TERN 2023 SCIENCE SYMPOSIUM

26-27 JULY

Book of Abstracts

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tern Ecosystem Research Infrastructure

NCRIS National Research Infrastructure for Australia An Australian Government Initiative

Program

Day 1 Wednesday 26 July 2023

Tea and Coffee served from 08:00 am	Time	Location	Page
Beryl Morris Housekeeping	08:30 - 08:35	Auditorium 1	1
Hugh Possingham Acknowledgement of Country Why are we here and what are the end goals?	08:35 - 08:45	Auditorium 1	1
Andrew Campbell Opening remarks	08:45 - 09:00	Auditorium 1	1
Session 1: *Environmental scenarios, forecasts and predictions* Chair: Belinda Medlyn Presenters: David Hamilton, Jurgen Knauer, Lucia Morales-Barquero, Jo Owens, Matt Stenson, Kristen Williams, Will Woodgate	9:05 - 10:20	Auditorium 1	2
Morning Tea	10:20 - 10:45	The Terrace	
Session 2: *Evidence-based environmental decisions* Chair: Megan Lewis Presenters: Geofrey Heard, Donald Hobern, Peter Johnson, Cassandra Malley, Nicolas Rakotopare, Mohammad Taghadosi, Tim Wardlaw, Eleanor Velasquez, Jenny Wang	10:45 - 12:45	Auditorium 1	6
Lunch	12:45 - 13:45		
Poster Presentations Presenters: Mark Grant, Cho-Ying Huang, Kerry Mora, Sally O'Neill, Abbey Yatsko, Peter Zund	13:15 - 13:45	The Terrace	10
Session 3: *Land management for sustainable ecosystem services* Chair: Tim Wardlaw Presenters: Maree Bowen, David Chittleborough, Will Edwards, Eriita Jones, Beng Umali, Shuangxi Zhou	13:45 - 15:00	Auditorium 1	13
Light Afternoon Tea	15:00 - 15:30	The Terrace	
Session 4: *Biodiversity stewardship* Chair: Matthew Luskin Presenters: Thomas Baumgartl, Celine Frere, Salit Kark, Michael Liddell, Edward Narayan, Arun Singh Ramesh, Simon Robson	15:30 - 16:45	Auditorium 1	16
Beryl Morris Day 1 close	16:45 - 16:50	Auditorium 1	

Evening activities are self-organised. The TERN 2023 Science Symposium will recommence at 8:30am Thursday 27 July.

Program

Day 2 Thursday 27 July 2023

Tea and Coffee served from 08:00 am	Time	Location	Page
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Bronwyn Harch Opening Plenary	08:35 - 09:00	Auditorium 1	1
Session 5: *Technology for conservation, AI, ML and associated data challenges* Chair: Will Woodgate Presenters: Thomas Bruce, Kathryn Hall, Paul Nevill, Zefang Shen, Ashley Sommer, Alison Specht	9:00 - 10:15	Auditorium 1	19
Morning Tea	10:15 - 10:45	The Terrace	
Session 6: *Ecosystem monitoring, assessments and reporting* Chair: Tim Clancy Presenters: Andy Allen, Patrick Baker, Zach Brown, Robert Hassett, Jokotola Omidiji, Jeongsoo Park, Laura N Sotomayor, Beng Umali, Kristen Williams	10:45 - 12:45	Auditorium 1	22
Lunch	12:45 - 13:30	The Terrace	
Session 7: *Environmental standards, methods and protocols* Chair: Mike Grundy Presenters: Wes Cooper, Katie Irvine, Vilim Filipovic, Noam Levin, Donna Lewis, Arko Lucieer, Sally O'Neill, Jinyan Yang, Maxine Newlands	13:30 - 15:15	Auditorium 1	26
Light Afternoon Tea	15:15 - 15:30	The Terrace	
Session 8: *Net carbon and sequestration* Chair: Jamie Cleverly Presenters: Lucas Cernusak, Simon Kelderman, Mingxi Zhang	15:30 - 16:15	Auditorium 1	30
Beryl Morris Symposium highlights & closing comments	16:15 - 16:25	Auditorium 1	
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We at TERN acknowledge the Traditional Owners and 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.

Welcome

Since it commenced in 2009, TERN has consistently aimed to provide a community infrastructure for ecosystem monitoring and data collection and access. TERN oversees and supports a network of facilities across Australia and collaboration by people in Australia and other countries focused on obtaining and sharing high-quality, standardised data.

Such collaboration was initially a very different way of doing science in the terrestrial ecosystem field. More than a decade later, evidence of the success of the vision is embedded in these 2023 Science Symposium abstracts. The talks and posters at this TERN Symposium exemplify how scientists are now routinely applying big data, establishing long-term trends and undertaking macrosystem science, notions that were much more abstract and infeasible before TERN.

I am delighted to see that this year's rich collection of abstracts has been submitted by a diversity of students and established researchers, who variously provide site to global perspectives. At the same time, the breadth of scientific, modelling and data expertise is evidence of the range of skills necessary to tackle complex, interdisciplinary challenges related to climate change, biodiversity, soils and food security.

The 2023 Science Symposium is a celebration of those who are at the forefront of monitoring and understanding our environment. This is essential to help ensure that management and policy decisions are informed by better knowledge of critical processes of terrestrial environmental change.

Thank you all for your work, and for sharing your knowledge in this important symposium.

Professor Andrew Campbell
Patron, TERN Biennial Science Symposium

TERN is a National Research Infrastructure project funded by the Australian government through the NCRIS program.

TERN operates as a collaboration of universities, CSIRO and other institutions, using expertise, sensors, surveys & tools to produce long-term open access data, samples, models and analytics related to terrestrial ecosystems to enable research and prediction about change in climate, biodiversity and soils.

Read more at www.tern.org.au

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Opening Speakers

Dr Beryl Morris

Beryl has been Director of TERN, Australia's national ecosystem monitoring observatory, since 2016, overseeing its strategic direction. Beryl has worked in executive roles in public and private sectors and has been the CEO of several companies in the life sciences area. She has also been on the Board of Directors of listed companies and not for profits.

Beryl has a track record in commercialising technology, running award-winning national science communication programs and authoring books and papers on a breadth of topics in the fields of science, education and management. Beryl has an international reputation in forensic entomology. Her research interests include insect behaviour and the role of trust in collaborations. She is a Fellow of the Royal Entomological Society, Fellow of the Australian Institute of Company Directors, Fellow of the Institute of Managers and Leaders, and Member of the Public Relations Institute of Australia.

Professor Hugh Possingham

Hugh is currently Chair of the TERN Advisory Board. He is also Chief Councillor of the newly created Biodiversity Council and Chief Scientist of Accounting for Nature, and has previously been Queensland Chief Scientist and Chief Scientist of The Nature Conservancy, the world's largest environmental non-government organisation. He retains a 20 percent appointment at The University of Queensland and was an ARC Laureate Fellow until the end of 2018. His research interests are in conservation research, operations research and ecology. More specifically, his research interests include securing the world's biological diversity: efficient nature reserve design, habitat reconstruction, monitoring, optimal management of populations for conservation, cost-effective conservation actions for threatened species, pest control and population harvesting, survey methods for detecting bird decline, bird conservation ecology, environmental accounting and metapopulation dynamics.

Professor Andrew Campbell

Professor Andrew Campbell was the Inaugural Chair of the TERN Advisory Board from November 2009 to December 2016. He is currently Chief Executive Officer of the Australian Centre for International Agricultural Research (ACIAR), appointed by the Foreign Minister in 2016.

Among influential roles in sustainable agriculture and research management in Australia for over thirty years, Andrew Campbell was Australia's first National Landcare Facilitator, and CEO of Land & Water Australia for seven years from 2000. He is Patron of Landcare in Victoria, succeeding the late Joan Kirner in 2015.

Professor Campbell is an elected Fellow of the Australian Academy for Technology and Engineering, a Professorial Fellow at the ANU Fenner School, and a Fellow of the Australian Institute for Company Directors. He represents Australia on the System Council of the CGIAR, and has also been a past Chair of the Global Research Alliance on Agricultural Greenhouse Gases (GRA).

Andrew Campbell has written widely on landcare, sustainability and the science-policy interface. Andrew Campbell is still involved in landcare work on his farm in south-eastern Australia, where his family has been farming since the 1860s.

Professor Bronwyn Harch

Professor Bronwyn Harch is a leader in research and innovation strategy with a passion for brokering transdisciplinary collaboration through private-public alliances.

With a statistics and data science background, Professor Harch has significant research and innovation leadership experience, having been in senior executive roles in Queensland Government, UQ, QUT and CSIRO. She was named in the top 60 Australian Statisticians as part of the 60th birthday celebrations of the Statistical Society of Australia in 2023. Professor Harch is the incoming Griffith University Vice President Industry and External Engagement (from October 2023).

She holds a Bachelor's Degree in Science (with Honours) in Australian Environmental Studies, a Graduate Diploma in Secondary Teaching, plus a PhD in biometrics.

Professor Harch is passionate about science and innovation endeavours that make our communities more secure, resilient and sustainable. She currently serves on several Australian and international boards and advisory committees relating to research and innovation, including the Federal Government Co-operative Research Centre Advisory Committee, AgResearch New Zealand, Future Drought Fund Resilience Hubs Advisory Committee, Australian Pork Limited, and is an elected Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE).

Session 1

Session 1: **Environmental scenarios, forecasts and predictions**

Session 1 chair - Dist. Prof. Belinda Medlyn *University of Western Sydney*

Belinda Medlyn is Distinguished Professor of Ecosystem Modeling at the Hawkesbury Institute for the Environment, Western Sydney University and chair of TERN's Science Advisory Board. Her research bridges from plant and ecosystem scale experiments to predictive models of vegetation responses to global change. She leads model synthesis activities at the *Eucalyptus* FACE experiment in Western Sydney, and has been instrumental in international projects evaluating ecosystem models against Free-Air CO_2 Enrichment (FACE) experiments. Her work predicting stomatal behaviour and drought mortality led her to establish the Dead Tree Detective citizen science initiative in 2018. Belinda has been a Clarivate Analytics Highly Cited Researcher since 2018. In 2019 she won the Australian Research Council Georgina Sweet Laureate Fellowship and currently heads a team of researchers developing the new Dynamics of Australian Vegetation (DAVE) model.

Deliberative planning tools to build catchment resilience

Prof. David Hamilton[1], Prof. Stuart Bunn[1], Sarah Cochrane[1], Dr Jagriti Tiwari[1]

[1]Griffith University, Queensland, Australia

Our catchments are no longer resilient to extreme weather events and there is a growing recognition of the need to invest in 'nature positive' remediation projects as a cost-effective long-term management approach to reduce erosion and flood risk. While we understand the causal processes of river and catchment degradation and what kinds of on-ground management actions are effective, a key challenge remains to move beyond the current incremental 'project by project' approach and develop coordinated, catchment-scale plans so that investment can be optimized to achieve multiple benefits for the least cost. The Building Catchment Resilience (BCR) Project (https://www.catchmentresilience.org/) has addressed this challenge through the development of a deliberative decision support tool that can be used to explore options for optimal on-ground investment to reduce catchment erosion and associated pollutants, minimize flood risk and capture other benefits (e.g. carbon sequestration). This has been coupled with an innovative digital interface to enable realistic visual representations to facilitate discussion and build confidence with investors and the local community. This presentation will provide the background to the project and an overview of the development of the modelling and visualization tools.

Present and future C3 and C4 grass distributions and associated carbon fluxes across Australia: insights from a process-based model

Dr Jurgen Knauer[1], Dr Assaf Inbar[1], Prof. Belinda Medlyn[1], Dr Lina Teckentrup[1], Drew Holzworth[1], Dr Laura Williams[1], Prof. Ben Smith[1]

[1]Western Sydney University, Sydney, Australia

Grasslands are one of the most widespread vegetation cover types worldwide and fulfill a range of important ecosystem services, including carbon sequestration and climate regulation. Grasses are expected to show differential responses to climate change depending on their photosynthetic pathway. C3 grasses show a strong response to increasing CO_2 concentrations, but are less well adapted to hot climates and are less efficient in their water use compared to C4 grasses, which are expected to have a competitive advantage in a warmer and drier environment. We implemented state-of-the-art representations of C3 and C4 grass physiology, growth, and phenology into the dynamic vegetation model LPJ-GUESS to predict the future distribution of C3 and C4 grasses across Australia. We focus on the combined and individual effects of the following main drivers on shifts in grassland vegetation distribution: 1) increases in CO_2 concentration, 2) increases in temperature, and 3) changes in rainfall patterns associated with an overall decrease in water availability. The model simulations are further used to assess the impacts of C3/C4 grassland shifts on the future carbon balance and carbon sequestration potential of Australia's grasslands. Results point to divergent regional responses in carbon uptake capacities driven by changes in C3/C4 grassland distribution.

