More recently, Ben held the position of Principal Scientist – Land Resources, and managed the Land Resources section of the NT Government for the southern Territory.

Extracting the signal of biodiversity change from unstructured species-occurrence data

Simon Ferrier, CSIRO, Andrew Hoskins, Drew Terasaki Hart, Chris Ware

Structured spatiotemporal data on change in species presence/absence or abundance, generated by repeated application of the same survey technique at the same set of locations over time, rightly continue to be regarded as the 'gold standard' for monitoring change in biodiversity. However, such data constitute only a fraction of the vast quantities of biodiversity data now being amassed both across Australia and worldwide. Big-data initiatives such as the Global Biodiversity Information Facility and the Atlas of Living Australia have revolutionized access to data on known occurrences of species across space and time. Growth in the volume of these data is continuing at a rapid pace, thanks in large part to the advent and popularity of citizen-science apps for recording species observations (e.g. iNaturalist, eBird). However, the relatively unstructured nature of many species-occurrence datasets has long presented a major challenge for any attempt to extract useful information on biodiversity change, as records distributed across time have most often been generated not through repeated sampling of the same spatial locations, but rather through largely opportunistic or ad hoc observation. Differences in the spatial distribution of observation effort over time are largely unknown, therefore posing a significant challenge for any attempt to disentangle the signal of actual biological change from shifting spatial biases in sampling. This presentation will introduce a new TERN activity advancing analytical approaches to addressing this challenge, and testing these solutions for a range of Australian taxa.

10.5281/zenodo.16301737

A generalised state-and-transition model template linked to ecosystem condition

Suzanne Prober, CSIRO, Anna Richards, Megan Good, Helen Murphy, Alison O'Donnell, Melissa Piper, Kristen Williams, Beryl Morris, Felipe Albornoz, Shaun Brooks, Don Butler, Jacqui England, Katherine M Giljohann, Sarah Luxton, Samantha Munroe, Stephen Roxburgh, Ellen Rochelmeyer

The growing commitment to nature positive initiatives by industry, government and communities globally has led to a pressing need for consistent methodologies for predicting and evaluating outcomes of land use change and ecological restoration interventions. State-and-transition models are a simple and established tool for synthesising and communicating scientific and expert knowledge about ecosystem dynamics, that are increasingly applied in such contexts. However, models have typically been developed for localised or ecosystem-specific purposes, resulting in a plethora of different models at a range of scales and resolutions. TERN's National Ecosystem Assessment System for Australia (NEASA) project is aiming to facilitate consistency in development of state-and-transition models across disparate ecosystems, for application to nature positive initiatives. Towards this goal, the NEASA project worked in collaboration with DCCEEW, CSIRO and >50 Australian ecological scientists, restoration practitioners and policy makers to develop a set of generic templates of ecosystem states for application to (1) forests and woodlands, (2) shrublands, and (3) grasslands. Coupled with these are guides for assigning attribute descriptions, identifying plausible transitions, and quantifying ecosystem condition for each ecosystem state. The templates have already contributed to development of 17 regional scale state-and-transition models for Australia's new Ecological Knowledge System for the Nature Repair Market and are being used to guide international initiatives. The templates currently focus on site-scale characteristics, and we propose further work to identify landscape metrics that reflect configurations of states and internal successional dynamics at broader spatial scales.

10.5281/zenodo.16301913

Data challenges in farm-level environmental reporting for Australia's beef industry

Ella Dewilde, Queensland University of Technology, Louisa Coglan, Elaine Mitchell, David Tucker, David Rowlings

The validity and reliability of environmental sustainability reporting by agricultural companies is limited by the availability of high quality data. Companies at all levels of Australia's beef supply chain are under pressure to measure and report on environmental sustainability, especially at the farm level since this production segment has the largest environmental impact and is the most tangible to consumers. Our research investigated what data-specific challenges beef industry stakeholders face with measuring farm-level environmental sustainability, to ultimately support further research on the potential of research infrastructure networks to overcome these challenges and supply high quality data for industry reporting purposes. Through conducting interviews with 24 industry and expert (research, academia) stakeholders we learned companies collecting new data on farm-level environmental sustainability are met with cost, practicality and low economic return of measuring sustainability performance as the dominant challenges, leading the majority of companies to rely on secondary data. Secondary data (usually government sources) were largely perceived as being of poor data quality and not easily usable or interpretable. Other higher-level challenges included the lack of standardisation in sustainability language and methodologies for data collection, worsening existing challenges in data consistency and quality. Although translating technical datasets into an interpretable and usable source of information for industry is an ambitious undertaking, the longevity and scientific rigour of data produced by research networks such as TERN have the potential to overcome current industry challenges related to data quality and consistency.

10.5281/zenodo.16304326

Developing a forest-dwelling species list and threat ranking for Australia

Annisa Satyanti, Australian Bureau of Agricultural and Resource Economics and Sciences, Steve Read

Knowledge of forest biodiversity, including species, genetic diversity and threats, is critical for adaptive and sustainable forest management and monitoring. It also provides baseline information for policy, and supports Australia's national and international forest-related reporting responsibilities, such as through the Australia's State of the Forests Report, the Montreal Process, and the FAO Global Forest Resources Assessment.

Here we present a new approach to reporting Australia's forest-dwelling species that, rather than drawing on a range of state and territory inputs, solely uses nationally curated data and national data-sources. These include records from the Atlas of Living Australia, the spatial forest coverage from the National Forest Inventory, and conservation documentation from the Species Profile and Threats Database. We then outline the strategies used for systematic and robust quantification of forest-dwelling species and their threat profiles from these data-sources. Challenges included identifying and removing cryptic duplicate records, and harmonisation of the diverse datasets.

This process identified 1,788 forest-dwelling vertebrate fauna species and 13,788 forest-dwelling vascular flora species in Australia, of which 244 fauna and 983 flora taxa are listed as threatened under the Environmental Protection and Biodiversity Act 1999, as at December 2021. The most prevalent threats were land-use change and/or forest loss, unsuitable fire regimes, and impacts from introduced species; forestry operations is among the least frequently cited threats.

10.5281/zenodo.16391521

Pixels to patterns: Interactive tool for satellite time series analysis

Krishna Lamsal, University of Tasmania, Arko Lucieer

Robust ecosystem assessment requires consistent, scalable, and transparent data analysis workflows. This study presents a comprehensive satellite time series analysis of photosynthetic vegetation (PV) cover from Landsat derived fractional cover (FC) data and Sentinel-2 derived spectral indices: Normalised Difference Vegetation Index (NDVI), Normalised Difference Moisture Index (NDMI), and Normalised Burn ratio (NBR), across 987 spatially referenced TERN AusPlots distributed throughout Australia's bioregions. The data were accessed from Digital Earth Australia (DEA) using the DEA Explorer SpatioTemporal Asset Catalogue (STAC) API. The data processing workflow involved retrieving FC and Sentinel-2 imagery for each site, extracting PV data and computing spectral indices, generating cloud- and shadow-free monthly median composites, and time series analysis.

We analysed PV data from January 2010 to November 2024, and NDVI, NDMI, and NBR data from January 2018 to December 2024. Temporal and seasonal metrics were derived including monotonic trends, breakpoints in trends and seasonality, probabilities of change occurrence, and inter-annual variability. The resulting metrics facilitate cross-ecosystem comparisons and support reproducible assessments of long-term vegetation dynamics. To enhance accessibility and interpretability, the results are presented via an interactive web-based mapping platform, allowing users to explore trends and seasonal characteristics of individual sites. This tool serves as a prototype for scalable, open-access infrastructure for environmental reporting, data dissemination, and decision-support applications.

10.5281/zenodo.16392334

Standardised Tools and Data Infrastructure for State and Transition Models

Ellen Rochelmeyer, CSIRO, Peter Fitch, Megan Good, Helen Murphy, Suzanne Prober, Anna Richards, Samantha Munroe, Dayani Gunawardana, Ian Warren

State and Transition Models (STMs) are useful tools to synthesise knowledge of the dynamics, management and restoration of ecosystems. They underpin the Ecological Knowledge System (EKS) which supports Australia's Nature Repair Market. Supported by a collaborative partnership with TERN, STMs are produced using an expert elicitation process combined with multiple other sources of knowledge. This unconventional type of data requires the development of new tools, processes and data infrastructure to ensure consistency, trust, transparency and integrity of the models.