Session 1

Modelling vegetation condition for biodiversity in Queensland

Dr Lucia Morales-Barquero[1,2], Dr Leonardo Hardtke[1,3], Chris Pennay[2], Shannon Hudson[2], Dr Teresa Eyre[2], Dr Robert Denham[1,3], Evanthia Karpouzli[2], Annie Kelly[2], Dan Hede[2], Dr Dan Ferguson[2]

[1]Remote Sensing Sciences, Deparment of Environment and Science, Brisbane, Australia, [2]Queensland Herbarium and Biodiversity Science, Department of Environment and Science, Brisbane, Australia, [3]Joint Remote Sensing Program, The University of Queensland , Brsibane, Australia

Accurately mapping the condition of native vegetation over large areas is important for applications related to biodiversity offsetting, natural capital accounting, vegetation management policies and conservation planning. Typically on-site frameworks to evaluate condition use a suite of compositional, structural, and functional attributes of vegetation as surrogates for biodiversity and compare sites to a reference derived from relatively undisturbed 'best-on-offer' sites within the same ecosystem type. In this work, we moved from a site-based to a state-wide product by undertaking a modelling and mapping approach using remote sensing data. As predictor variables we used Sentinel-2 derived green and bare fractional cover temporal statistics, phenology metrics and the minimum foliage projective cover (2017-2019). Our final gradient boost regression tree model used 8 predictor variables 17,000+ training points and had an R2 = 0.73 (estimated using 25% of points exclusively for testing). Here we present the spatial data products for the biocondition of the Brigalow Belt and South-east Queensland Bio-regions. Field validation assessment for these two bioregions using 235 points, collected by stratified random sampling, showed good agreement (R2 = 0.68, and MAE = 12.91). The release of these first two spatial datasets of native vegetation condition, demonstrates a systematic and repeatable method to assess vegetation condition at the landscape and regional scales.

Bridging Gaps In Modelling Grazed Savanna Ecosystems With Measurements From The New TERN Fletcherview SuperSite In North Queensland

Jo Owens[1], Dr Jamie Cleverly[2], Dr Mirko Karan[3], Prof Lindsay Hutley[4], Dr Andrew Frost[5], Prof Andrew Western[6]

[1]University of Southern Queensland, Toowoomba, [2]James Cook University, Cairns, Australia, [3]TERN, Cairns, Australia, [4]Charles Darwin University, Darwin, Australia, [5]Bureau of Meteorology, Sydney, Australia, [6]University of Melbourne, Melbourne, Australia

Knowledge of inter-annual variability, seasonal patterns and the magnitude of evapotranspiration is essential for understanding and managing impacts such as drought and plant mortality in water limited ecosystems, such as the savanna woodlands of northern Australia. While there is data from monsoonal grazed savannas in the Northern Territory, there is limited understanding of evapotranspiration dynamics for grazed savanna woodlands of Queensland to support operational modelling, largely due to lack of data, with no other current canopy scale field measurements of water, carbon and energy fluxes in this ecosystem. To fill this gap, a new flux monitoring site has been established – the TERN Fletcherview Tropical Rangeland SuperSite. The objective of this study is to improve evapotranspiration estimates in the grazed savanna woodlands of Queensland using direct measurements from flux towers, combined with approaches from modelling and remote sensing. Savanna ecosystems occupy approximately 40% of Queensland, 25% of Australia and 20% of the global land surface, and they contribute significantly to regional and global water and carbon budgets. We present measured datasets from the first 18 months of water and carbon flux measurements, coupled with phenology and soil moisture monitoring. We use the eddy covariance method to measure water and carbon fluxes; a PhenoCam to measure greenness; and field measurements of pasture biomass. Sapflow sensors have recently been installed to partition evapotranspiration into tree and grass water use, a key uncertainty in savanna ecohydrological modelling These datasets will improve our understanding of the links between hydrological, meteorological and ecological processes in tropical savanna woodlands that are subjected to natural climatic variability as well as grazing pressure. Given the site is a well-managed grazing operation, it will contribute important ground truthing data for parameterising, evaluating and improving modelling of evapotranspiration, soil moisture and vegetation dynamics using models such as GRASP and AWRA.

Session 1

TERN Landscapes Phase II Highlights

Matthew Stenson[1], Prof. Alfredo Huete[8], Dr Shaun Levick[5], Prof. Arko Lucieer[9], Dr Ben Macdonald[7], Dr Stefan Maier[10], Dr Brendan Malone[7], Dr Dave McJannet[1], Dr Tim McVicar[2], Prof. Graciela Matternicht[11], Prof. Budiman Minasny[12], Dr Glenn Newnham[3], Dr Luigi Renzullo[13, 16], Dr Mercedes Román Dobarco[12], Dr Ross Searle[6], Ashley Sommer[1], Prof. Ben Sparrow[14], Dr Tom Van Niel[4], Dr Alexandre Wadoux[12], Dr Will Woodgate[15, 17]

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TERN Landscapes complements and completes the national land observatory with continent-wide, temporally dynamic information infrastructure. Drawing from other TERN Platforms (Surveillance, Processes and Data Services) and with connections across relevant R&D providers, Landscapes provides the scaling component of the TERN Observatory across space and time. During phase II of Landscapes, it and its partners at UTas , UAdel , USyd , UNSW, DES, DEA, CSIRO, JCU, maitec and UTS have developed and delivered multiple high impact data products

- A second version (V2) of the Soil and landscape Grid of Australia, expanding its scope and range as well as improvements and updates to V1 products
- A soil infrared spectral library and soil spectral inference capability based on TERN Surveillance soil specimens
- Daily continental scale volumetric soil moisture
- High resolution, national scale Actual Evapo-transpiration
- A Cosmic Ray Soil Moisture Network
- Terrestrial Lidar scans to support Solar Induced Fluorescence product development
- Federation of national soils information
- Development of 'One TERN' protocols for the collection of UAV/Drone data
- Support for TERN representation in the development of nationally consistent fire mapping products
- And support for the development of key chapters in the latest State of the Environment Report.

Within the next year, TERN Landscapes will be releasing several new and exciting data products including resurrection of the complete AVHRR archive from 1992 to the present. This data will form the longest complete timeseries of remotely sensed data available to TERN researchers. There will also be multiple high temporal resolution derived data products from the geostationary Himawari satellite, such as phenology, reflectance, land surface temperature, latent and sensible heat fluxes from 2015-current. Additionally, the Landscapes team has been working on new ways to access and interact with data products that are often too large to download, methods such as in situ access/visualisation and services based sub-setting, drilling and processing.

Using community-level modelling to identify the fingerprint of recent climate driven ecological change in Australia

Dr Kristen Williams[1], Dr Thomas (Tom) Harwood[4], Dr Christopher (Chris) Ware[2], Dr Andrew Hoskins[3], Dr Suzanne Prober[1], Dr Alexander Herr[1], Fiona Dickson[5], Peter Lyon[5], Dr Simon Ferrier[1]

[1]CSIRO Environment, Canberra, Australia, [2]CSIRO Environment, Hobart, Australia, [3]CSIRO Environment, Townsville, Australia, [4]Environmental Change Institute, University of Oxford, United Kingdom, [5]Department of Climate Change, Energy, the Environment and Water, Canberra, Australia

Land surface temperatures across Australia have warmed by about 1.47°C ± 0.24 °C on average since records began in 1910. Changes to rainfall quantities and patterns have also been experienced variously across the continent since the 1970s (State of the Climate 2022, CSIRO & Bureau of Meteorology). This change has ecological consequences and a burgeoning literature has explored the implications for biodiversity and options for management. While considerable investment has been directed toward forecasting how climate influences species and ecosystem redistributions under various change scenarios in Australia, few studies have applied the same methods to hindcast how much ecological change has already occurred. Given substantial recent improvements in access to extensive historical aggregations of biological data; for example through the Atlas of Living Australia; and high resolution environmental datasets; for example through the TERN soil and landscape grid; an opportunity exists to develop and test methods used to measure the implications of climate on biodiversity by examining types of change that have already occurred, to what extent and where. In this project we examined the historical record of climate and investigated the potential ecological consequences of these changes using Generalised Dissimilarity Modelling. The project identified areas under ecological pressure, and developed new metrics to better describe this change. We also developed, implemented and tested a new approach to modelling which works with the time series of climate to model conditions immediately before each species observation. This new approach demonstrates an improvement over simpler models and offers significant potential for further application.

Session 1

Tumbarumba: A long term TERN site supporting fire recovery research and global calibration and validation efforts

Dr Will Woodgate[1]

[1]*The University of Queensland, Brisbane, Australia*

The Tumbarumba tall forest TERN/UQ site is recognised as one of the top sites globally supporting satellite product calibration and verification. The site was initially developed to provide long-term data streams of the exchanges of carbon dioxide, water vapour and energy between the forest and the atmosphere using micrometeorological sensors on a 70 m flux tower. It is one of Australia's longest running flux towers, with multi-million dollar investments via CSIRO and TERN. In addition to the core long-term data streams, new technological investment has seen the site become one of the few sites globally that is equipped with the breadth of infrastructure to comprehensively link ground-based observations to the satellite level. This includes some truly world-leading remote sensing instruments, partnerships, and data sharing arrangements with NASA and the European Commission through the European Space Agency (ESA).This presentation will discuss the site's research applications and impact in the context of domestic and international collaborations. One such application is supporting bushfire recovery research after a major fire disturbance as part of Australia's 2019/20 Black Summer.

Session 2

Session 2: **Evidence based environmental decisions**

Session 2 chair - Emerita Prof. Megan Lewis *The University of Adelaide*

Megan Lewis is a distinguished environmental scientist specialising in remote sensing, vegetation ecology, and environmental science. As President of Earth Observation Australia and Australian Co-Chair of the Coordinating Board of AOGEO, she plays a pivotal role in advancing the field. Megan is also the Chair of the CSIRO NovaSAR-1 Steering Committee and a member of the TERN Scientific Advisory Committee. With extensive academic experience, she focuses on using remote sensing, particularly hyperspectral sensing, to study landscape composition and temporal variations. Megan collaborates with government agencies, ecologists, and environmental managers to develop innovative tools for comprehensive assessments, aiming to provide objective insights and cost-effective monitoring methods.

The Threatened Species Index — compiling multi-species trends to inform conservation planning in Australia

Dr Geoffrey Heard[1], Tayla Lawrie[1]

[1]TERN, Brisbane, Australia

Conservation planning for threatened species hinges on up-to-date and robust information on population trends. Such trend estimates are fundamental to listing processes, prioritisation analyses, designing conservation interventions and evaluating species' response. Yet, until recently, Australia had limited infrastructure for collating the required data and consistently producing and reporting on threatened species trends. Here, we highlight the Threatened Species Index (TSX) as a key tool that collates threatened species monitoring data from across the country and represents a growing resource for conservation practitioners and researchers. We will present findings of the 2022 index, based on the collation of extensive new monitoring data for birds, mammals and plants from across the country. National and state-level trends will be described, as will trends for each index (birds, mammals and plants) and functional group within each index (e.g., terrestrial birds and migratory shorebirds). We will close with current and future priorities for the TSX. We will outline which species groups will next be integrated into the index and describe plans for ongoing development of the TSX platform to support data contribution and curation, and use of the index by practitioners and researchers to advance the conservation of Australia's most imperilled species.

EcoAssets – a common vocabulary

Donald Hobern[1]

[1]Atlas of Living Australia, Canberra, Australia

The EcoAssets project (https://ecoassets.org.au/) was a collaboration between TERN, the Integrated Marine Observing System (IMOS), the Atlas of Living Australia (ALA) and the Australian Research Data Commons to improve access to research data to support national environmental assessment activities, in particular State of Environment reporting. EcoAssets included work to summarise environmental survey and monitoring efforts across the Australian continent and marine areas by faceting metadata records from TERN, IMOS and the ALA to simplify discovery of relevant data by time, space and earth-science feature. Aggregating these metadata also highlights and to some extent quantifies unevenness in coverage current sampling. The three infrastructures did not share any common vocabulary to document the features measured or observed in each study. EcoAssets addressed this gap by developing the EcoAssets Earth Science Features vocabulary (https://ecoassets.org.au/data/vocabulary-ecoassets-earth-science-features/), a mapping between the Global Change Master Directory (GCMD) keyword vocabulary, the TERN feature of interest vocabulary and the Australian National Species List classification. The resulting hierarchical vocabulary is used throughout the EcoAssets monitoring assets and is intended to simplify faceting metadata at multiple levels of granularity.

Session 2

Strategic Conservation Analysis for Queensland's Protected Areas

Peter Johnson[1], Brad Ellis[1]

[1]Department of Environment and Science, Brisbane, Australia

The first step in Queensland's protected area investment decisions is driven by a strategic conservation analysis tool developed in the Department of Environment and Science. The core of the toolkit is a geospatial relational database in which biodiversity data such as regional ecosystems and priority species mapping is related to land parcels, protected areas, and other tenures of interest across the State. Metrics that describe various aspects of the importance of biodiversity values are built into an account-keeping framework to guide decisions including:

- The creation of protected areas to work towards a comprehensive, adequate, and representative (CAR) protected area system for Queensland;
- Selecting biodiversity values of protected areas most in need of monitoring and targeted management;
- The relative investment in management efforts across national parks;
- The provision of incentives for private protected areas; and
- Identifying values most at risk from incompatible land uses.

Queensland's protected area system is largely composed of residual lands, i.e., lands for which there was little demand from other uses and hence, has done relatively little to prevent threats to biodiversity. To achieve meaningful conservation gains that address biodiversity loss, opportunities need to be identified in landscapes that are threatened by other uses. The strategic conservation analysis tool provides a means for quantifying transactions that deliver conservation benefits in landscapes that are at risk.

Commonwealth Government use of the novel Habitat Condition Assessment System

Cassandra Malley[1], Peter Lyon[1], Dwaipayan Deb[1], Dr Kristen Williams[2]

[1]Department of Climate Change, Energy, the Environment and Water, Canberra, Australia, [2]Commonwealth Scientific and Industrial Research Organisation, Canberra, Australia

The Australian Government is striving to improve the trajectory of our environment through evidence-based conservation and restoration of species and ecosystems. This goal will require national scale information about the capacity of landscapes to support biodiversity. Habitat condition and landscape connectivity are important metrics as good quality and intact habitat are essential for native species persistence. The Habitat Condition Assessment System (HCAS) is a remote-sensing based approach that is the result of years of collaborative effort between the Department of Climate Change, Energy, the Environment and Water (DCCEEW), and CSIRO. The HCAS is a first for Australia, producing a nationally consistent, landscape scale model predicting species' habitat condition across the continent. DCCEEW have already implemented the HCAS to better inform decisions relating to major policy initiatives, including (but not limited to) annual corporate reporting on Australia's environments, the State of Environment 2021 report, planning for regional management outcomes, and the production of experimental environmental - economic accounts. It has also been used in pilot projects in collaboration with stakeholders in non-profit, education and industry sectors. To further harness the power of the HCAS, it has been integrated with other data to produce new metrics and analytical tools, such as the new HCAS-derived National Connectivity Index, co-developed with CSIRO, which measures the amount of habitat connected to a location, and a conservation prioritisation support tool for Matters of National Environmental Significance. The department continues to work closely with CSIRO to maximise the value that can be derived from the HCAS for all stakeholders, and work is underway to identify, prioritise and implement enhancements to both the HCAS and auxiliary products. We will present on the department's current and future work with the HCAS and potential for further engagement with external stakeholders to determine future opportunities for use and integration in priority program initiatives.

Science communication and video

Nicolas Rakotopare[1]

[1]TERN, Brisbane, Australia

Video is an essential tool for effective science communication, from playing a crucial role in bridging the gap between complex scientific concepts and the public to highlighting projects and putting a face to your organisation. As the most widely consumed medium on social media, it's the perfect tool for building strong connections with your audience. With examples from areas such as ecosystem science, this talk will showcase the way we use video and data to tailor the content to a specific audience and grow digital asset management for effective use.

Session 2

Monitoring diurnal to seasonal vegetation dynamics with Himawari-8 geostationary satellite

Mohammad Mahdi Taghadosi[1], Dr Ankur Srivastava[1], Dr Yi Qin[2], Dr Jamie Cleverly[3], Dr Andeise Dutra[1], Prof Alfredo Huete[1]

[1]University Of Technology Sydney, Sydney, Australia, [2]CSIRO, Oceans and Atmospheres, Canberra, Australia, [3]James Cook University, Cairns, Australia

The Advanced Himawari Imager (AHI) onboard the Himawari-8 satellite provides high-temporal imagery, at 10 minute intervals, to better understand how terrestrial ecosystems function by tracking important sub-daily and daily processes over multiple years. These next generation geostationary sensors are equipped with new spectral bands to observe critical land parameters including land surface temperature, albedo, vegetation indices, evapotranspiration, photosynthetic activity and landscape phenology. As part of a multi-institutional TERN project, we evaluated the use of AHI data to track vegetation productivity and monitor land surface phenology across a network of eddy covariance flux tower sites, OzFlux. We assessed AHI observations of vegetation dynamics at diurnal, daily and seasonal scales and compared with their relationships with flux tower and phenocam measures across a gradient of dry to wet savanna sites, grasslands, and evergreen broadleaf forest biomes. Our results show the acquisition of high quality, cloud-free data was significantly higher than from traditional polar orbiting satellites and enabled increased fidelity in landscape phenology retrievals, including better characterisation of biophysical relationships and phenology driven hysteresis effects. Unique biome-dependent diurnal vegetation greenness/ moisture index patterns were found that were related to ecosystem structure. These results demonstrate an improved biophysical understanding of ecosystem processes which will better enable predictions of how ecosystems will respond to climate change and other disturbance regimes. The combined use of geostationary and polar orbiting satellite data will allow for a consistent comparison of a variety of ecosystem properties across all biomes and over long-term decadal time periods.

Key findings from the 2022 TERN Vegetation Data Synthesis Challenge

Dr Eleanor Velasquez[1]

[1]TERN, Brisbane, Australia

A common bugbear of researchers, public servants, and consultants alike, is the inability to access already collected vegetation datasets that would enable them to answer critical environmental management or research questions using all relevant information and without wasting additional precious funds on laborious field work. In collaboration with Queensland Government partners, TERN (Terrestrial Ecosystem Research Network) led the Vegetation Data Synthesis Challenge workshops, in December 2022, which aimed to identify data sources, address research and environmental questions, identify data gaps, and uncover barriers to data sharing. The workshops involved a panel of fifteen experts from various sectors, including government, academia, research infrastructure, and consulting. Through online sessions, the panel discussed key objectives, including improving data access for decision-making based on previously undiscovered information. Key environmental questions and data gaps identified through the workshops focused on vegetation condition, height, Diameter at Breast Height (DBH), wet and dry sclerophyll forests, and weed/exotic species extent. The workshops highlighted the need for up-to-date ground-truthed data and standardised protocols for data collection. Hurdles to data sharing were identified, such as concerns about data sharing agreements, time required for data preparation, and privacy issues. However, the online format of the workshops facilitated rich discussions and valuable insights. Six key insights emerged from the workshops, providing a foundation for the future of vegetation data collection, storage, and utilization in Queensland. These insights will help shape a vision for practical transformations in data access and utilization. The workshops were considered successful, enabling TERN and participating organizations to gain valuable insights into the current state of already collected vegetation data in Queensland. Further exploration of the identified data sources will significantly contribute to addressing vegetation data challenges in Queensland, empowering end-users to make informed decisions based on previously inaccessible information.

Session 2

Diagnosis of the high sensitivity to warming temperatures of *Eucalyptus obliqua* tall forest at Warra, and implications for management

Dr Tim Wardlaw[1]

[1]University of Tasmania, Hobart, Australia

Tasmania's *Eucalyptus obliqua* tall forests are among the most productive and carbon dense natural forests in the world. The discovery of sharply declining productivity of the *E. obliqua* forest at Warra Supersite during heatwave events presage a threat to the persistence of these forests as heatwaves occur with increasing regularity. Management intervention will be needed if these forests are to be made more resilient to a rapidly warming climate. Confident diagnosis of causality is the critical first step for developing effective management interventions. Why is the productivity of *E. obliqua* tall forest at Warra so sensitive to warming temperatures? Findings from research done using TERN data from Warra and other SuperSites were reviewed and used to identify unique responses to environmental change seen in the forest at Warra that may point to causality of their strong sensitivity to warming temperatures. The unique response to heatwaves shown by the forest at Warra appears unrelated to either moisture limitation or high temperature anomaly. Rather, the high sensitivity to supra-optimal temperatures was best explained by the high latitude occupied by these Tasmanian forests. These findings suggest that accelerated adaptation of local genotypes to warmer temperatures, rather than assisted migration of climate-adapted genotypes, is the preferred management approach to improve the resilience of Tasmania's *E. obliqua* tall forest to a warming climate.

Applying alternate risk transfer solutions for synergising climate change mitigation and adaptation

Dr Jenny Wang[1], Prof. Shahbaz Mushtaq[1], Dr Jarrod Kath[1], Prof. Tek Maraseni[1], Torben Marcussen[1]

[1]University of Southern Queensland, Queensland, Australia

Based on the Australian case study, we develop an integrated conceptual framework for synergising climate change mitigation and adaptation strategies. The proposed framework can simultaneously improve agricultural resilience and reduce disaster recovery costs through alternate risk transfer solutions (e.g. crop insurance, discretionary mutual funds), increase carbon sequestration to mitigate climate change, and increase natural capital and biodiversity by providing incentives to increase forest cover. Moreover, the developed framework is designed to overcome the often currently inhibitive transaction costs of many carbon sequestration programs and thus facilitate more widespread adoption of climate change mitigation activities. Our approach would see producers dedicate 'surplus' marginal land or assets (e.g., family's surplus labour) to carbon sequestration which would be converted to carbon credits. In turn, carbon credits could be used as a revenue proxy to purchase insurance to protect against climate disasters. Our study provides important implications for governments to expand existing emissions trading systems to encourage farmers to use their marginal land for the purchase of insurance. Fostering the establishment of plantations for carbon storage would reduce carbon dioxide levels to further facilitate the environmental (e.g., increased land dedicated to natural values), economic (e.g., faster production recovery from climate disasters), and social (e.g., reduction of socio-economic hardship of producers impacted by climate disasters) benefits.

Posters

Addressing pressing global societal research challenges through targeted harmonisation of macrosystems ecology datasets

Dr Beryl Morris[1], Dr Werner Kutsch[2], Dr Michael SanClements[3], Dr Henry Loescher[3], Melissa Genazzio[3], Dr Michael Mirtl[4], Dr Jaana Back[4], Dr Tommy Bornman[5], Dr Paula Mabee[3], Dr Xiubo Yu[6], Dr Steffan Zacharias[4], Dr Gregor Feig[5], Mark Grant[1], Dr Emmanuel Salmon[1], and Dr Leiming Zhang[6]

[1]TERN, Brisbane, Australia, [2]ICOS, Helsinki, Finland, [3]NEON, Boulder, USA, [4]eLTER, Leipzig, Germany, [5]SAEON, Pretoria, South Africa, [6]CERN, Beijing, PRC

Guided by the Framework Criteria of the Group of Senior Officials (GSO) on Global Research Infrastructures, 6 major ecosystem research infrastructures (SAEON/South Africa, TERN/Australia, CERN/China, NEON/USA, ICOS/Europe, eLTER/Europe) came together in 2020 under an MOU, establishing the Global Ecosystem Research Infrastructure (GERI). With its goal of providing interoperable data and services based on terrestrial and coastal in-situ observations from a high number of observational sites, organised in a common hierarchical system and standardised in the highest possible degree, GERI provides a unique opportunity to advance our understanding of ecological processes across continents, decades, and disciplinary boundaries. Aggregating ecological and biogeophysical data is complex. Not only do those data cover a myriad of different types of natural phenomena, and the interactions between, but the data are generated in different jurisdictions using different standards and approaches. Thus, as a critical first step in understanding the challenges and potential of its multi-institutional, multi-country data landscape, GERI has identified and mapped all the data types from each of its members, grouping the data suites provided by each GERI member into the drivers of changes (causes) and the ecological processes (effects) and then visualising it into broad (searchable) respective common ecological categories. This exercise has allowed evaluation of the potential for a targeted data harmonisation effort based on a subset of data products with high relevance to specific use cases (e.g., drought across multiple continents). By using the subset of relevant data as a community test case, GERI can ascertain the efficacy of a specific harmonised data set in advancing a priority area of science. Such a prototype will set the stage for future efforts and ensures GERI addresses the most pressing global research challenges, i.e., those frontiers of knowledge where a globalcritical-mass effort is required to achieve progress.

Mapping the spatiotemporal dynamics of tea farms in a tropical mountainous region in challenges Southern Taiwan using machine learning

Dr. Cho-ying Huang[1], Zih-Yu Shen[1], Dr Tzu-Hsin Chen[2]

[1]National Taiwan University, Taipei, Taiwan, [2]Yale University, New Haven, USA

Tea is the second most popular drink (next to water) in the world and a major cash crop in many tropical countries. Many tea farms are situated in mountainous regions suitable for tea tree growth. However, the change in land cover types (from forests to tea farms) can fragment wildlife habitats and may cause significant impacts on biodiversity and biological conservation. Therefore, to effectively manage this coupled human-natural system, it is important to monitor the spatiotemporal dynamics of mountain tea plantations. Satellite remote sensing image classification is the most prevalent approach for quantifying land cover types. However, conventional image classification methods may not be suitable for this task since the spectra of tea farms and surrounding forests are very similar. Thus, an advanced machine-learning approach is indeed necessary. In this study, we applied two machine-learning methods, Random Forests (RF) and U-net&Resnet-18 (UR), to classify time-series (2019-2022) Sentinel-2 surface reflectance data covering the tropical mountain tea farms (Ali Mountain) in Taiwan. We arbitrarily defined five land cover types for the study region (tea farm, cropland, forest, bare soil, and impervious surface) and classified the images at three different temporal resolutions (annual, seasonal, and image date) using Google Earth Engine with Colaboratory. Results showed that the performances of both RF and UR were satisfactory (overall accuracies > 0.9) at the annual and seasonal time steps. Using UR to classify seasonal data yielded the best outcome (overall and producer's/user's accuracies of 0.949, and 0.916/0.939, respectively). We found that tea farms have decreased by 19% (from 2,532 ha to 2,063 ha) since 2019, which could be due to local economic transformation and global climate change. The proposed method (classifying time-series Sentinel-2 imagery with UR) may be feasible for mapping other mountain evergreen crops such as coffee trees.

A connected research ecosystem through trust and identity

Kerry Mora[1]

[1]Australian Access Federation, Adelaide, Australia

The Australian Access Federation (AAF) is the national capability that delivers trust and identity services. We facilitate trusted connection and collaboration between education and research institutions, nationally and internationally. Through our Trust and Identity Pathfinder Project we're partnering with national research infrastructures (NRI) to build a system-wide approach to identity and access management, which will improve connectivity across the NRI ecosystem.