Here, we present the tools and workflow being used to (1) develop STMs, and (2) the datamodel used to store, manage and transfer STM data. We will also discuss the opportunities for improving the tools and infrastructure supporting STM development.

We describe a streamlined workflow that guides ecological experts through the identification of ecosystem states, transitions and drivers which form the STM. The workflow enforces consistent terminology, maintains referential integrity with master data lists and the datamodel, prevents data duplication, and enables automated validation and quality control. The datamodel ensures robust storage, integration and transfer of data to other users or systems. As part of the EKS, the datamodel also facilitates direct integration with the National Biodiversity Assessment System for the Nature Repair Market.

By harmonising expert knowledge capture with robust data standards, these tools establish a scalable foundation for trusted ecological model development, ensuring consistent and comparable synthesis of ecological information across Australia's diverse landscapes.

10.5281/zenodo.16398491

Session 5

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Session 5: **About Data**

Session 5 chair - Professor Albert Van Dijk *Australian National University*

Albert Van Dijk established and leads the Centre for Water and Landscape Dynamics at the Fenner School of Environment and Society.

Professor Van Dijk has authored more than 200 publications including the annual Australia's Environment Report which he initiated in 2015. The report has evolved into a comprehensive annual assessment of the nation's environmental condition, synthesising large volumes of environmental data into accessible insights.

His research often addresses the interaction between vegetation and the hydrological cycle and related processes, such as soil erosion, nutrient cycling, salinity, the surface energy balance, the carbon cycle, fire risk, biodiversity, ecological resilience, and crop growth.

He has a passion for practical, often spatial research applications, including the observation and forecasting of natural hazards, water resources, environmental condition and agricultural production. The theory and technology involved are drawn from environmental science and management, satellite remote sensing, IT, statistics and simulation modelling.

Secure access to Ecosystem Research Data Infrastructure

Anurag Katariya and Gerhard Weis, *Australian Access Federation and TERN Australia*, ***Kerry Mora, Siddeswara Guru***

Collaboration between TERN and the Australian Access Federation (AAF) has significantly improved the streamlined implementation of secure access to TERN's data infrastructure. AAF's federated identity service has enabled a seamless, secure, and scalable user authentication capability, to integrate with the TERN data platforms.

Users can now access TERN tools and services using their institutional credentials, eliminating the need for multiple accounts. The federated identity solution has simplified access to TERN data and services, strengthened data security, and fostered cross-institutional collaboration.

The TERN and AAF partnership exemplifies commitment from national research infrastructure facilities to provide seamless, secure digital infrastructure for research and policy-making.

In this presentation, the AAF will provide an overview of what a federation is and how it enables researchers in Australia to access digital services both nationally and internationally — without managing multiple accounts or credentials. With over 1000 connected services, including many aligned with Earth and Environmental Sciences, the AAF supports scalable Trust and Identity (T&I) infrastructure for the research community.

TERN will share their experience as one of the earliest service providers to integrate with the AAF and other identity service providers, lowering the barrier to using the TERN platform and services without compromising on security. The presentation will highlight the different identity providers that TERN supports and showcase a streamlined process to access TERN platforms and services.

10.5281/zenodo.16398996

Ecosystem Vocabularies: Management and Practices

Junrong Yu, *TERN Australia*, ***Siddeswara Guru, Javier Sanchez Gonzalez, Arun Singh Ramesh, Enzhen Luo, Keion Larson***

The Terrestrial Ecosystem Research Network (TERN) has developed a comprehensive controlled vocabulary management system to address interoperability challenges in ecological data across Australia. Our framework encompasses vocabularies for features of interest, platforms, instrumentation, methods, observable properties, organisations, and administrative regions—creating a unified language for diverse ecological datasets.

Challenges in ecological data integration stem from inconsistent terminology across research groups and disciplines. TERN's solution includes a SKOS-based vocabulary architecture that provides persistent identifiers for each concept, making ecological terms discoverable, reusable, and machine-readable. Our system values community input and balances centralised governance with community input through an innovative dual-track approach. This approach involves expert curation via VocBench for internal stakeholders, ensuring the quality and consistency of vocabularies, and structured community contributions via spreadsheet templates processed through automated workflows. These processes allow for the inclusion of diverse perspectives and ensure that the vocabularies are comprehensive and reflective of the entire ecological research community.

Through publication via Research Vocabulary Australia and implementation in TERN's Data Discovery Portal, we've created a model for ecological data harmonisation that bridges institutional boundaries. Our poster demonstrates how structured vocabulary management transforms fragmented ecological data collections into cohesive, interoperable knowledge resources, sparking a new era of data-driven environmental research. These vocabularies drive harmonisation in Applications such as TERN Data Discovery Portal, EcoPlots, and EcoImages.

10.5281/zenodo.16398784

TERN Data Infrastructure for Ecological Research and Environmental Decision-Making

Siddeswara Guru, *TERN Australia****, Gerhard Weis, Wilma Karsdorp, Arun Singh Ramesh, Yong Liaw, Enzhen Luo, Megan Edward, Keion Larson, Junrong Yu, Tiancheng Lan, Avinash Chandra, Javier Sanchez Gonzalez, Mosheh EliYahu, Guohualing Huang***

TERN provides an integrated, standardised, and openly accessible data infrastructure that facilitates the collection, curation, analysis, and distribution of high-quality ecological and biogeophysical data across Australia's diverse landscapes.

TERN's data infrastructure is built on the FAIR data principles—Findable, Accessible, Interoperable, and Reusable—to ensure that its data sets are not only openly available but also are structured to be of value to researchers, data scientists, government agencies, and other stakeholders. The infrastructure integrates several data streams from ecosystem monitoring sites, automated in-situ sensors (flux towers, phenocams, and acoustic sensors), remote sensing platforms (satellites and drones), and model-derived data. These data products cover a wide range of ecological attributes like vegetation structure, soils, climate variables, biodiversity, biogeophysical metrics, and water and carbon fluxes.

TERN's data infrastructure provides tools and services for effective data lifecycle management. The presentation will highlight TERN's data infrastructure, its capabilities, and its impact, showcasing how an open environmental data infrastructure can drive collaboration, innovation, and effective ecosystem management.

10.5281/zenodo.16399190

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Session 6: **Earth observation and in-situ validation**

Session 6 chair - Dr Ben Macdonald *CSIRO*

Dr Ben Macdonald seeks to improve land management through the measurement of nutrient and water fluxes within agricultural and natural ecosystems. Dr Macdonald's goal is to enable the development of resilient and sustainable agro-ecosystems. Over the last 20 years he has investigated soil nitrogen and carbon cycling in diverse ecosystems, from cotton and sugarcane production systems, semi-arid rangelands to tropical biodiverse Pacific farming systems. This work has focused on quantifying carbon and nitrogen cycling, improving profitability and reducing environmental impacts. Besides working on intensive Australian production systems he has worked with small holder farmers in Vietnam, Tonga, Fiji, Kiribati, Tuvalu and Samoa.

Dr Macdonald is the current leader of the Soil and Landscapes Group within the Sustainability Program of the CSIRO Agriculture and Food Research Unit. The group is aiming to improve resilience and sustainability of Australian and regional agroecosystems. The group will achieve this aim by innovating and collaborating with diverse range of institutions, industries, and people.

Global Airborne Lidar Coordination for GEOTREES

Laura Duncanson

We currently have several satellite missions collecting data relevant to mapping forest biomass, including NASA's GEDI and ICESat-2, ESA's BIOMASS, JAXA's ALOS, and soon NASA/ISRO's NISAR. This wealth of data will yield a large number of differing biomass maps, which can confuse users and ultimately slow down science. At the same time, there is insufficient global reference data to validate these products. GEOTREES is a global initiative aimed to fill this gap. One goal of the GEOTREES airborne lidar group is to develop open source workflows to process airborne lidar data toward local biomass reference maps, and use these maps to validate global EO products. This presentation introduces the GEOTREES lidar concept, and provides an update about the status of new data acquisitions and processing workflows. TERN is a GEOTREES partner, and the TERN lidar model is largely mirrored by GEOTREES, however challenges remain given the large number of countries, plot and lidar configurations collected via GEOTREES. This presentation aims to seed a discussion on how TERN and GEOTREES lidar efforts can be linked moving forward toward biomass product validation in Australia and beyond.