Posters

Ecological Monitoring System Australia: Pest fauna

Sally O'Neill[1], Beth Cox[2]

[1]TERN, Urrbrae, Australia, [2]The University of Adelaide, Urrbrae, Australia

Absence of consistent, authoritative data that considers impacts spatially and temporally, inhibits our ability to understand where Federal Government's pest fauna management programs and investments have been effective. Currently, there is no national supply chain for pest fauna monitoring information. Both monitoring methods and subsequent data obtained by states, organisations and individuals is often incompatible. An effective and standardised monitoring program is needed to obtain accurate population and density estimates and assess the impacts of pest fauna. An extension of the suite of 19 ecological survey protocols developed by TERN and the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) are 7 survey protocols to collect consistent and comparable monitoring data on the distribution, density and impact of Australia's key medium-large pest fauna species. The focal species for these protocols are feral cats, wild dogs, pigs, rabbits, goat and deer. The standardised monitoring protocols are being built to support future DCCEEW natural resource management programs that benefit the environment, farms and communities. These protocols will be released as a component of the Ecological Monitoring System Australia (EMSA) alongside the Monitor data collection app for practitioners to use in the next phase of the National Landcare Program.

Biomass measurement and structural ecosystem metrics across the landscape with multi-scale LiDAR, satellite imagery and machine learning

Abbey Yatsko[1], Dr Jed Calvert[1], ArborMeta Research Team[1]

[1]ArborMeta, Byron Bay, Australia

Above-ground biomass (AGB) of forests is a major carbon sink, and biodiversity condition assessments rely on above-ground structural vegetation attributes. To meet the demands of natural resource managers and nature-capital markets, tools capturing biodiversity measures require updating for accuracy, auditability, shareability, and integration with remote sensing and carbon markets. In a forest carbon context, estimates of AGB using terrestrial laser scanning (TLS) are more accurate and less biased than estimates generated by widely-used allometric scaling models. In an ecological context, the information-rich LiDAR point clouds generated by TLS contain 'digital twins' of structural vegetation attributes. Using multi-scale LiDAR as ground-truth data to train machine learning models, we developed landscape models of two important structural vegetation attributes (AGB and canopy cover) under Australian rangeland conditions. We used a nested approach, positioning near sensing TLS point clouds inside remote sensing aerial laser scanning (ALS) surveys and satellite imagery. When variation in plant communities was well represented in training data, mean residuals for convolutional neural network (U-Net) satellite biomass modelling were -4.28 % of TLS woody volume. Reliable canopy cover models were produced from satellite data (Landsat-8, Sentinel-2, Maxar) with model performance improving with data resolution. When validated against ground-truth data, Maxar-based models correctly predicted forest cover 94 % of the time. We propose to further develop accurate, cost-effective structural vegetation metrics for biodiversity assessment and monitoring that support confidence in emerging biodiversity markets, assist methodology development, and facilitate deployment at the landscape scale across Australia's varied environments.

Do hollow trees confound estimates of carbon carbon in savanna ecosystems? Destructive harvest with allometric scaling models and terrestrial laser scanning

Abbey Yatsko[2], Dr Jed Calvert[1], ArborMeta Research Team[1]

[1]ArborMeta, Byron Bay, Australia, [2]University of Miami, Miami, USA

Forests are critical carbon stores, but to accurately measure carbon in above-ground biomass (AGB), methods need to be precise and sources of error identified. Limitations of allometric scaling models (ASMs), traditionally used to estimate tree AGB, have led to a push for rapid and accurate biomass estimates using terrestrial laser scanning (TLS). However, an unresolved source of error is internal tree stem damage from termites, fungi and fires, which neither ASMs nor TLS are able to detect. Given the prevalence of stem damage, especially in the tropics, accuracy of AGB assessments may be compromised. We carried out a destructive harvest in Far North Queensland (FNQ), Australia in a savanna with internal stem damage present. We asked three main questions: How accurately does TLS measure AGB in comparison to ASMs? How does stem damage vary through the tree? Do trees with higher degrees of damage have overestimates of AGB? Our results combine TLS, ASMs, field-measured biomass, and a quantification of stem damage volume and distribution. TLS was a more accurate method for quantifying AGB compared to ASMs in terms of aggregated biomass and at the individual tree level. However, one pantropical ASM performed well at estimating total tree weights across the study area. AGB measurements were not confounded by hollowing as there was no significant relationship between extent of internal damage and error in TLS-predicted tree weights. Finally, internal damage was concentrated in the lower region of the tree, with cross-sectional damage most significant at the scarf and middle of the trunk and very little damage in the middle and upper crown. By testing TLS and measuring the extent and patterns of internal stem damage, we have a better understanding of TLS as a tool for AGB estimation, and the extent to which internal stem damage is a source of error.

Posters

Novel, new and updated soil data layers for modellers

Peter Zund[1]

[1]*CSIRO, St. Lucia, Australia*

Australia's soil scientists have been hard-at-work improving and creating new soil data layers for the TERN Soil and Landscape Grid of Australia. The grid already contains 14 soil attributes and 17 landscape attributes. These attribute layers uniformly cover the whole of the Australian continent at a resolution of 3 arc seconds (90 m X 90 m). The soil attributes are also predicted over six standard soil depths. These data layers have brought together all the disparate soil data available across Australia into a uniform resource for modellers and anyone else who needs soil information. Since 2020 TERN has been funding updates to eight of the soil attributes and commissioned 10 new soil attributes. Six of the physical soil attributes have been updated and added too, including available soil water capacity, which has been improved and drained upper limit (field capacity) and lower limit (wilting point) added. All the particle size attributes (clay, silt and sand) have been updated and percent course fragments added. Soil depth and soil bulk density have been updated and a soil colour for the surface and subsoil produced. Organic carbon has been updated and the new attribute, organic carbon fractions produced. Plant available phosphorus has been added to compliment the existing total phosphorus soil attribute. Soil pH in water has been added to compliment the existing pH in calcium chloride soil attribute. The soils cation exchange capacity attribute has been updated and novel soil attributes created that describe the soils microbial biodiversity and stratify the landscape into pedogenons and soil orders. All this spatial data is available now from the Soil and Landscape Grid of Australia.

Session 3

Session 3: **Land management for sustainable ecosystem services**

Session 3 chair - Dr Tim Wardlaw *University of Tasmania*

Tim has a research career in applied forest ecology and forest health management spanning 40 years. He has been the author, or co-author of more the 100 papers in scientific journals and book chapters. For the first 20 years of his career, Tim was Forestry Tasmania's forest pathologist where he worked on a wide range of diseases affecting native forests and plantations, including Phythophthora root rot, fungal leaf diseases, wood decay and crown diebacks. From 2001, Tim managed the Ecosystem Services group within Forestry Tasmania, which undertook applied research in conservation biology and forest health management. Since 2009, Tim has managed the Warra Long-Term Ecological Research site and was instrumental in getting Warra included in the Terrestrial Ecosystem Research Network that led to the establishment of a flux tower and become one of the sixteen SuperSites in the network. Tim is currently based at the University of Tasmania as an Honorary Research Associate within Plant Science where he maintains the role of Principal Investigator of Warra.

The tension between achieving profitable grazing businesses whilst maintaining land condition

Dr Maree Bowen[1], Fred Chudleigh[2]

[1]Queensland Department of Agriculture and Fisheries, Rockhampton, Australia, [2]Formerly Queensland Department of Agriculture and Fisheries, Toowoomba, Australia

Despite the empirical evidence supporting sustainable grazing practices, and a concerted extension effort over more than 3 decades, there is evidence of continuing land condition decline across Queensland's grazing lands. To better understand this challenge, we have reviewed the literature and present a synthesis of economic analyses of grazing management strategies and interventions to address land condition decline, with a focus on Queensland, Australia. To obtain appropriate conclusions from economic analysis, of grazing management and changes to land condition, it is important that the correct economic method and perspective is applied. A marginal analysis at the property level, incorporating the full economic and financial impact of the implementation phase, must be conducted. Additionally, the results from research trials must be interpreted and applied in a commercially relevant context. Those economic analyses conducted using sound methodology and perspective have indicated a strong economic incentive to apply high pasture utilisation rates even when this resulted in declining land condition and individual grazing animal performance. Analyses have also indicated that the economically optimal stocking rate rises with lower property sizes, higher discount rates, higher commodity prices and declining risk aversion. Importantly, a strategy of high stocking rates, with potential for rangeland degradation, could be an optimal response to the economic and social factors that confront graziers. It is evident that the tension between achieving profitable grazing businesses and maintaining land condition over time will continue to present challenges for managers of grazing businesses across Queensland. The strong economic and financial incentive to apply high pasture utilisation rates, even when this results in declining land condition and animal performance, must be recognised and understood before effective solutions to address land degradation can be found.

Session 3

How is a Critical Zone Ecosystem Observatory assisting in determining if the vegetation and groundwater of the Mallee region are approaching critical tipping points?

Prof David Chittleborough[2], A/Prof. Wayne Meyer[1], Dr Cacilia Ewenz[3], Dr Alex Franke[2], Dr Juraj Farkas[2]

[1]University of Adelaide, Urrbrae, [2]University of Adelaide, [3]TERN, Brisbane,

Eddy covariance methodology deployed through TERN flux tower installations is giving detailed monitoring of the CO_2, H_2O and energy exchanges of a few diverse ecosystems across Australia. It's clear that atmospheric CO_2 concentration is increasing while in many regions there is greater variability of rainfall than has been the case for most of the 20th century. For semiarid Calperum the period from 2017 has been one of ongoing limited rain (180mm versus 250mm long term annual rainfall). Observations of the vegetation canopy indicate that it is under increasing stress. When rain is limited and measured ecosystem ET exceeds it, the water loss (ET) would be met by extraction of water from deeper in the soil and net upward movement ("upflow") would likely occur. This implies a significant shift in the recharge/discharge balance of the regional groundwater, a result that has significant implications for the water and salt balance of the River Murray. With detailed quantification of the above ground carbon, water and energy exchange there is a critical need to improve the quantification of the below ground carbon, water and elemental exchanges. Measuring the whole system is the essential concept of a Critical Zone Observatory (CZO).

Installation of sensors to monitor groundwater characteristics and of the unsaturated vadose zone adjacent to the flux tower is underway. The Vadose Zone Monitoring System (VMS) will enable water and gas status (O2, CO_2) of the soil profile to be monitored that should pinpoint where roots are active. Water and soil profile samples will support isotopic analysis of deposited and current phytoliths to develop an interpretative framework with phytolith oxygen isotope analyses as indicators of water uptake in Australia's iconic mallee vegetation. Additional isotopic analyses of O, U, Ge, Si and Sr are planned to improve understanding of depositional processes and paleoclimate conditions.

Toward Rapid Ecosystem Function Assessment: An automated pathway for assessing seed dispersal and harvesting by ants

Prof. Will Edwards[1], Dr Mark Payne[1], Andrew Grey-Spence[1], Ben Lyons[1], Damon Colman[1], Jaimee Hamilton[1]

[1]James Cook University, Cairns, Australia

Automated technologies commonly provide measures describing taxon-level estimates of species abundances and/or occurrences across landscapes. While taxon-level abundance, presence/absence or diversity indices assess biological diversity, they do not assess ecological function. Here we demonstrate a simple, automated image capture device for measuring seed removal rates by ants; an ecological function crossing trophic/taxonomic boundaries that has shaped the evolution of the Australian flora for millions of year. The device is user-friendly in all aspects and requires minimal time for installation. It is thus capable of being employed as a component of almost any field exercise by any interested party, nationwide. All data acquisition and analysis are automated and return simple graphical and numerical estimates of instantaneous seed removal probabilities and removal rates, easily interpretable by any user and directly comparable across time and space. At a national scale, this data could be combined to provide insight into ecosystem function and: (i) overall biodiversity, (ii) trajectories of conservation and restoration initiatives and/or invasive species impacts, and (iii) the state of fundamental ecosystem services.

Session 3

Using High Resolution Satellite Products To Link Estuarine Health and Land Water Use

Dr Eriita Jones[1], Prof. David Antoine[1], Dr Kieryn Kilminster[2], Dr Frances D'Souza[3]

[1]Curtin University, Success, Australia, [2]University of Western Australia, Perth, Australia [3]Department of Water and Environmental Regulation, Perth, Australia

respond to physical and chemical inputs from surrounding agricultural, industrial and urban activities, particularly after significant rainfall events. In particular, nutrient and sediment loading into estuarine waters can be a source of ecosystem stress. Many studies have established relationships between water optical properties and water usage in land-use and landcover (LULC) categories surrounding estuaries, using in situ information (ie. field monitoring of water quality). Our research instead used optical remote sensing to explore the impact of LULC water use on water quality at the scale of estuarine environments to inform future strategies for monitoring and sustaining these precious ecosystems. This talk will discuss the outputs of a pilot research project done in partnership with the Western Australian Department of Water and Environmental Regulation (DWER). We demonstrated that Sentinel-2 satellite derived evapotranspiration and water quality products can be used to identify the sources of threats to estuary ecosystem health and water quality, and identify the impacts of increased irrigation, herbicide and pesticide use, and agricultural intensification. We found that evapotranspiration patterns can be used to identify potential sources of chemical and sediment inputs into at-risk estuarine environments and inform land water management. This research contributed actionable data products of: estimated soil and vegetation water usage, chlorophyll-a (Chl-a) concentrations in estuary water (phytoplankton abundance and biomass), and total suspended matter concentration (organic or inorganic sediment particles suspended) to DWER, to assist with decision making around future estuarine management. The three chosen estuary sites studied were the Martuwarra/Fitzroy estuary, Kuwinywardu/Gascoyne, and Miaritch/Oyster Harbour. The interpretation of the data products and the relationships between LULC water use and estuarine water quality at the sites will be discussed, as will other environmental applications of satellite evapotranspiration products.