10.5281/zenodo.16556023

Correspondence between remotely-sensed and ground-based vegetation cover change in Australia

Krish Singh

Remotely-sensed measurements are commonly used to identify long-term trends in vegetation greenness and cover, but it is unclear how spectrally-derived insights reflect changes on the ground. We compared the remotely-sensed record of Landsat-derived fractional cover (RS FC) with the fractional cover measured in-situ (in-situ FC) by TERN Ausplots at 735 1-ha sites across Australia. Using field data, the sites were classified by the dominant vegetation growth form: grass, shrub, or tree. We investigated (1) whether the RS FC data show a long-term greening trend; (2) how well RS FC and in-situ FC correspond; and 3) how temporal changes in in-situ FC compare with short-term and long-term trends in RS FC. The RS FC data show widespread greening in Australia over the period 1987-2022. Correspondence between the in-situ FC and RS FC was moderate in the Photosynthetic Vegetation (PV) and Bare Soil (BS) fractions, but weak in the Non-Photosynthetic Vegetation (NPV) fraction. The correspondence was consistently the weakest among the grass-dominated communities. There were systematic biases for PV and NPV fractions, likely due to differences in sampling methodologies between the dataset used to calibrate RS FC and the AusPlots dataset. Changes in FC between in-situ visits were related to seasonal and interannual variability and had no relationship with the long-term trends in cover estimated from RS FC. Our results highlight the challenges inherent in detecting long-term trends in vegetation cover from in-situ monitoring. They also demonstrate the potential for new understanding of vegetation change from integration of in-situ and remotely-sensed monitoring.

10.5281/zenodo.16556040

Geostationary satellite surface-air temperature difference anomaly to detect vegetation stress

Dejun Cai, CSIRO, Tim McVicar, Thomas Van Niel, Randall Donohue, Yuhei Yamamoto, Stephen Stewart, Kazuhito Ichii, Matthew Stenson

Land surface temperature (Ts) can detect plant physiological stress prior to visible greenness decline in droughts via its biophysical linkage to plant transpiration. New-generation geostationary satellites offer unique opportunities to monitor sub-diurnal variations in Ts and track plant physiological processes occurring at sub-daily timescales. Here, we developed a parsimonious Surface-Air Temperature Difference Anomaly (SATDA) method to track vegetation drought stress using the cumulative sub-diurnal difference, from late-morning to early-afternoon, between Ts from Himawari-8 geostationary satellite and gridded hourly air temperature (Ta). We used SATDA to monitor the spatio-temporal patterns of the 2017-2019 Tinderbox Drought in southeast Australia. We analysed the skill of SATDA in forecasting visible drought-induced vegetation greenness decline, and benchmarked it against (i) conventional water availability-based indices (precipitation, soil moisture) and (ii) two satellite Ts-only indices (TCI, TRI). SATDA effectively captured a rapidly intensifying "flash drought" event at multi-week timescales (Jul to Sep 2019) embedded within the broad multi-year drought progression. SATDA showed the best vegetation greenness forecast skill in the transitional semi-arid and sub-humid climates, with forecast correlation > 0.5 at 32-day lead time. Advantage of SATDA over water availability indices was more evident in woody-dominated ecosystems than herbaceous-dominated ecosystems, likely due to the importance of physiological regulations by trees during droughts such as deeper roots and stronger stomatal control. SATDA, based on Ts-Ta, showed overall better vegetation greenness forecasts than two Ts-only indices, especially in woody vegetation. The parsimonious process-based SATDA method suits global-scale operational implementation to complement vegetation drought monitoring and early warning systems.

10.5281/zenodo.16556047

Mapping ecosystem extent in the Great Western Woodlands

Adriana Parra Ruiz, CSIRO, Zheng-Shu Zhou, Matt Garthwaite, Shaun Levick

The Great Western Woodlands (GWW), located in south-western Australia, is the largest temperate woodland ecosystem in the world and is of significant ecological importance due to its high level of biodiversity. Despite having minimal human intervention, the GWW faces threats related to climate change, particularly, increases in aridity and fire frequency. Alterations in the disturbance regime are expected to produce shifts in vegetation composition with possible cascading effects on biodiversity, and carbon budgets. To detect ecological change and inform management strategies, a TERN SuperSite was established in this region in 2012.

In this study, we build on the research goals of the GWW TERN SuperSite by focusing on producing maps of ecosystem extent using Earth Observation (EO) data. We aim to establish baseline conditions of ecosystem extent and design a scalable workflow for map production that can be incorporated into monitoring protocols. To achieve this goal, we incorporated satellite optical and Synthetic Aperture Radar (SAR) imagery from different sources in our analysis and evaluated improvements in classification accuracy through the implementation of different machine and deep learning approaches. Moreover, we evaluated the integration of ground field data and UAV LiDAR acquisitions from the TERN SuperSite into the classification workflow.

We will present our first results of ecosystem extent mapping in the GWW and discuss the challenges of integrating in-situ measurements into the map production workflow, with focus on the preprocessing requirements for scaling the field measurements to the resolution of the EO imagery.

10.5281/zenodo.16556248

Mapping a dynamic vegetation height for Australia

Shaun Levick**, CSIRO, **Catherine Ticehurst, Rakesh Joshi, Shehza Hussain, Stephanie Johnson

Vegetation height and its variation through space and time provides important information for understanding natural ecosystem functions and habitat structure. Along with vegetation height, the sub-canopy structure plays a key role in the level of biodiversity than an ecosystem can support. Monitoring these changes is not only necessary for assessing ecosystem condition, but also important in estimating bushfire fuel loads.

Earth observation data enables the capability to produce nationally consistent vegetation height and monitor its change through time. Satellite LiDAR sensors, such as the Global Ecosystem Dynamics Investigation (GEDI) instrument, measure canopy profiles at discrete points. This can be combined with spatially complete earth observation data to estimate vegetation height across the continent.

The National Bushfire Intelligence Capability (NBIC) supported the development of a vegetation height model using GEDI height to train various datasets, including Digital Earth Australia Landsat annual products, the Advanced Land Observing Satellite-2 (ALOS-2) Synthetic Aperture Radar backscatter, a Digital Elevation Model and climate data through a machine learning algorithm. This model focused on improving low vegetation height estimates, which is important when assessing bushfire fuel loads, compared to existing national and global vegetation height products. Validating with airborne LiDAR and TERN AusPlots showed improved results, however the canopy height of tall vegetation was being underestimated.

Future work through TERN will focus on improving the national scale estimate of vegetation height across diverse ecosystem types. Drone and airborne LiDAR will also be used to develop relationships with national datasets to incorporate vegetation structure into the model output.

10.5281/zenodo.16556379

NASA's Global Ecosystem Dynamics Investigation (GEDI): Australian Cal/Val Activities

***John Armston**, University of Maryland, College Park*

The NASA Global Ecosystem Dynamics Investigation (GEDI) is a geodetic-class laser altimeter that has provided high quality observations of vegetation structure over the Earth's temperate and tropical forests. These are the first set of satellite measurements from an instrument specifically designed to measure canopy structure (height, cover and vertical profile metrics) within a novel, theoretical sampling design that estimates aboveground biomass (AGB) and its uncertainty across a variety of spatial scales. Here we discuss the role that in situ and airborne data available through the Terrestrial Ecosystem Research Network (TERN) has played in the mapping of vegetation structure and AGB over Australia. Highlighting a collaborative multi-agency in situ and airborne data collection campaign undertaken in 2024 at the Injune Study Site in Queensland, we also look ahead to new possibilities enabled by GEDI's next observational epoch alongside the NISAR L-band SAR mission.