An Update on Plant Water Status Measurements at the TERN Fletcherview Tropical Rangeland Supersite

Beng Umali[1]

[1]ICT International

This short presentation will showcase the latest collaborative field work involving measurement of plant water status using sap flow and psychrometer sensors at the Fletcherview Tropical Rangeland Supersite. The University of Southern Queensland, James Cook University and ICT International have teamed up to measure water status of over a dozen plants consisting of 3 tree species and the dominant Carissa saltbush. The work is to support USQ's research goal towards evapotranspiration (ET) partitioning in a savannah woodland. Insights about installation protocol, maintenance of instrument and initial data will be presented. A discussion on future work involving remote access to data will also be given.

Representing fundamental eco-physiological processes to improve evaluating climate change consequences on ecosystems and orchard systems

Dr Shuangxi Zhou[1,2], Prof Iain Prentice[1,3], Prof Belinda Medlyn[1,4], Dr Everard Edwards[2], Dr Rob Walker[2]

[1]Macquarie University, Sydney, Australia, [2]CSIRO, Adelaide, Australia, [3]Imperial College London, Ascot, United Kingdom, [4]Western Sydney University, Penrith, Australia

The global carbon and water cycles are governed by the coupling of CO_2 and water vapour exchanges through the leaves of terrestrial plants, controlled by plant adaptations to balance carbon gains and hydraulic risks. Process-based models must be informed by experiments on fundamental eco-physiological processes to determine the differential drought resilience of plants and ecosystems from different climates. We tested whether variable drought sensitivities are needed to explain the observed large-scale patterns of drought impact on the carbon, water and energy fluxes. We found that high drought sensitivity at the most mesic sites, and low drought sensitivity at the most xeric sites, was necessary to accurately model responses during drought. Here, this presentation will demonstrate what and how experimentally derived quantitative information can improve the representation of stomatal and non-stomatal photosynthetic responses to drought in large-scale vegetation models. In particular: (1) Which photosynthetic processes are affected under short-term drought? (2) How do the stomatal and nonstomatal responses to short-term drought vary among species originating from different hydro-climates? (3) Do plants acclimate to prolonged water stress, and do mesic and xeric species differ in their degree of acclimation? (4) Does inclusion of experimentally based plant functional type specific stomatal and non-stomatal response functions to drought help Land Surface Models to reproduce key features of ecosystem responses to drought? The experiment-model integration, and the below-ground considerations, will interest audiences of monitoring, evaluation and/or decision-making backgrounds.

Session 4

Session 4: **Biodiversity stewardship**

Session 4 chair - Dr Matthew Luskin *The University of Queensland*

Matthew is the Director of the Wildlife Observatory of Australia (tern.org.au/wildobs), a Senior Lecturer at The University of Queensland, a current ARC DECRA fellow, and a Chief Investigator at the UQ Centre for Biodiversity and Conservation Science. Matthew obtained BAs from UCLA in Economics and Geography and a PhD from UC Berkeley's Dept of Environmental Science, Policy and Management. Before coming to Australia, Matthew spent 5 years with the Smithsonian Institution's Forest Global Earth Observatory and conducted fieldwork in a dozen tropical countries. Matthew's lab (www.ecologicalcascades.com) focuses on wildlife and plant-animal responses to global change.

Conservation and ecosystem research at the arid zone research centre Nanya Station

Prof Thomas Baumgartl[1], A/Prof Philip Barton[2], Prof Singarayer Florentine[1], Dr Vilim Filipovic[1]

[1]Federation University, Churchill, Australia, [2]Deakin University, Geelong, Australia

Nanya Station lies in the Scotia mallee region of far western NSW. It is a unique system of natural salt lakes and old growth Mallee. The station contains a variety of intact ecosystems with a landform representative of the Australian desert dunefields. Federation University has owned the 40,000 ha property since the early 2000s, which is used for education and research. Although early European grazing at Nanya Station was limited due to unsuitable feed and limited water supplies, it did nevertheless alter the landscape. Protection from all grazing and other pests (for example goats), with large areas that have been not burnt for over 100 years, has created a matrix of mallee patches of unique ecological value and high diversity. Research at Nanya Station investigates and monitors the role of conservation for the recovery of ecosystems and their transitional change from land previously used for grazing. Despite the adaptation of these ecosystems to variability in climate, the consequences of climate change for biodiversity and ecosystem functions are not well understood. Current and future research aims to incorporate and highlight consequences from climate change for the stability of the landform and services it provides and develop potential adaptation strategies for the mitigation of impacts that could also be applied to other similar environments. The presentation provides an overview of Nanya research Station and will highlight some of the initial soil hydrological research of the dune environment, which is currently underway.

Koalas, friends, and foes - the application of airborne eDNA for the biomonitoring of threatened species

A/Prof. Celine Frere[1], Dr Nicola Kent[1], Alejandro Oliveros Sandino[1], Jarred Moreno[1], Dr Sarah Ball[1], Dr Daniel Powell[1]

[1]University of Queensland, St Lucia, Australia

Perched high up in a *Eucalyptus* tree, swaying from side to side, lies a sleepy koala unaware of the means spent each year trying to obtain accurate baseline information about its presence. We have thrown all we could at it, from wildlife surveys to night spotting, bioacoustics, detection dogs, and drones equipped with thermal cameras. Yet, whilst critical to its conservation and management efforts, finding a koala remains an ambitious, time-consuming, and costly endeavour often producing insufficient results. However, little did we know that traces of koalas' presence and that of its predators along with other native, domesticated, and invasive species, float in the air and can be detected using metagenomics. This study and despite high levels of co-sampled non-target DNA (e.g. humans and domesticated animals) confirms that koalas, species belonging to the wallaby and possum family and threats such as domestic dogs (a major predator contributing to koala population declines) can successfully be detected by sampling airborne particles. Together, it demonstrates the potential of airborne eDNA for the detection of terrestrial wildlife under natural conditions and presents achievable optimisation steps to increase its field applicability and validity.

Session 4

Advancing conservation of threatened species on Australian islands

Prof. Salit Kark[1]

[1]University of Queensland, St Lucia, Australia

Islands are some of Earth's most precious, rich and unique natural environments, yet islands are also prone to many threats, such as biotic invasions, overharvesting, land use change and climate change. Australia has over 9000 islands ranging from large to small, nearshore to offshore and tropical to sub-Antarctic. Our team developed and analysed the first database of threatened species on Australian islands, which helps better direct conservation and management actions and efforts across islands. Ambitious projects, such as the removal of invasive species from large islands, have achieved significant conservation wins for diverse island landscapes and stakeholder groups. Because different islands often share similar challenges, national and regional frameworks to support collaborations to address both human and biodiversity needs, joint research, and information sharing across islands can help address the diverse and often complex environmental challenges facing islands and their people. Frameworks that can be applied across Australia are required and include knowledge, data, and experience sharing that can help disseminate the lessons learned from island projects, their success and challenges, among island stakeholders. We provide examples from our work in Norfolk Island, Minjerribah (North Stradbroke Island)) and other islands around Australia and beyond and present the new database and the opportunities it provides.

LTER Research in the Wet Tropics

A/Prof. Michael Liddell[1], Dr Nara Vogado[1]

[1]James Cook University Cairns, Australia

The Wet Tropics of Far North Queensland is an international biodiversity hotspot with 700+ endemic plants and 49 endangered species. Climate change is expected to impact this repository of biodiversity. The tracking of changes in floral and faunal biodiversity requires a long term ecological research (LTER) effort. Research activities in the latter part of the 20th century established a solid baseline understanding of biodiversity in this region. In 2000 the first LTER science station was established in the Wet Tropics at Cape Tribulation. This station, now called the Daintree Rainforest Observatory, continues to provide high quality science outputs. This talk will provide an update of LTER activities in the Wet Tropics and how phenocams are enabling the plant community to be tracked through time. The importance of ground truthing conclusions drawn from sensor data using classical field based methods will also be discussed. The wrap up will expose the clear and critical data gaps that are currently undermining conservation success in this region.

Assessing Physiological Fitness of Wildlife Using Conservation Physiology (Endocrinology) Tools

Edward Narayan[1]

[1]The University of Queensland, Gatton, Australia

In today's world of rapid expansion of human population, animals are facing increased pressure from human induced changes in the environment. The questions that often remain unanswered are: can animals perceive environmental change; do they have the capacity to adjust to human related environmental change; and if adaptation does not occur then what are the likely consequences? These research questions are relevant to animal welfare science and have been explored using several animal models. Our research program focuses on the theme of stress. Stress occurs as a result of any unpleasant change in an animal's surroundings, and it creates a physiological response. One of the key neuroendocrine systems that is responsive to stress is the hypothalamus-pituitary adrenal (HPA) axis. Activation of the HPA-axis during stress results in the secretion of stress hormones such as glucocorticoids. With the current modern technological advancements in biomarker detection techniques, steroid metabolites can be readily measured in non-invasively obtained samples such as urine, faeces and hair. This technique is 'welfare friendly' and it can be applied to animal study systems to explore specific research questions related to stress. This method provides a quantitative way of profiling the stress responses of individual animals within a population, distinguishing between acute and chronic stress and also establishes relationships with animal health and behaviour. In this presentation, I discuss this topic of stress physiology in the context of animal welfare by exploring the applications of noninvasive hormone monitoring techniques in wildlife models. I will discuss how this field of research can be used to increase our understanding of animal response to environmental change using examples of koalas in relation to environmental trauma and disease.

Session 4

Microclimate in the Australian Wet Tropics in a warming world

Dr Arun Singh Ramesh[1], Dr Alexander W. Cheesman[2], A/Prof. Lucas Cernusak[2]

[1]TERN, Brisbane, Australia, [2]James Cook University, SmithField, Cairns, Australia

Tropical rainforest ecosystems are projected to become warmer by ca 4°C towards the end of this century. Such an increase in surface warming will have dire consequences on key ecosystem processes and likely alter the future landscape of tropical rainforests. However, our ability to predict changes in key ecological processes such as seed germination or sapling growth is limited by paucity of data relating to in-situ microclimate to better inform species distributions across space and time. Here, we present a snapshot of high-resolution microclimate data currently being monitored along an elevation gradient since 2019 in the Australian Wet Tropics World Heritage Area. We present trends in Soil, near Surface and above ground Air temperatures and discuss key bioclimatic variables for Soil and Air that are important to consider in ecological studies. We also discuss possible collaborative opportunities of using these long-term measures of microclimate from the Terrestrial Ecosystem Research Network, Data Discovery Portal platform to forecast rainforest microclimates and improve projections in bioclimatic models via machine learning..

Microbat Monitoring for the ILTER-EAP Region

Prof. Simon Robson[1], Prof. Will Edwards[2]

[1]Central Queensland Univeristy, Townsville, Australia, [2]James Cook University, Cairns, Australia

Bats comprise approx. 20% of the world's mammal biodiversity and Southeast Asia is a global hotspot for bat diversity. Unfortunately, many of the almost 400 species are highly threatened with approx. 23% of Southeast Asian species predicted to become extinct by 2100. Understanding population status and change over time is vital for effective conservation as species' abundances and range extents shift in response to changing climates. Here we report on an initiative to establish a multinational microbat remote monitoring network across ILTER-EAP members (Philippines, Thailand & Vietnam, plus Australia). The program will provide ultrasound recording equipment and in-field training to generate baseline data enabling understanding of state and change in bat species populations across relevant spatial scales. This proposal builds on existing Australian-based work utilising new approaches for bat acoustic monitoring and survey. Further, the project will strengthen connection across ILTER-EAP members, and other science networks (i.e GBatNet, SEABCRU), and provide opportunity for training undergraduate, postgraduate and early career researchers in ecological, data-science and machine learning domains.

Session 5

Session 5: **Technology for conservation, AI, ML, and associated data challenges**

Session 5 chair - Dr Will Woodgate *The University of Queensland*

Will is a University of Queensland Amplify Research Fellow and recent ARC DECRA holder (DE190101182). His research aims to bridge scales for remotely sensing dynamic vegetation productivity and health. Will is the Principal Investigator of the TERN-OzFlux Tumbarumba tall forest research site. Now in its 23rd year it is one of Australia's longest continuously running flux tower sites and rated equal second globally for verification of environmental satellite products. Previously Will held the position of Research Scientist at CSIRO, after commencing as a Postdoctoral Research Fellow in 2015.
Will has experience with a range of passive and active remote sensing technologies including combining LiDAR, optical and thermal-imagery for estimating vegetation structure and function. His current research focus is scaling observations of sun-induced chlorophyll fluorescence (SIF) from leaf to canopy scales at flux tower sites.

The Wildlife Observatory of Australia: the camera trap database solution

Dr Thomas Bruce[1], Dr Matthew Luskin[1]

[1]University of Queensland, St Lucia, Australia

Camera traps have become an invaluable tool for wildlife monitoring, generating millions of images annually. However, effectively storing, processing, and sharing these vast datasets poses significant challenges. The Wildlife Observatory (WildObs) is an innovative data system designed to address these challenges and revolutionise wildlife camera data attribution, management, and analysis while cementing Australia's reputation as a global leader in the wildlife camera space. WildObs aims to benefit Australian conservation efforts by providing unprecedented access to the continent's rich camera trap data. The initiative brings together government agencies, industry partners, non-profit organisations, and academic institutions to establish a comprehensive database and a user-friendly analysis hub. This collaborative effort enables efficient knowledge creation and sharing about wildlife distributions and population trends, benefiting various stakeholders, including research communities, government bodies, conservation managers, indigenous groups, and industries such as forestry and sustainable energy generation. By leveraging WildObs, decision-makers in Australia gain access to relevant and nuanced analyses of diverse wildlife metrics at an accelerated pace compared to traditional methods. This pioneering observatory holds global significance and promises substantial societal impact beyond academia.

Integrating biodiversity data with genomic data: the Australian Reference Genome Atlas (ARGA)

Dr Kathryn Hall[1], Matt Andrews[1], Keeva Connolly[2], Yasima Kankanamge[1], Christopher Mangion[2], Winnie Mok[2], Dr Lars Nauheimer[1], Sarah Richmond[3], Goran Sterjov[1], Dr Nigel Ward[2], Peter Brenton[2]

[1]Atlas Of Living Australia, Australia, [2]Australian BioCommons, Australia, [3]Bioplatforms Australia, Australia

Genomics (and genetics) is used widely within biosciences to inform taxonomy, infer phylogeny, and guide conservation decisions. Increasingly, Australia's 15,000 biosciences researchers also employ genomics tools to study factors conferring environmental resilience, to ensure biosecurity for Australia's ecosystems, and to drive improvements in crops and livestock breeding. Locating genomics data is a significant impediment for researchers: while data are online, repositories are largely disconnected and data are formatted differently depending on their type and source. This means that genomics data are hard to find and do not interoperate with occurrence and ecological datasets. The Australian Reference Genome Atlas (ARGA) has been developed to overcome the barriers faced by researchers in finding and collating genomics data for Australia's species within context. We have built a novel data model and framework to integrate genomics data from domain-specific repositories and align it with Darwin Core formatted occurrence records, and other biodiversity data, from the Atlas of Living Australia and other sources. ARGA indexes data from a comprehensive suite of genomics repositories, including NCBI GenBank, Bioplatforms Australia, BOLD Systems, DNA Zoo and EMBL-ENA. The portal allows users to find data from these sources, cross-referenced with occurrence data from collectories, like museums, herbaria and biobanks. We have built custom filters using authoritative lists, covering management traits, such as conservation status and bushfire vulnerability, as well as ecological information relevant to habitat, biomes and ecosystems. Under the hood, ARGA integrates data via a series of ingestion scripts implementing customised field mappings to harmonise genomics, ecological traits and occurrence data within an extended Darwin Core Event framework. In this presentation, we demonstrate the ARGA platform and highlight three key use cases:* finding taxa of interest;* browsing genomic data based on management group; and* calculating metrics for data availability for a specific geographic region.

Session 5

eDNA Metabarcoding : a new approach to the monitoring of mine site restoration

A/Prof. Paul Nevill[1], Dr Mieke van der Heyde[1], Prof. Michael Bunce[1], Dr Grant Wardell-Johnson[1], Dr Nicole White[1], Dr Kristen Fernandes[1], Prof. Kingsley Dixon[1]

[1]Curtin University, Perth, Australia

Monitoring is critical to mine site restoration as it enables tracking of restoration trajectories, adaptive management, and assessment of whether goals are reached. However, traditional monitoring approaches are time-consuming and expensive, and so are rarely undertaken effectively. Application of molecular tools has made important contributions to understanding restoration success, and eDNA metabarcoding is a relatively recent tool used to monitor ecosystem recovery. Here, I will discuss our application of eDNA metabarcoding to monitoring the recovery of everything from soil microbes to mammals at mine sites in Western Australia. Findings from numerous studies suggest that implementing eDNA-based surveys in restoration monitoring requires informed design. DNA-based biomonitoring of ecological restoration can increase the scope of biomonitoring but requires careful consideration of survey design.

Miniaturised sensing and machine learning for rapid assessments of soil health indicators for mine site soil rehabilitation

Dr Zefang Shen[1], Prof Raphael A. Viscarra Rossel[1], Dr Haylee D'Agui[2], Dr Lewis Walden[1], Dr Mingxi Zhang[1], Tsoek Man Yiu[1], Prof Kingsley Dixon[2], Prof Paul Nevill[2,3], Dr Adam Cross[2,4], Mohana Matangulu[1], Yang Hu[1]

[1]Soil and Landscape Science, School of Molecular and Life Sciences, Faculty of Science and Engineering, Curtin University, Perth, WA 6845, Australia, [2]ARC Centre for Mine Site Restoration, School of Molecular and Life Sciences, Faculty of Science and Engineering, Curtin University, Perth, WA 6845, Australia, [3]Trace and Environmental DNA Laboratory, School of Molecular and Life Sciences, Faculty of Science and Engineering, Curtin University, Perth, WA, 6845, Australia, [4]EcoHealth Network, Brookline, USA,

Mining can cause severe disturbances to the soil. Post-mining rehabilitation relies on measuring soil properties that are critical indicators of soil health. Soil visible–near-infrared (vis–NIR) spectroscopy is rapid, accurate, and cost-effective for estimating a range of soil properties. Recent advances in infrared detectors and microelectromechanical systems have produced miniaturised and relatively inexpensive spectrometers. However, their capability of predicting soil health indicators for mine site rehabilitation has not been assessed. We sampled topsoils from undisturbed native vegetation (reference) and stockpiles from seven mines in Western Australia. Spectra were collected using one miniaturised visible, three miniaturised NIR spectrometers, and a full-range vis–NIR spectrometer for modelling 29 soil physical, chemical, and biological properties used to assess soil health at mine sites. We evaluated the spectrometers' repeatability and accuracy in spectroscopic modelling using seven statistical and machine learning algorithms. The spectra from the visible spectrometer could estimate sand, silt, and clay with similar or better accuracy than the NIR spectrometers. However, the spectra from the NIR spectrometers produced better estimates of soil chemical and biological properties. By combining the miniaturised visible and NIR spectrometers, we improved the accuracy of their soil property estimates, which were similar to that from the full-range spectrometer. The miniaturised spectrometers and combinations predicted 24 of the 29 soil properties with moderate or greater accuracy (Lin's concordance correlation coefficient, CCC ≥ 0.65). The repeatability of the NIR spectrometers was similar to that of the full-range, portable spectrometer.The miniaturised NIR spectrometers produced comparably accurate soil property estimates to the full-range portable system which is an order of magnitude more expensive, particularly when combined with the visible range sensor. Thus, the miniaturised spectrometers could form the basis for a rapid, cost-effective soil diagnostic capacity to support mine site rehabilitation and deliver positive economic and environmental outcomes.

Extracting value from TERN Landscapes datasets through server side geospatial processing operations.

Ashley Sommer[1]

[1]CSIRO, Dutton Park, Australia

Many of the time-series datasets published by TERN Landscapes are very high spatial resolution. When combined with the temporal dimension, the datasets can be tens of terabytes in size. While the files are published in the form of Cloud Optimised GeoTIFFs and can be used in-situ online, users have expressed their desire for a way to exploit the data products in a more targeted manner. The ability to subset a dataset spatially with user-provided polygon bounds, aggregate statistical data for a region over time, or extract a time-series from a given point, were the most desired features. These kinds of derived data are generally not pre-computed but are delivered by a service that ingests the base dataset, slices it, computes it, and packages the response on-the-fly. The OGC Web Processing Service (WPS) specification is a protocol that allows a server to expose these kids of operations (processes) and a standardised way for client applications to execute these operations and download the results. While the delivery of a TERN Landscapes WPS server in itself is useful, as an API and protocol it by itself is not usable to the majority of users. To complete the feature set, we added support to the Landscapes Explorer web app to execute operations on the WPS server, written example Juypyter Notebooks show how to use the service with Python, and we published the Landscapes Cookie Cutter app, an example of a simple tool that allows users to drag-and-drop shapefiles to run operations and Landscapes datasets and download the results.

Session 5

Applying Open Science: tools for researchers and research teams

Dr Alison Specht[1], Shelley Stall[2], Dr Laurence Mabile[3], Dr Solange Santos[4], Nobuko Miyairi[5], Dr Romain David[6]

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The UNESCO Recommendation on Open Science (2021) states that increased openness leads to increased transparency and trust in scientific information. The key pillars of their argument are that open science knowledge can be achieved through open scientific publications, open research data, open-source software and source code, and open science infrastructures. From the very beginning of the research process, the researcher takes advantage of the open science practices of the research community by sourcing literature, and possibly even examining previous work openly accessible. Their own contribution to the open information world is fairly well established in the journal publication process (the importance of the citation of others' work, for example, is well understood) but is less well established for data and software outputs. This paper describes an initiative of a multinational project funded by the Belmont Forum in which data scientists worked alongside researchers in a multi-disciplinary project to develop ways to enhance open science practices. We have done this in two ways, first by applying an interactive Data and Digital Object Management Plan, and second by devising a series of intuitive checklists to make open science practices easy. Diagnosing the pressures of 'classical' research work and the research environment, this series of checklists (translated in five languages) is aimed to assist the researcher and the research team to be pro-active in open science. They enable (a) the researcher to ensure the entirety of their work is discovered, and they gain credit for it, and (b) the team to work openly and collaboratively. We have harnessed existing infrastructure such as ORCID, collaborated with the World Data System, and have worked with DataCite to develop a tool that captures researchers' data and code outputs. Effective application of open science practices enhances the researcher's career, and smooths the management of a research project.

Session 6

Session 6: **Ecosystem monitoring, assessments and reporting**

Session 6 chair - Dr Tim Clancy *Department of Environment, Parks and Water Security, Northern Territory Government*

Tim Clancy (BSc Hons PhD EMPA) is the Manager Wildlife Use and Pest Animals at the Northern Territory's Department of Environment, Parks and Water Security, and is responsible for science-based management of a range of sustainable use programs including the saltwater crocodile, magpie goose and bush tucker. His role involves monitoring key species and pest animals across the Top End as well as maintaining strategic partnerships with a range of stakeholders including Aboriginal landholders and organisations.
He is a University Fellow at Charles Darwin University and Honorary Terrestrial Ecosystem Research Network (TERN) Fellow.
Dr Clancy was previously Director of TERN, an Australian Government-funded research infrastructure project creating a national approach for collaborating and sharing the multiple disciplines of ecosystem data from 2011 to 2016.
Prior to this Dr Clancy had six years as Director of the Arthur Rylah Institute for Environmental Research in Victoria. Other roles include principal ecologist with NSW State Forests and Manager of the Threatened Species Unit for the Queensland Department of Environment and Heritage.

AusCalVal: Australia's national facility for Earth Observation calibration and validation

Andy Allen[1], Dr Matt Garthwaite[1], Dr Alex Held[1]

[1]CSIRO, Black Mountain, Australia

Australia is reliant on international satellite missions and partners for Earth Observation (EO) data that is used extensively for research activities and critical government services delivered by organisations such as Geoscience Australia and the Bureau of Meteorology. Australia's southern hemisphere position and diverse range of climatic and ecosystem environments presents a globally unique offering for the quality assurance of data from EO satellite missions. Through our highly capable expertise and existing infrastructure in Australia is contributing value back to the international community and opportunity exists to further solidify our position as a world leader in EO calibration and validation (cal/val).In 2021 FrontierSI published the AusCalVal report which outlines the vision from the Australian EO community for a coordinated national facility for EO cal/val that enhances the existing network of infrastructure through centralised communication and advocacy, consistency and standardisation of products, and investment to provide continuity of funding as well as to uplift infrastructure to deliver an operational service. CSIRO Space and Astronomy began implementation of the AusCalVal Facility in 2022 with the goal of supporting a sustained network of sites across Australia for calibration of Earth observation sensor data and validation of derived products. This includes providing free and open access through a single interface to the routinely acquired, quality assured and consistent calibration and validation data for use by government, international partner, industry and research customers. In this presentation we will give an overview of the CSIRO AusCalVal facility and plans for future activities and investment.

ForestGEO in Australia: The Starvation Creek Forest Dynamics Plot

Prof. Patrick Baker[1]

[1]University Of Melbourne, Richmond, Australia

The Forest Global Earth Observatory (ForestGEO) is a network of large-scale, long-term forest dynamics plots (FDPs) and collaborating scientists that spans all of the major forest types in the world. The ForestGEO network has 75 plots that include ~7.5 million trees from 12,000 tree species. Initiated in the 1980s to focus on the dynamics of species-rich tropical forests, ForestGEO has expanded into temperate zone forests over the past 20 years. However, ForestGEO has not had any FDPs in Australia. Here I describe the first ForestGEO plot to be established in Australia – the Starvation Creek FDP – a 16-ha plot in low-elevation, mixed eucalypt forest east of Melbourne. Initiated in 2021, the initial census of the Starvation Creek FDP was completed in 2023. The plot provides unique opportunities for research and education in a structurally, floristically, and historically complex temperate forest. I present an overview of the plot, describe initial results from the first census, and discuss the range of long-term studies that have been initiated at the plot.