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Quantifying Night Sky Brightness as a Stressor for Coastal Ecosystems

Noam Levin**, The Hewbrew University of Jerusalem, The University of Queensland, **Salit Kark, Rachel Madeleine Cooper

Light pollution is increasing globally, having negative impacts on many species in terrestrial and marine ecosystems. While light pollution is increasingly studied in terrestrial environments, research on night lights in coastal ecosystems remains limited. We aimed to complement spaceborne remote sensing with ground-based hemispheric photos to quantify the exposure of coastal habitats to light pollution. We used a calibrated DSLR Canon camera with a fisheye lens to photograph the night sky in the rapidly developing area of Moreton Bay, Queensland, Australia, extracting multiple brightness metrics. We also examined the use of the LANcubeV2 photometer and night-time satellite data from the SDGSAT-1 satellite for coastal areas. We found that the skies were darker in less urbanized areas and on islands compared with the mainland. When examining light pollution horizontally 10–20° above the horizon, we found that the seaward direction was brighter than the landward direction in most sites due to urban glow on the seaward side. These findings emphasize the importance of ground measurements of light pollution alongside satellite imagery. In order to reduce the exposure of coastal ecosystems to light pollution, actions need to go beyond sites with conservation importance and extend to adjacent urban areas. We recommend that monitoring light pollution will be included within Australia's Terrestrial Ecosystem Research Network, developing a ground-based national network of dedicated sensors.

This is especially relevant for Australia's coastal areas, where the majority of the human population resides, and where many critical habitats and threatened species are found.

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Canopy to Groundwater: supporting coastal vegetation mapping through on-ground measures

Christopher Owers, *University of Newcastle****, Gabriel Rau, Rachel McGivern, Jeffrey Kelleway, Rafael Carvalho, Tanya Mason, Warren Brown, Fabienne D'Hautefeuille, Daniel Swadling***

Coastal vegetated ecosystems (e.g. mangrove, saltmarsh, seagrass, supratidal forests) are unique landscapes that provide important ecosystem services to society. At the same time, coastal vegetated ecosystems are vulnerable to the impacts of climate change, including sea-level rise, and shifts in precipitation regimes, as well as impacts from human development. Large scale mapping efforts have provided valuable contributions to identify the current and changing distribution of vegetation in response to impacts. These are well established for mangrove and saltmarsh, and recently for supratidal and coastal lowland forests across Australia. Currently, validation of these maps rely on on-ground occurrence data to establish presence or absence, however knowledge of vegetation condition and long-term resilience of these ecosystems is highly desirable.

To support current and future mapping efforts, on-ground measures, from canopy to groundwater, are required to identify long-term resilience of coastal vegetation condition and its response to changes in key biophysical drivers. However, monitoring and identifying these interactions between vegetation condition and biophysical processes is currently lacking. Emerging research, including our pilot study, demonstrate significant variations in biophysical drivers, such as the interactions of saltwater with fresh groundwater across intertidal and supratidal zones, uncovering gaps in scientific knowledge. Similarly, changes in vegetation structure, function and composition needs to be characterised across space and time, to determine long-term trends. We propose that establishing the first comprehensive coastal vegetation resilience monitoring sites will provide a long-term reference to support large-scale mapping in a similar way to existing TERN long-term surveillance sites.

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Infrastructure for the Earth Observation Community

Ben Sparrow, *TERN University of Adelaide****, Arko Lucieer, Gerhard Weis, Glenn Newnham, Krishna Lamsal, Matt Garthwaite, Megan Lewis, Peter Isaac, Peter Brady, Senani Karunaratne, Shaun Levick, Siddeswara Guru, Stefan Maier, Thomas Van Niel, Will Woodgate***

TERN's infrastructure can assist in the validation of Earth Observation products in many ways. TERN freely provides a range of data and information through all of Australia's major terrestrial vegetation types, including over 1000 accurately collected field plots with detailed soil and vegetation information. TERN recently developed a UAV program to re-visit these plots and collect orthophotography, multispectral imagery and LiDAR data to more frequently track change than is possible with field data alone and scale up field data to satellite products. TERN also supports 12 highly instrumented Supersites that provide far more detailed information on the environments they are located in and are used widely by the Cal/Val community internationally. In addition, TERN provides many hundreds of thousands of environmental samples that can be used for subsequent research, including a program to spectrally scan (400-2500nm) all soil samples. The feasibility of a similar program for vegetation samples is currently being investigated. All of TERN's data and samples are made available to the ecosystem science community free of charge, with all digital data made available based on the FAIR principals.

TERN is working towards provide the Australian Earth Observation community with a comprehensive and trusted source of ecological data, standards, instruments and infrastructure for the validation of satellite imagery and the calibration of associated models. This work will develop and quantify the accuracy of a range of biological and biophysical products to predict where and when environmental change is occurring, from local to continental scales and for the long-term.

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Robson Creek: a TERN tropical rainforest reference cal-val site

Mike Liddell, *James Cook University****, Kim Calders, Shaun Levick***

The Wet Tropics of Far North Queensland is an international biodiversity hot spot with 700+ endemic plants and 49 endangered species. Robson Creek was established by TERN as a reference site in the Wet Tropics in 2013 [1]. As a research infrastructure site the purpose of the site was to track changes in carbon cycling, floral and faunal biodiversity. Prior to the establishment of a 25Ha census plot and OzFlux tower at Robson Creek a long term 0.5Ha monitoring plot was established in 1971 by CSIRO. This talk will provide an update on activities at Robson Creek through the use of census plots and how coupling this with technologies such as flux towers, phenocams, TLS and air-borne laser scanning are enabling the plant community to be tracked through time [2]. Long term highly instrumented, tropical rainforest sites that are rich in multi-scale data are rare. In 2025 Robson Creek has been being embedded into global efforts through GEOTREES, an international network that provides high accuracy cal-val data for satellite derived estimates of biomass. Addressing societal grand challenges such as how biomass and productivity is changing in forests globally require sites such as Robson Creek. The wrap up will indicate future directions for where TERN EP is heading in using technologies such as LEAF scanners at Robson Creek and how important it is to keep classic field-based measurements running alongside newer technologies to provide long time series data.

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Session 7: **Impact stories**

Session 7 chair - Professor Graciela Metternicht *Western Sydney university*

Graciela Metternicht is the Dean of Science and Professor of Environmental Geography at Western Sydney University. She also is an Adjunct Professor at the Earth and Sustainability Science Research Centre of the UNSW Sydney. Prior appointments include as Senior Officer for Environmental Assessments and Early Warning with the United Nations Environment Program, and full professor at UNSW Sydney, University of South Australia, and Curtin University of Technology. She works at the interface of science and policy for ecological sustainable development. With over two decades of experience in applied research, training and as an adviser on environmental management, her skills range from the development of tools and approaches to map and monitor land degradation processes and for land use change to the operationalization of socioecological frameworks for sustainable land management.

Prof. Metternicht has been instrumental in the development of the Conceptual Framework for Land Degradation Neutrality (LDN), implemented in 128 countries and central to the UN Sustainable Development Goal of Life on Land. She has authored or co-authored over 200 scientific reports and publications and is the author of the book "Land Use and Spatial Planning: Enabling Sustainable Management of Land Resources", which informed the first edition of the Global Land Outlook.

Metternicht's working experience spans over five continents. During her academic career, she held advisory roles in Australia and internationally, including Chair of the NSW Biodiversity Conservation Advisory Panel; Chair of the Australian Academy of Science Committee for Geographical Science, Australian Research Council College of Experts; Board Member of the Western Australia Land Information System; Global Environment Facility Scientific and Technical Advisory Panel (Land degradation and Ecosystem Restoration); Science-Policy Interface member of the UNCCD; 6th Global Environmental Outlook Assessment Methodology Group; Scientific Steering Committee of the Future Earth Global Land Programme.

Operationalising AusEFlux: Monitoring of Australia's Terrestrial Carbon and Water Fluxes

Chad Burton, *Geoscience Australia****, Albert Van Dijk***

AusEFlux (Australian Empirical Fluxes) is a set of high-resolution (500 m) gridded datasets that estimate Net Ecosystem Exchange (NEE), Gross Primary Productivity (GPP), Ecosystem Respiration (ER), and Evapotranspiration (ET) across Australia from 2003 to the present. Initially developed for research, AusEFlux has been transformed into an operational workflow to support continuous monitoring of Australia's terrestrial carbon and water cycles.