Session 6

Monitoring and experimental exploration of Australia's mountains with the Australian Mountain Research Facility

Dr Zach Brown[1], A/ Prof. Susanna Venn, Prof. Mark Hovenden

[1]Australian National University, Canberra, Australia

The Australian Mountain Research Facility (AMRF), launched in late 2022, consists of a replicated array of monitoring sites spread across four jurisdictions as well as a range of infrastructure for controlled simulations of future climate scenarios. AMRF recognises that predictive capacity around biophysical and biological feedbacks is limited by a lack of observational and experimental infrastructure and seeks to provide unified infrastructure, support excellent science and lead to effective management solutions to future-proof our mountains. AMRF was built with support from ARC LIEF funding and data streams will be publicly available. The sites also provide an opportunity to bring together researchers of diverse disciplines for field studies and to catalyze interdisciplinary work. We'll provide an overview of the monitoring network and manipulative climate experiments and present some examples of research that is being undertaken across the AMRF.

Increasing awareness, accessibility, stewardship, capability, and natural resource data collection through design—the Land Condition Assessment Tool

Robert Hassett[1]

[1]Queensland Department of Agriculture and Fisheries

The land condition assessment tool (LCAT) was developed in 2020 by the Queensland Department of Agriculture and Fisheries (DAF) to support a range of sustainable land management, and other rapidly emerging natural resource initiatives. The LCAT was deliberately designed to fill the niche space between time-consuming and complex qualitative methods, and rapid, and more subjective, qualitative methods. The LCAT is an enabler of increased knowledge and awareness, the collection of land condition, land resource, and natural capital data, analysis, and communication. Through integration of a science-based assessment framework, simple and intuitive design, contemporary technology, and provision of immediate in-field results, it provides greater accessibility to a wider-range of users. Whether novice or experienced; interested citizen or research scientist; for general interest or research, development, and reporting—it strikes a balance between comprehensive and fewer assessments, and an acceptable minimum dataset and greater volume of assessments. Operating on mobile devices, user's answer 'questions' related to long-term indicators of land condition, by selecting pictograms (stylised pictures) representing otherwise complex, science-based concepts and land condition values. A framework of 380 indicators and values; more than 1,400 plant species; 4,500 weightings; and 300 algorithms; are calibrated to generate fifteen purpose-specific results related to grazing land management, ecological risks and processes, landscape stability, and indicative natural capital and indicative carbon store. In 2 ½ years, more than 200 users have assessed nearly 6,000 sites across Queensland—the largest contemporary dataset of its kind. Data and results have been used to support Queensland and Australian government Paddock to Reef and Natural Resource Investment programs; calibrate and validate private and government developed remote sensing and modelling products; support management practice change and evidence-based decision making; and enhance stewardship and awareness of the current state, and emerging impacts on our natural resources—through the simplicity and accessibility of design.

Erosion rates reveal tectonism influences the short and long-term variability of a rocky coastline

Dr Jokotola Omidiji[1], Prof Wayne Stephenson[1], Prof Mark Dickson[2], Prof Kevin Norton[3]

[1]School of Geography, University of Otago , Dunedin, New Zealand, [2]School of Environment, University of Auckland, Auckland, New Zealand, [3]School of Geography, Environment and Earth Sciences, Victoria University of Wellington, Wellington, New Zealand

On tectonically active rock coasts, there is a dearth of erosion data documenting how rocks adjust in response to marine and sub-aerial processes immediately after coseismic uplift. Here we report erosion rates and evidence of reshaping of shore platform morphology on shore platforms using the micro-erosion meters (MEM) and Structure-from-Motion Multi View Stereo (SfM-MVS) surveys at Kaikōura and Kahutara Point Māhia Peninsula, on the east coast of the South and North Islands of New Zealand. At the Kahutara Point, a 3.1 m coseismic event around 100 to 300 years ago lifted a vast expanse of seafloor into the intertidal zone and created the anomalously wide inter-tidal shore platform. In comparison, at Kaikōura, a 7.8 Mw earthquake in 2016 (six years ago) uplifted all platforms by ~1 m and extended the widths of a few platforms. Four-years post-uplift MEM erosion data from Kaikoura show a resetting of erosion rates and faster rock breakdown on both mudstone and limestone lithologies compared to pre-uplift rates. Over the 4-year period, surface downwearing rates for all platforms was 2.25 mm/yr, a 104% increase from a pre-uplift rate of 1.10 mm/yr. At the Kahutara Point, erosion rates measured from the inter-tidal mudstone shore platforms ranged from 0.069 to 5.820 mm/yr, with a mean annual erosion rate of 1.937 mm/yr. Results reveal a comparable pattern of erosion response at both sites following coseismic uplift and imply a centennial scale response time at Mahia that would have implications for erosion timescales at Kaikoura. The SfM-MVS derived orthomosaics revealed evidence of changing rock morphology and processes such as intense granular disintegration, flaking, algal growth, and boring. On tectonically active rock coasts, the strong fluctuations in erosion rates and platform morphological expressions indicate the actions of not only waves, tides, and weathering processes but also tectonics in shore platform development.

Session 6

Korea ecological research network: Developing national ecosystem Observatory

Dr Jeongsoo Park[1], Jea-yeon Lee, Dr. Hyohyemi Lee

[1]National Institute Of Ecology, Seocheon-gun, Republic of Korea

Dramatic climate change is posing severe threats to the stability of ecosystems and biodiversity. According to the 2022 Climate Change Report by the Intergovernmental Panel on Climate Change (IPCC) under the United Nations, the scope and scale of the impact of climate change on the ecosystem are larger than previous estimates. In developed countries, an ecological observation center is established and operating to monitor the signs of ecosystem change to cope with the impact of climate change. The United States operates the National Ecological Observatory Network (NEON), which includes 81 observatories across the continent, while Australia operates the Terrestrial Ecological Research Network (TERN), which connects 13 aircraft bases and 16 super-sites. In South Korea, as part of a national long-term ecological research program, an ecological observatory has been operated since 2012 on Mt. Jeombong, a deciduous broadleaf forest in the central part of the Korean Peninsula. To evaluate the carbon cycle of this forest ecosystem, we have established a carbon uptake monitoring system (CO2 flux tower and soil respiration measurement) and a hydrological observation system (V-notch weir). However, in order to effectively respond to climate change, we have developed a plan to expand the number of ecological observatories and metrics by 2026. We are planning to build an ecological observation station at more than five points in the major ecosystem of the Korean Peninsula and an integrated information management system including a network of ecological observatories. The Integrated Climate-Ecological Information Management System will serve as an observation center for ecosystem responses and carbon transfer due to climate change and will provide a direction for nature-based climate change response.

Improved monitoring of ecosystem resilience using high-resolution remote sensing

Laura Sotomayor[1], Prof. Arko Lucieer[1], Dr Teja Kattenborn[2], Dr Darren Turner

[1]University of Tasmania, Hobart, Australia, [2]Remote Sensing Centre for Earth System Research (RSC4Earth), Leipzig University, Germany

Terrestrial ecosystems are prone to impacts from global climate change, such as shift in rainfall and temperature, and rising levels of atmospheric carbon dioxide (CO2) concentration. Monitoring terrestrial ecosystems has become important to decisionmaking by governments and to establish sustainable development goals to effectively manage natural resources and assess their condition for rapid environmental changes. Environmental mapping is very important for the assessment of vegetation health. Healthy vegetation plays an important role in carbon stock, where an increase in cover is linked to a global increment in biomass carbon. Therefore, assessment of vegetation biomass is key to quantify carbon stocks capacity and maintain the stability of terrestrial ecosystems. Consequently, there is a need to accurately map ecosystems composition, structure, and function at a range of spatial and temporal scales to understand the effects of land use and climate variability. Drone remote sensing technologies provide new opportunities to capture the fine-scale spatial variability of vegetation. These drone products allow to derive ecological variables (i.e. Fractional Vegetation Cover (FVC)), biophysical variables (i.e. aboveground biomass) and biochemical variables (i.e. leaf chlorophyll content). The calibration and validation of drone products (at local scale) are suitable to upscale field observations to coarser spatial scale satellite observations leading to a better understanding of the vegetation product at national scale for further change detection analysis. This research will advance understanding of ecosystem composition, structure, and function by developing remote sensing algorithms to assess terrestrial ecosystems across a variety of Australian environments. The project will utilise advanced deep learning techniques to derive ecosystem information from raw drone data. Aiming to deliver automated workflows to assist in systematic assessment of ecosystem health and contribute to validation of satellite observations. A framework will be modelled to investigate the potential of Deep Learning methods for generating FVC Products using drone data.

Sap flux measurements in ET partitioning: A Revisit and Implication to Terrestrial Ecosystems Monitoring

Dr Beng Umali[1]

[1]ICT International, Armidale, Australia,

Meaningful partitioning of evapotranspiration involves accurate measurement of stand transpiration. One approach for measuring stand transpiration that has gained popularity is using sap flow sensors on trees which is then scaled up to represent stand-level transpiration. Stand transpiration becomes an integral information for ecological water balance and in managing water resources in built environments (e.g. crop water requirement). This paper summarizes past and recent works that coupled sap flux and eddy covariance measurements. Key techniques in sap flux measurements on trees and other plant species that have been employed in these studies will be discussed. Sampling intensities and treatment of measured data prior to scaling up will also be scrutinized in this review. The limitations of the approach and how these can be overcome are also discussed. This will then highlight best practices in the use of sap flux measurement in estimating stand transpiration in the context of terrestrial ecosystems monitoring. A new breed of sap flux sensors that integrates both Internet-of-Things technology and cloud computing will also be presented.

Session 6

Improving the accuracy and utility of the Habitat Condition Assessment System (HCAS) as a national tool for monitoring ecosystem condition using satellite-based remote sensing

Dr Kristen Williams[1], Dr Simon Ferrier[1], Peter Lyon[6], Dr Eric Lehmann[4], Dr Thomas (Tom) Harwood[5], Dr Thomas (Tom) Van Neil[3], Dr Kate Giljohann[2], Dr Roozbeh Valavi[2], Dr Ning Liu[1], Dr Glenn Newnham[2], Mathew (Matt) Paget[1], Luke Pinner[6], Cassandra Malley[6], Dr Rebecca (Becky) Schmidt[1], Dwaipayan (Dave) Deb[6]

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Land surface temperatures across Australia have warmed by about 1.47°C ± 0.24 °C on average since records began in 1910. Changes to rainfall quantities and patterns have also been experienced variously across the continent since the 1970s (State of the Climate 2022, CSIRO & Bureau of Meteorology). This change has ecological consequences and a burgeoning literature has explored the implications for biodiversity and options for management. While considerable investment has been directed toward forecasting how climate influences species and ecosystem redistributions under various change scenarios in Australia, few studies have applied the same methods to hindcast how much ecological change has already occurred. Given substantial recent improvements in access to extensive historical aggregations of biological data; for example through the Atlas of Living Australia; and high resolution environmental datasets; for example through the TERN soil and landscape grid; an opportunity exists to develop and test methods used to measure the implications of climate on biodiversity by examining types of change that have already occurred, to what extent and where. In this project we examined the historical record of climate and investigated the potential ecological consequences of these changes using Generalised Dissimilarity Modelling. The project identified areas under ecological pressure, and developed new metrics to better describe this change. We also developed, implemented and tested a new approach to modelling which works with the time series of climate to model conditions immediately before each species observation. This new approach demonstrates an improvement over simpler models and offers significant potential for further application.

Session 7

Session 7: **Ecosystem monitoring, assessments and reporting**

Session 7 chair - Adjunct Prof. Mike Grundy *The University of Sydney*

Adjunct Professor, School of Agriculture, The University of Sydney; Member Wentworth Group of Concerned Scientists; Specialist Advisor TERN. 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 Standards and Accreditation 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 recently a proud grandfather of three and that role is becoming an increasing obsession!

Spectral colour calibration of phenocam imagery for enhanced vegetation change detection

Wesley Cooper[1], Dr Caitlin Moore[1]

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The study of phenology provides important insights on how species are reacting to changes in the global climate. Earlier onset of flowering has been documented in some plant species and attributed as a response to the changing climate. A valuable tool for automated vegetation phenology monitoring are field mounted digital cameras, known as phenocams. These cameras capture regular colour JPEG images during daylight hours. Colour indices, such as green chromatic coordinate (GCC) can be calculated from the phenocam images and used as indicators of change in plant phenology. To improve the detection of subtle changes in vegetation phenology from phenocams, including the accuracy of colour reproduction under all lighting conditions, a new method was tested using spectrally corrected raw images and calculating the hue of a colour as an index for identifying change. The colours recorded from the corrected raw images were a closer match to ground truth measurements than the JPEG images, with a mean colour difference (ΔE 2000) of 3.49 for the raw images, compared to a mean ΔE 2000 of 21.70 for the JPEG images. There was a significant difference ($p < .001$) between the GCC values calculated from raw and JPEG images, and for the hue values ($p < 0.001$). The hue values more closely followed the visible phenological events in the captured images than GCC, and showed a stronger signal for detecting changes that may otherwise be undetected. Spectrally corrected raw phenocam images were closer in colour to ground truth leaf measurements, more consistent under changing lighting, and hue displayed excellent potential as an index for detecting change in vegetation phenology.