This workflow integrates eddy covariance (EC) measurements from TERN's OzFlux network with openly available remote sensing and meteorological data. Leveraging TERN's data infrastructure, standardised EC datasets, and machine learning methods, the system enables the ongoing production of high-resolution flux estimates. It also allows for the rapid integration of new EC data and the incorporation of improved or additional feature layers, supporting continuous refinement of the products.

AusEFlux provides an important resource for researchers, offering data to benchmark land surface models, assess ecosystem responses to climate variability, and inform carbon accounting and climate mitigation strategies. The datasets underpin key indicators in TERN's annual Australia's Environment report, including national-scale estimates of GPP and NEE, which contribute to the Environmental Condition Score, a composite metric of national environmental health.

Openly accessible via the National Computational Infrastructure, AusEFlux exemplifies the power of coordinated national data infrastructure in advancing ecosystem science.

10.5281/zenodo.16923216

Tracking Australia's Biocomplexity: Towards a National Invasive Species Index

Tayla Lawrie, *TERN Australia****, Sarah McGrath, Geoffrey Heard***

Australia's biodiversity is under increasing pressure from a range of threats, including invasive species. While national-scale indices such as the Threatened Species Index (TSX) provide important long-term trend information to researchers, the public and government, the development of such data products has primarily focused on threatened species. This presentation explores the potential to expand efforts at the Terrestrial Ecosystem Research Network (TERN) to include an Invasive Species Index, drawing on insights from the development of the TSX. First, we provide a brief overview of the TSX and introduce a conceptual model for an Invasive Species Index. Using the TSX as a reference point, we then explore several key challenges likely to arise in building a complementary index. These include nomenclature inconsistencies, taxonomic and spatial data gaps, siloed monitoring and data management, and hesitancy around data sharing.
In considering the feasibility and value of an Invasive Species Index, we highlight the importance of not developing or using such indices in isolation. By linking national-scale indices for both threatened and invasive species, Australia can build a more holistic, ecosystem-wide understanding of biodiversity trends. This integrated approach can support more informed conservation decisions, help answer critical research questions and deepen our understanding of biocomplexity in a changing Australia.

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Recent innovation and improvements in the Habitat Condition Assessment System

Glenn Newnham, CSIRO, Kristen Williams, Roozbeh Valavi, Simon Collings, Katherine M Giljohann, Eric A Lehmann, Shaun Levick, Ning Liu, Samantha Munroe, Neil Sims, Elizabeth J Botha, Dayani Gunawardana, Geoff Hosack, Claus Joehnk, Stephanie Johnson, Cassandra Malley, Matthew Paget, Anna Richards, Ross Searle, Poornima Sivanandam, Sally Tetreault-Campbell, Thomas Van Niel, Peter Lyon, Simon Ferrier

The Habitat Condition Assessment System (HCAS) is an innovative framework designed to provide reliable, robust, consistent and repeatable assessments of terrestrial habitat condition at a national scale. Since 2015, CSIRO has been developing HCAS in collaboration with the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW). HCAS is a remote sensing-based monitoring approach to condition assessment that provides site-level estimates of habitat condition benchmarked against high ecosystem integrity reference sites.

The HCAS data collection follows FAIR (Findable-Accessible-Interoperable-Reusable) principles, and includes a time series of short-term epochs derived from three years of remote sensing data for each year from 1990 to 2024, the National Connectivity Index which uses HCAS as an input, as well as input data used in developing HCAS and supplementary data to support use.

The 2025 release of HCAS (v3: https://data.csiro.au/collection/csiro:63571) incorporates substantial advancements to enhance accuracy and utility for a range of applications. This includes a finer spatial resolution (90m) and longer time series (1988-2022), achieved by replacing MODIS with Landsat data, incorporating products generated by Geoscience Australia, new environmental data developed by TERN, and a revised approach to delimiting locations of 'reference' sites.

Technical innovations in software development and workflow management using high performance computing have substantially reduced run times, and minimised manual intervention in processing, enabling bootstrapping to provide 95% confidence intervals from model-based uncertainty quantification.

We describe technical details and advancements of the method, briefly point to current applications, and outline where future improvements are needed to address known limitations.

10.5281/zenodo.16923262

Science and knowledge to support the Nature Repair Market

Peter Lyon, DCCEEW, Ian Warren, Dayani Gunawardana

The Nature Repair Act 2023 (the Act) establishes a framework for a voluntary national biodiversity market including requirements for transparency and integrity. This includes requirements designed to ensure that biodiversity projects registered in the market are evidence-based and will deliver positive outcomes for biodiversity.

The first Nature Repair Method, made in February 2025, is supported by the Ecological Knowledge System (EKS). Established by DCCEEW in partnership with CSIRO, the EKS establishes a transparent and authoritative source of information and biodiversity assessment capability for the Nature Repair Market. The EKS draws upon TERN data and infrastructure including: the National Ecosystem Assessment System (NEASA) to support development of ecosystem models that synthesise knowledge about the dynamics, management and restoration of ecosystems; and TERN environmental covariates used in the Habitat Condition Assessment System (HCAS) supporting a nationally consistent approach to biodiversity assessment within the EKS.

10.5281/zenodo.16923330

The fate of low elevation coastal mangroves under sea-level rise

Vicki Bennion, TERN Australia

Seaward fringing mangroves that occur at mean sea level are at future risk of loss and degradation unless they can vertically accumulate soil surface elevation at the same or higher rates than sea-level rise. Mangrove mortality from extreme weather events can however interrupt the maintenance of soil surface elevation, and its resilience to sea-level rise. In Quandamooka, extreme weather events resulted in the toppling of several large individuals of Avicennia on the edge of Eprapah Creek where surface elevation tables had previously been installed. Using these surface elevation tables ~30m away from the damaged trees, we monitored changes in surface elevation for two years. Surface elevation in the mangroves declined by 26.3 ± 3.59 mm year-1 following severe storms in early 2021, and by 9.11 ± 9.46 mm year-1 following flooding events in early 2022. Accumulation of sediments observed upon the surface were positive indicating that below-ground processes were responsible for the decline in soil surface elevation. Losses in surface elevation from extreme events as observed within these mangroves could result in mangrove fringes that are unable to maintain their elevation relative to sea-level rise, leading to enhanced vulnerability to sea-level rise and the eventual retreat of mangroves and subsequent transition to unvegetated mud flats.

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Session 7

The Ecological Monitoring System of Australia – standardised methods to track environmental change and inform decision-making investments

Sally O'Neill, *TERN University of Adelaide****, Ellen Kilpatrick, Luke Derby, Megan Jenssen, Mark Laws, Jin Zhou, Katie Irvine, Andrew Tokmakoff, Ej Henderson, Amelia Cook, Jacqueline De Chazel, Ashley Leedman, Ben Sparrow***

The Australian Government makes significant investments to improve the stewardship of Australia's environment and the sustainable management of natural resources. On-ground actions aim to improve or restore natural ecosystems and the diverse species they support, including threatened and unique taxa. Ideally, government investments are directed towards highly effective activities that result in positive conservation outcomes. Quality scientific data is critical not only to improve our understanding of the effectiveness of funded actions and their impact on species and ecosystems, but also to track climate-driven change, and enable policy-makers to make informed decisions.

The Ecological Monitoring System of Australia (EMSA) is a collaboration between the Terrestrial Ecosystem Research Network (TERN) and the Australian Government. EMSA provides the infrastructure, tools and resources to support data collection, analysis, and evaluation, meeting the national requirement for a streamlined, consistent, automated, and robust ecological monitoring system.

EMSA builds on TERN's history as Australia's terrestrial ecosystem observatory. EMSA's consistent standardised observation methods provide on-ground practitioners with a modular suite of standardised survey protocols, comprehensive instruction manuals, a field data collection app, and a centralised data management and storage system for the Biodiversity Data Repository. Ongoing support is provided via a help desk, community of practice, training and outreach activities.

EMSA is being delivered across Australia by partners funded and is being considered for other future Australian Government programs. As a result, an Australian-wide network is being strengthened, generating invaluable, science-rich data that improves our understanding of ecosystem restoration and climate change impacts and supports our planning, decision-making, and reporting of investment programs.

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Harnessing TERN Infrastructure for Open Data: VegMachine Case Study

Rebecca Trevithick, *Department of the Environment, Tourism****, Science and Innovation, T Beutel, R Denham, Gerhard Weis, P Scarth***

VegMachine© is an innovative online platform that transforms satellite-derived vegetation and rainfall data into interactive time-series visualisations. VegMachine provides several tools for extracting, summarising and visualising numerous massive, dense timeseries products including fractional cover, ground cover, burnt area mapping, and persistent green for selected eastern states for Sentinel-2 products, and national data for Landsat products.

Developed by the Joint Remote Sensing Research Program (JRSRP), in conjunction with The Queensland Government (DETSI and DPI), VegMachine.net was first released in 2016 and has recently undergone a significant upgrade. The platform is underpinned by Terrestrial Ecosystem Research Network (TERN) infrastructure managed by the Queensland node at the University of Queensland which also stores and makes accessible the state and national data products produced by DETSI and the JRSRP. VegMachine relies on TERN for scalable storage and data delivery mechanisms, which enables VegMachine to handle the massive time-series datasets which it uses as input. Outputs are delivered via Cloud Optimised GeoTIFFs (COGs) and web mapping services. This system ensures rapid, reliable access to data, overcoming challenges associated with the size and complexity of satellite-derived products.

VegMachine has had a significant impact delivering data to a wide audience across Australia. VegMachine is used by extension officers, researchers, and policymakers with approximately 300 regular users located in all Australian states. VegMachine has been referenced as a data source in over 30 peer-reviewed journals across fields such as carbon accounting, ecology, hydrology, and grazing management. All VegMachine datasets are available under Queensland Government open data policies, and the platform ensures free public access, fostering widespread adoption and supporting evidence-based decision-making for sustainable land management.

10.5281/zenodo.16923373

The Habitat Condition Assessment Tool: Improving understanding of Australia's ecosystems

Samantha Munroe, CSIRO, Kristen Williams, Katherine M Giljohann, Geoff Hosack, Anna Richards, Peter Brenton, Jack Brinkman, Simon Checksfield, Joseph Salomon

Reliable on-ground assessments of habitat condition are essential for managing Australia's wildlife and ecosystems. Ecological scientists and practitioners possess invaluable knowledge, yet expert assessments are often fragmented and difficult to collect. Additionally, no universal method exists for measuring 'ecosystem condition'. While empirical data on ecosystem characteristics provide insight into structure, composition, and function, interpreting these data requires subjective decisions, making national integration challenging. Originally piloted in 2018, the Habitat Condition Assessment Tool (HCAT) is a web-based platform designed to provide a nationally consistent approach for gathering expert assessments of ecosystem condition while accounting for natural subjectivity. Hosted by the Atlas of Living Australia, HCAT enables ecological experts to delineate familiar areas using an interactive mapping interface and contribute site-level condition scores. Scores are defined as a departure from reference and benchmarked against extreme endpoints: 0 (completely removed habitat) and 1 (high ecosystem integrity, pre-European colonization). Experts also assign condition scores to landscape images to calibrate site assessments across peers. Rather than eliminating subjectivity, HCAT recognizes expert judgment as fundamental to assessing ecosystem condition. We assert that subjectivity in empirical measurements is comparable to intuitive scoring by well-informed experts. HCAT is re-launching with improved usability and capabilities. We are now seeking contributions across Australia to establish a national library of site condition assessments. Data will be used to enhance validation and calibration of remotely-sensed condition assessment and contribute to improved forecasting for applications such as the Nature Repair Market with estimates of habitat rarity and the impacts of restoration on connectivity.

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Session 8: **About the future**

Session 8 chair - Jill Penridge *TERN Australia*

Jill Penridge is Associate Director (Operations) at TERN Australia, where she leads the operational strategy to support ecological monitoring research infrastructure across the country. With over 20 years' experience in the higher education and legal sectors, Jill specialises in enabling research through integrated approaches to governance, project delivery and strategic partnerships. She has held senior leadership roles at The University of Queensland as well as successfully operating within other regional and hybrid universities, with a background spanning research operations, institutional strategy and commercial negotiations. Jill is known for her pragmatic, customer-focused mindset in delivering complex, multi-stakeholder initiatives. In any spare time, you'll find her in traipsing through a hinterland rainforest or paddling around Mudjimba Island.

Richer Forecasts from Repeated Measures: A Bayesian Multivariate Approach

Karunarathna K. A. N. K., *University of Queensland*

In forecasting applications, repeated measurements from multiple experimental plots or replicates are often aggregated typically via sums or average into a single time series to simplify modelling and improve predictive reliability. However, this aggregation can obscure important variability and distributional features present in the original data. Summary statistics such as the minimum, maximum, and key quantiles (e.g., quartiles, median) may capture meaningful aspects of the system's behaviour, including extremes and distributional shifts, which are lost when using only aggregate measures.

This study proposes a multivariate modelling framework that retains and leverages this additional information. Using rodent abundance data collected across multiple sampling plots, I construct a multivariate response vector of different types comprising the minimum, first quartile, median, third quartile, maximum, mean, and sum of the repeated measures. These derived features capture additional perspectives of the underlying process and enrich the forecasts.

To jointly model these mixed-type responses while accounting for their temporal dynamics and interdependencies, I employ a Bayesian multivariate autoregressive models, estimated via Hamiltonian Monte Carlo (HMC) in Stan. Results show that this multivariate modelling approach improves both inferential and forecasting aspects compared to traditional aggregation approaches. This framework provides a flexible and effective strategy for leveraging information from repeated measurements in forecasting applications.

10.5281/zenodo.16923522

The AMRF Mountain Observatory as a Forecasting Tool for Climate Resilience

Nathan Battey, *Australian Mountain Research Facility*

Australia's high mountain ecosystems face accelerating risks from compounding climate stressors, including warming, altered precipitation, and land-use change. The Australian Mountain Research Facility (AMRF) provides a modular, multi-site platform for environmental monitoring and climate scenario experimentation across these sensitive landscapes. AMRF enables long-term forecasting and modelling of ecological processes that underpin carbon storage, hydrological regulation, and regional biodiversity.

AMRF supports predictive science through high-resolution time series of meteorological data and field-scale experiments that simulate future climate conditions AMRF datasets, soon to be available on the TERN data portal, include an eddy covariance flux tower, soil moisture profiles, phenocam imagery, and fine-scale climate records. These observations are informing research across disciplines and institutions to predict how processes within mountain systems (including snowpack dynamics, groundwater pathways, and soil–vegetation interactions) respond to environmental change. AMRF's design supports spatial comparison and modular deployment, offering a transferable framework for expanding mountain research and informing regional adaptation.

In addition to monitoring infrastructure, AMRF supports experimental manipulations. For example, the FutureClim plots provide infrastructure to assess compound heat–drought treatments on the intact native community and to assess the resilience of transplants. A novel set of mobile heatwave chambers can be used to simulate heatwaves in situ. Data arising will contribute to informing strategies for restoration and management.

AMRF aligns its research with evolving land management priorities by linking observation to simulation and experimentation to decision-making. The facility acts as both an observatory and a forecasting engine—informing adaptive strategies for ecosystem stewardship in a time of rapid change. This presentation highlights how researchers are making use of AMRF's infrastructure and datastreams to explore collaboration opportunities and co-develop new applications that ensure Australia's mountain regions are not just monitored—but understood, modelled, and protected.

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Simulating and sampling species assemblages across environmental gradients

Drew Terasaki Hart, CSIRO, Simon Ferrier, Andrew Hoskins

Spatial patterns of biodiversity are of core interest to ecology and biogeography. Various forms of data are derived from spatially located observations of species and are used to study biodiversity patterns, ranging from comprehensive censuses of the relative abundances of all detectable species, to presence/absence records for a range of species, to presence-only records often derived from opportunistic observations. Universal methods (e.g., generalized dissimilarity modeling (GDM)) are often applied to all such data, but we lack a comprehensive understanding of the sensitivity of the performance of these methods to the type and structure of the data. We present a user-friendly Python-based framework for simulating both environmentally driven community composition patterns and the effect of different observation processes on the data we rely on to model these patterns. We then share a series of analyses to demonstrate the utility of our software for: 1.) simulation of multiple types of observation datasets from the same underlying community composition patterns; 2.) assessment of method performance as a function of data type; and 3.) assessment of the ability of a method to detect shifts in community composition that are driven by environmental change. We anticipate that this open-source and easily installed software will prove useful for a range of applications in community ecology, biogeography, and biodiversity studies, and we hope to continue developing and extending it to meet the emerging needs of the broader research community.

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Challenges of unlocking and sharing a century of ecological data

Alison Specht, TERN Australia, Miranda Fittock, Wilma Karsdorp, Arun Singh Rahmesh

Results of research funded by public agencies should be openly available and usable by others, i.e. comply with Findable, Accessible, Interoperable and Reusable (FAIR) principles in a secure open repository, preferably domain specific. Furthermore, in order to sustainably manage and conserve our natural heritage long-term, systematically collected and available data are needed. Researchers commonly work, however, in the short-term, within the timescales of grants and their employment. Such work rarely extends beyond these short timescales and seldom is made available in a timely and reusable fashion.

Recently the authors have been involved in re-curating a large dataset of observations from a century old enclosure in semi-arid Australia. This enclosure was reserved in 1925 and fenced in 1926 to prevent rabbits, sheep and 'other vermin', by Prof. TGB Osborn at the University of Adelaide. A variety of biodiversity measurements have proceeded since that date. Over this time several comprehensive temporal analyses were conducted, but it was not until 2014 that the data were digitised and preliminary data made available through TERN. It is these data that we now are making available for re-use in a fashion that will provide a valuable benchmark for today and for the future.

The quality and wide availability of such measurements allows integration with other data types, such as climate and remotely sensed data. These 'points-of-truth' provide the basis for model-training. The application of AI and ML will enhance analysis while the addition of new monitoring tools will complement base-line measurements and vice versa.

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Next-generation of SLGA: space-time mapping, visualisation of soil organic carbon

Sebastine Ugbaje, CSIRO, Brendan Malone, Ross Searle, Chiara Pasut, Ben Macdonald, Senani Karunaratne

The Soil Landscape Grid of Australia (SLGA) is a foundational resource for soil information, supporting a wide range of applications, from national greenhouse gas inventories to biogeochemical modelling. Since its establishment in 2014, the SLGA has undergone a major update completed in 2023, expanding its coverage to include additional soil attributes and functions. While the SLGA has made significant progress, its capacity to represent spatio-temporal variation remains limited. This has highlighted the growing need for soil information aligned with specific timeframes in order to determine temporal soil change. Emerging technologies, new spatial data streams, and advances in modelling and interpretive functions are now enabling broader integration of spatio-temporal dynamics into the SLGA mapping system. In response, we are harnessing these developments through a space-time modelling framework to generate annual estimates of soil organic carbon (SOC) stocks (0–30 cm) from 1990 to 2018 at a 90 m resolution across the Australian continent. The model integrates a suite of covariates, including dynamic environmental variables (e.g., vegetation, climate) and static terrain features (e.g., slope, elevation). The evaluation of the model on a test set was satisfactory. To improve accessibility and user engagement, we developed an interactive application that allows users to visualise and generate the SOC trends and time series for any specific locations or custom-defined regions. Future work will expand this framework to additional dynamic soil attributes, such as pH, and across standard depth intervals. Once incorporated into the SLGA, these enhancements will significantly advance soil health monitoring and trend analysis capabilities.

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Poster session chair - Eleanor Velasquez *TERN Australia*

I am a dedicated advocate for education, scientific communication, and research, utilising the power of storytelling to make scientific knowledge accessible to all. I have experience in ecological research, theatre, policy development, community consultation, educational theory and practice, and university and school teaching. As a registered teacher and former lecturer at Griffith University and Queensland University of Technology, I have a deep commitment to fostering learning and understanding.

Currently, I am leading the development of the TERN Australia education strategy and modules, which aims to democratise access to Australia's most comprehensive ecosystem monitoring data through transformative data-driven learning experiences for diverse audiences from primary school students to industry professionals. I am also collaborating on the Forest Art Intelligence (FAI) Project, an innovative research project and artwork integrating art practice with forest regeneration at the Samford Ecological Research Facility. This work positions regenerating woodland as a 'meta-artwork' embedded with evolving Art Intelligences, challenging traditional conservation narratives by emphasising non-human agency and the interconnectedness of ecological and cultural systems.

Mapping small waterbody dynamics in North-West Queensland using High-Resolution Satellites

Keleisha Moore, *James Cook University*, ***Ben Jarihani***

The accelerating impacts of climate change are intensifying the hydrological cycle, driving increased demand for high-resolution satellite imagery (HRSI) in water-based applications. While these tools are commonly employed for managing large-scale water bodies such as reservoirs, dams, and anthropogenic river systems, small water bodies (SWBs) in semi-arid rangelands are often overlooked despite their critical ecological importance.

This study investigates the accuracy of optical satellite imagery in extracting surface water area for SWBs with a minimum size of 10 m^2. Using the Flinders and Gilbert catchments in Queensland as a case study, Landsat (30 m pixel), Sentinel-2 (10 m pixel) and Planet Explorer (3 m pixel) imagery were overlaid and compared to assess total area coverage and the number of detected water bodies for catchment scale monthly dynamics. At a finer scale, all three products were analysed across 50 sites monthly throughout 2024 to capture dynamic shrink-swell patterns of SWBs. These sites include ephemeral water bodies in an anastomosing river system, farm dams, and abandoned mine pits, selected based on diverse geometry, depth, bathymetry, and vegetation characteristics.

For ground-truthing, drone-captured imagery with a resolution of 2 cm per pixel will be used at selected sites to validate surface water area estimations. The results will provide a detailed linkage between small- and large-scale hydrological systems, showcasing the utility of HRSI for managing ecologically significant SWBs in semi-arid rangeland environments. This comprehensive approach will advance the role of HRSI in addressing water resource challenges exacerbated by climate variability.

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Contribution of deadwood decomposition to ecosystem level carbon fluxes

Baptiste Wijas, *Cary institute of Ecosystem Studies*, ***Habacuc Flores-Moreno, Amy Zanne***

Deadwood represents ~8% of global forest carbon (C) stocks and its decay is a major driver of C cycling. Despite deadwood being an important source of C as it decomposes, little is known of its contribution to the total flux of C within ecosystems. Deadwood C stocks constantly change through time and can become especially large after disturbance events such as windstorms, fires or beetle outbreaks. Understanding deadwood decomposition rates through time is crucial to better understand total contribution of deadwood decomposition to ecosystem C budgets. Towards this goal, I set up a wood decomposition experiment across six climatically diverse TERN SuperSites. This experiment builds off a similar protocol used 8 years ago at all TERN SuperSites and at a total of 133 sites globally, value adding by putting in additional wood pre-treatments simulating fire or flooding exposure. Further, it provides an additional set of deadwood decomposition measures for six SuperSites. To better understand Australian carbon stores, I also repeated measurements of deadwood C stocks at the six SuperSites to characterise temporal changes in deadwood C stocks. Next, I plan to combine temporal dynamics in deadwood decomposition rates and C stocks with flux tower measurements to build a more accurate picture of deadwood contribution to total ecosystem C emissions through time. By combining field experiments with flux tower measurements, I will increase understanding of ecosystem C cycling improving modelling of deadwood in process-based Earth System models. This knowledge can be used to better predict future C emissions from natural ecosystems.

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Posters

Tiny Engineers, Big Impact: Modeling Termite Biogeochemical Ecosystem Processes

Umar Farooq, CSIRO, Chiara Pasut, Ben Macdonald, Senani Karunaratne

Termites are key ecosystem engineers influencing soil nutrient cycling and GHG dynamics in terrestrial ecosystems, particularly in tropical and semi-arid regions. Despite their well-documented biogeochemical importance, termite-mediated processes are often neglected in soil biogeochemical cycling models. In this study, we present a novel modelling framework that mechanistically integrates termite activity with soil processes to better represent carbon transformations and stabilisation and methane (CH_4) dynamics in terrestrial ecosystems. We propose to develop a new module to represent key termite-driven activities such as litter decomposition, organic matter redistribution, and CH_4 production and oxidation in termite mounds which will be parameterised using experimental and field datasets. Initial model development efforts focus on defining reaction network, defining termite-driven source and sink terms, and calibrating them against observed CH_4 fluxes and soil organic matter transformations in selected ecosystems in Australian landscapes. By embedding termite-driven biogeochemical pathways within the broader soil-atmosphere interface, this framework aims to quantify termite contributions to carbon budget under diverse climatic and land-use scenarios. This framework will enable exploration of the termite impact on soil carbon dynamics and long-term stabilisation, climate change feedback, and ecosystem functioning. The proposed integration lays the groundwork for future integration with ecosystem and land surface models, improving regional and global estimates of carbon and CH4 emissions for greenhouse gas inventories.

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The Threatened Species Index: Tools Supporting Australia's Threatened Species Conservation

Sarah McGrath, TERN Australia, Tayla Lawrie, Geoffrey Heard

Up-to-date and comprehensive information on population trends is crucial for many aspects of conservation planning for Australia's threatened species, including listing processes, prioritisation analyses, and designing and evaluating the impact of conservation actions. The Threatened Species Index (TSX) is an internationally bench-marked tool to aggregate data and provide reliable and robust measures of change in the relative abundance of Australia's threatened and near-threatened species at national, state and regional levels. The tool is used by government, non-government organisations, conservation practitioners and researchers across Australia. The TSX tool has so far been applied to develop trends from discoverable data related to plants, mammals, birds and frogs and continues to expand, integrating additional monitoring datasets from across the country each year into a centralised database. The 2024 release of the index included data on 335 taxa within the existing 4 groups, with more groups to be added in the coming years. In this poster presentation, we will explore the data management and analysis tools that form the TSX, specifically, our Trend Visualiser Tool and the Data Management Interface. We will demonstrate the features and benefits of these tools for both data providers and users. Finally, we will highlight how the TSX is being used by governments and others to support their conservation management of Australia's most imperilled species.

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Harnessing TERN Data for Smarter Ecosystem Models

Zac Pentecost, DCCEEW, Wes Davidson

As a result of a review of the National Vegetation Information System (NVIS), a pilot project was established in 2024 which uses vegetation plot data, remote sensing and machine learning to enhance the predicting of vegetation communities. Investigating approaches from different jurisdictions, 20 pilot sites were chosen around Australia to test whether a model could reproduce structural and species information to recreate NVIS requirements. This presentation highlights the lessons we've learned to date and underscores the importance of integrating TERN data in the development of the NVIS model as it combines species, height and cover (structure).

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The National Vegetation Information System Roadmap

Sarah Maunsell, DCCEEW, Wes Davidson

In February 2025 Environmental Information Australia released the National Vegetation Information System (NVIS) Roadmap. NVIS is a trusted national vegetation dataset that serves as a fundamental resource for understanding and protecting Australia's natural biodiversity and ecosystems. The department reviewed NVIS data in 2024 following stakeholder engagement which included representatives from TERN. This revealed barriers to using the data and new user requirements. The NVIS Roadmap sets out these findings and a plan for updating the data. This presentation will provide an overview of the creation of this roadmap including how this will ensure that the NVIS remains a trusted environmental dataset.

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Python library to access the TERN flux data collections

Siddeswara Guru, TERN Australia, Yong Liaw, Gerhard Weis, Peter Isaac, Ian McHugh, Deva Vengadasalam

The Australian Terrestrial Ecosystem Research Network collects data from eddy covariance flux towers, processes it, and makes the data available for use in NetCDF format from the OPeNDAP server. The time-series data is processed every six months and published in NetCDF format. Each flux tower's data is published as a separate file, with data collected at 30-minute intervals over several years.

Integrating data across multiple sites presents a challenge, and users must understand the NetCDF format to query and access data effectively. To simplify easy access to TERN flux data, the Python library is designed to abstract the complexity of NetCDF and the underlying data services. The terndata.flux package enables users to directly interrogate flux datasets hosted on the TERN OPeNDAP server, eliminating the need to download the dataset and providing easy and fast access to data over the network. Specifically, it provides a set of library functions to discover the sites of collections, interrogate datasets on data variables, attributes, and temporal coverage, and facilitate fast data access using Python's Xarray. The library will enable the use of Python's SciPy ecosystem (i.e., NumPy and Pandas) for numerical computing. It also provides subset functionality, allowing for a subset of the dataset based on specific data variables and a specified temporal coverage period. Other functionalities include exporting data in Excel or oneFlux formats, as well as time-series plots and fingerprint plots for an overview of the data.

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Spatial Data Management at Scale: TERN's Approach

Siddeswara Guru, TERN Australia, Gerhard Weis, Tiancheng Lan, Enzhen Luo

A substantial part of TERN's geospatial data holdings are regional and continental-scale raster datasets, complemented by high-resolution drone imagery and LiDAR datasets. Often, these datasets form a time series over multiple decades. The large volume and size of these datasets provide significant challenges in data movement, processing, publication and visualisation. The solution should be robust enough to support effective management and enable users to discover, visualise, and access data easily.

The poster will showcase how TERN is developing a spatial data infrastructure to support scalable and interoperable data services. The geospatial infrastructure utilises the GridFTP service provided by QRISCloud to transfer data from data providers to the Network File System (NFS) and subsequently to ARDC NeCTAR Swift storage in cloud-native file format, Cloud-optimised Geotiffs. After additional data validation, raster data will be published as an OGC-compliant Web Mapping Service and Web Coverage Service, accompanied by ISO 19115-3 compliant metadata that includes descriptions, citation information, platform and instrument details, methods, and additional information. In addition, the STAC catalog is created to enable users to discover, interrogate, visualise and easily access data on demand.

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Seven Years of the Australian Threatened Species Index: Achievements, Lessons, and Future Directions

Tayla Lawrie, TERN Australia, Sarah McGrath, Geoffrey Heard

Efforts to reduce species extinctions are advancing globally. Effective conservation planning for threatened species relies on up-to-date and robust information on population trends. Yet, until recently, Australia had limited infrastructure for collating the required data and consistently producing and reporting on threatened species trends. The first of its type in the world, the Australian Threatened Species Index (TSX) provides reliable and robust measures of changes in the relative abundance of Australia's threatened and near-threatened species at national, state, and regional levels. In this presentation, we will highlight the TSX's progress over the past seven years, including its expansion to cover more taxonomic groups and broader spatial coverage, the development of tools for data sharing and management, and its growing adoption by government and national reporting bodies. What began as a proof-of-concept for birds now includes mammals, plants, and frogs, with data contributed by hundreds of conservation groups, government agencies, and citizen science initiatives. We will reflect on key lessons learned in developing and scaling the index, identifying both successes and ongoing challenges. Finally, we will outline our vision for the TSX's future, including plans to expand data coverage, refine analytical methods, and further establish the index as Australia's central repository of threatened species abundance data, supporting data-driven conservation action.

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Translating Complexity: TERN's Bridge to Ecological & Environmental Understanding Through Education

Eleanor Velasquez, *TERN Australia****, Beryl Morris***

Science shouldn't finish when we hit 'publish' on a research paper. True scientific impact happens when knowledge moves from journals to classrooms, from laboratories to living rooms, from data to decisions. TERN's education philosophy centres on completing this scientific journey by democratising access to Australia's rich ecosystem monitoring data through transformative, data-driven learning experiences that bridge the gap between complex environmental and ecological science and practical application.

Recognising the urgent need for adaptive, innovative societies capable of addressing 21st-century environmental challenges, TERN's educational approach employs a three-tiered framework (beginner, intermediate, advanced) that enables learners to self-define their engagement level regardless of background or affiliation. The philosophy emphasises modular, self-paced learning that translates TERN's extensive monitoring networks and standardised data into accessible educational materials, ensuring environmental science reaches the communities that need it most.

This approach directly supports TERN's mission to advance ecosystem science by creating pathways for diverse audiences, from F-12 students to industry professionals, to understand, navigate, and apply environmental monitoring data. The educational framework facilitates free-choice learning opportunities that enable individuals to easily access, use, and contribute to TERN data-products according to their needs and interests.

Through comprehensive modules, TERN's philosophy transforms complex datasets into meaningful learning experiences that develop transferable skills whilst fostering environmental stewardship. This strategy ultimately aims to enhance scientific literacy throughout the broader community, ensuring the next generation is equipped to contribute to sustainable environmental management decisions.

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