TERN's collaboration with citizen scientists, industry, universities and government to develop and refine standardised ecological monitoring protocols for Australia

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TERN Adelaide and The Australian Government Department of Climate Change, Energy, Environment and Water have codesigned an innovative solution to the problem of monitoring the effectiveness of the billions of dollars spent on environmental management in Australia. Developed in collaboration with industry experts and on-ground practitioners, the Ecological Monitoring System Australia (EMSA) protocols are defining best-practice in ecological monitoring. This project combines widely accepted methods across 25 modules with next-generation technical solutions to create a system that enables data collection on a phone or tablet and synchronisation on a central database. In May 2021, TERN launched a citizen science project designed to test and refine the Bird survey protocol in the Vertebrate Fauna Module and at the same time collect biodiversity data. The project is based at the Queensland University of Technology Samford Ecological Research Facility (SERF) in peri-urban Brisbane and is being implemented by members of the Samford Eco Corridor community group. Citizen scientist expert birders undertake bird monitoring quarterly at SERF, providing feedback to TERN for the refinement of the standardised methods and associated progressive web application. Excitingly, this citizen scientist-collected long-term bird monitoring dataset is now available at the TERN Data Portal.

Session 7

The importance of precise quantification of water balance components in critical zone observatories: European perspective

Dr Vilim Filipovic[1], Vedran Krevh[2], Dr Jannis Groh[3], Prof Thomas Baumgartl[1], Dr Lana Filipovic[2], Dr Joan Cuxart[4], Dr Daniel Martínez Villagrasa[4], Prof Harry Vereecken[5], Dr Thomas Pütz[5]

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Precise quantification of water balance components provides essential information for water resource management, water availability assessments, hydrological modelling, environmental impact assessments, and climate change studies. Here, we represent the implementation of high precision weighable lysimeters at different critical zone observatories within different climatic zones in Europe. The CZO sites include SUPREHILL in Croatia, WET-ARID in Spain, as well as several sites from the TERENO-SOILCan lysimeter network in Germany. Highly precise and temporal resolved data from weighable lysimeters consider feedbacks across the entire hydrological cycle, from the soil to the atmosphere, allowing for a more holistic understanding of the dynamics of water flow and solutes (nutrient or contaminants) transport in soil. State-of-the-art weighable lysimeters are filled monolithically (undisturbed soil), equipped with a pressure-controlled lower boundary, and allow high precision and temporal resolution estimation of soil water storage changes and fluxes at the boundaries like rainfall, drainage, evapotranspiration, upward direct water form capillary rise, and non-rainfall water inputs (i.e., dew formation, fog, soil water vapor adsorption). Presented data regarding the soil water balance will be compared from different landscapes and networks that are important for understanding the hydrological cycle and for studying land-atmosphere interactions. The presented holistic datasets are crucial for developing and calibrating models, as well as quantification of soil-vegetation-atmosphere processes. The implementation of such systems within Australia would result in better understanding of water cycle allowing quantification of the impact of climatic extremes on ecosystems. There is a need to have a better understanding of non-rainfall contribution and its effects on ecosystem function in dry or drought prone environments.

Assessing the 2022 Flood Impacts in Queensland Combining Daytime and Nighttime Optical and Imaging Radar Data

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In the Australian summer season of 2022, exceptional rainfall events occurred in Southeast Queensland and parts of New South Wales, leading to extensive flooding of rural and urban areas. Here, we map the extent of flooding in the city of Brisbane and evaluate the change in electricity usage as a proxy for flood impact using VIIRS nighttime brightness imagery. Scanning a wide range of possible sensors, we used pre-flood and peak-flood PlanetScope imagery to map the inundated areas, using a new spectral index we developed, the Normalized Difference Inundation Index (NDII), which is based on changes in the NIR reflectance due to sediment-laden flood waters. We compared the Capella-Space X-band/HH imaging radar data captured at peak-flood date to the PlanetScope-derived mapping of the inundated areas. We found that in the Capella-Space image, significant flooded areas identified in PlanetScope imagery were omitted. Using VIIRS nightly imagery, we were able to identify grid cells where electricity usage was impacted due to the floods. These changes in nighttime brightness matched both the inundated areas mapped via PlanetScope data as well as areas corresponding with decreased electricity loads reported by the regional electricity supplier. Altogether we demonstrate that using a variety of optical and radar sensors, as well as nighttime and daytime sensors, enable us to overcome data gaps and better understand the impact of flood events. We also emphasize the importance of high temporal revisit times (at least twice daily) to more accurately monitor flood events.

Session 7

Enhancing the TERN Australia Soil and Herbarium Collection

Dr Donna Lewis[1,2], Sally O'Neill[1,2], Dr Katie Irvine[1,2], A/Prof. Ben Sparrow[1,2]

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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 that are available for researchers and practitioners to loan for further analyses. The TERN Australia Soil and Herbarium Collection comprises vascular plant voucher specimens, leaf tissue samples, soil samples and soil metagenomic samples and was officially opened in December 2022. In parallel, the vascular plant voucher specimen collection was registered with Index Herbariorum, a global network of herbaria. The TERN herbarium, comprising over 56,000 specimens from over 1,000 plots collected over 10 years, differs to that of a traditional herbarium because plant specimens are collected each time a plot is resurveyed. Voucher specimens are integral to cross-reference changes in plant classification over time and ensure currency and longevity of the data. To preserve and enhance the accessibility of vascular plant voucher specimens, TERN follows standard herbarium protocols. TERN recently commenced a digitisation program where high-resolution images of all vascular plant specimens will be scanned and made publicly available, and the collection preserved in archival material. The plant and soils collections are in the early stages of being managed in an open source Specify Collection Management Platform which handles data associated with specimens and samples in biological research collections, used globally. The data associated with the plant and soils collections are made available for researchers via numerous platforms including TERN EcoPlots, ausplotsR package, and soon through TERN EcoImages, the Atlas of Living Australia and the Global Biodiversity Information Facility.

Drone remote sensing for terrestrial ecosystem monitoring - protocols, challenges & outlook

Prof. Arko Lucieer[1], Poornima Sivanandam[1]

[1]University Of Tasmania, Hobart, Australia

TERN supports observation and monitoring of terrestrial ecosystem attributes from the continental scale to the field level at representative sites. However, there is a challenging gap between linking satellite and field-based measurements that must be addressed for effective ecosystem monitoring. Drone surveys can fill this gap and provide unique insights into ecosystem structure, composition, and function. The overarching aim of the TERN drone sub-project is to build a robust and operational drone remote sensing monitoring framework that complements ecosystem observations across the three TERN Platforms. The first phase of the project, supported by TERN Landscapes, has involved development of data collection and processing protocols. In this presentation, we will report on the following aspects of the project:

1. Field deployment of the latest drone hardware (DJI Matrice 300 RTK) with RGB, multispectral and Lidar sensors with specific focus on testing the direct georeferencing accuracy of the drone (without ground control points).
2. Standardised collection and data processing workflows essential to make the best use of drone data. Data collection protocols being developed, include pre-field and on-field checklists, and settings tuned for vegetation structural complexity. Processing workflows include steps to automatically co-register RGB and multispectral imagery and generate analysis-ready data products (RGB, multispectral orthomosaic; vegetation indices; 3D structural metrics, and plot summary metrics from lidar).
3. In collaboration with TERN Data Services, refine a data delivery system fit-for-purpose for sharing, visualisation, and exploration of ultra-high resolution drone data and analysis-ready products. We will also provide an update on field campaigns conducted in collaboration with TERN Surveillance to collect drone RGB, multispectral and lidar data across a range of TERN plots with varying structural complexity around Calperum Station, South Australia. Finally, we will provide an update on current progress in data processing and provide an outlook for future drone remote sensing opportunities.

Ecological Monitoring System Australia: standardising ecological monitoring and data systems for ecologists

Sally O'Neill[1,2], A/Prof. Ben Sparrow[1,2], Dr Andrew Tokmakoff[1,2], Dr Ashley Leedman[3]

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Having well-defined ecological field data collection protocols and associated tooling makes designing field surveys, costing activities, carrying out field surveys, and delivering curated quality data, repeatable, accurate, easier and faster to complete. TERN is working with the Department of Climate Change, Energy, the Environment and Water (DCCEEW) to co-design the ecological monitoring protocols and data exchange system that, once implemented, will greatly assist ecologists and NRM Regional Delivery Partners collect, manage and deliver quality, repeatable data that harmonises and brings together hundreds of individual projects from across Australia. Comprehensive instructions, guidelines, and training, together with field collection apps and web-based curation portals, will enable ecologists to collect data with scientific rigour. The standardised monitoring protocols are being built to support future DCCEEW natural resource management programs that benefit the environment, farms and communities. With 26 modules currently developed, the system enables ecological monitoring programs to be tailored to suit project needs.

Session 7

Rule-based annual assessment of habitat environmental condition for terrestrial decisions biodiversity to inform environmental management

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The ability of terrestrial habitats to support native biodiversity (i.e., habitat condition) has been degraded in many areas due to increasing human pressure. Effective policymaking on conservation and restoration depends on accurate mapping of and recognition of changes in habitat condition. Here, we developed a provisional dynamic habitat condition assessment approach focusing on reliability, flexibility, generalisability, and interpretability. We used Landsat-derived vegetation indices (VIs) to capture structural and compositional changes of habitats at 30m resolution. The VIs of a target site are compared with those of reference sites with known habitat condition (i.e. native species fraction) determined by field surveys, resulting in a probability of the target site being in good condition (P). The same probability is be calculated to each of the reference sites, allowing fitting a logistic regression of habitat condition against probability. P is then converted to habitat condition with the logistic regression. The P of each VI for the target site is then weighted by accuracy to calculate a habitat condition score. Our approach allows global annual assessment of habitat condition since 1984 at 30m resolution. The spatial resolution and coverage help trace and evaluate small-scale voluntary restoration and conservation by individual landholders as well as regional schemes implemented by governments and large corporates. The framework uses the same VIs globally but allows the impacts of VIs to vary by site to account for spatial heterogeneity while maintaining consistency. The predicted habitat condition score is effectively the fraction of native species richness and can be evaluated against field-based data. The change of habitat condition score can be attributed to each VI allowing for easy identification of drivers. We demonstrate the concept with data from Australia. This assessment framework supports both landholders and policymakers with a cost-effective way to monitor and assess the outcomes of environmental management.

Reef futures roundtables - Methodology for multiple lines of scientific evidence

Dr Maxine Newlands[1]

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This paper will outline why an inclusive environmental approach with multiple lines of evidence provides a more holistic basis for environmental decision support systems. We use the recent Australian Academy of Science Reef Futures Roundtables project to demonstrate how and why environmental management processes benefit from the inclusion of ecological, Traditional Knowledge and socio-ecological data.

Over three roundtables, the Reef Futures Roundtables project brought together 86 experts from across Australia, with ecological, climate, land, and marine management, social, Traditional Knowledge, governance, and regulatory expertise. Data was gathered using three different sources: 1) surveys, 2) an online interactive platform, and 3) roundtable discussions. All participants were provided with a set of climate change scenarios as stimuli prior to the survey questions and roundtable discussions. In the third roundtable, a set of provocations were used as stimuli for discussion. The data was coded in NVivo for thematic analysis, and a resulting synthesis report for the Reef 2050 Long-term Sustainability Plan Independent Expert Panel will soon be made public.

Each roundtable was co-chaired on the day by a Traditional Owner of Aboriginal and Torres Strait Islander descent and a specialist individual. The advantage of a co-chair model was the ability to identify Intellectual Property rights issues, any shared values, capacity needs and other matters during the discussions. Further, the processes recognised that Traditional Knowledges are at the core of Indigenous identities, cultures, languages and livelihoods. These dynamic and contemporary knowledge systems are based on over 60,000 years of Aboriginal and Torres Strait Islander people's experiences and observations. This paper concludes by highlighting the benefits and challenges of this inclusive approach for the basis of environmental decision support systems.

Session 8

Session 8: **Net carbon and sequestration**

Session 8 chair - Dr Jamie Cleverly *James Cook University*

Dr Jamie Cleverly obtained her PhD at the University of Nevada Las Vegas in ecology (plant physiological ecology and community ecology), soil science/agronomy and statistics. Currently, Jamie is a Senior Research Fellow at James Cook University Cairns Nguma-bada campus, and the PI for TERN's Ecosystem Processes sites in central Australia—the Alice Mulga SuperSite—and the new Fletcherview Tropical Rangeland SuperSite in north Queensland. She is currently standing as co-chair of the global FLUXNET community council, director of the Australian and New Zealand flux research and monitoring network OzFlux, and Chief Editor of the international journal Advances in Metoeorology. Dr Cleverly's research interests include the ecological forecasting, land–atmosphere exchange of carbon and water—and ecosystem ecology more generally—ecohydrology, ecophysiology, meteorology, climate, statistics and agronomy.

Photosynthetic acclimation of tropical trees in response to elevated atmospheric carbon dioxide

A/Prof. Lucas Cernusak[1], Dr Klaus Winter[2], Dr Martijn Slot[2]

[1]James Cook Universiity, Cairns, Australia, [2]Smithsonian Tropical Research Institute, Balboa, Panama

Multiple lines of evidence, including from tree ring studies and eddy covariance measurements, indicate that the water-use efficiency of tropical trees has increased as the atmospheric carbon dioxide concentration has risen over recent decades. Evidence that this may have led to an increase in tree growth rates is far more nuanced, with tree ring studies for the most part indicating no increase in growth rates of tropical trees coincident with the increase in water-use efficiency. While these two results may, at first glance, appear to be somewhat contradictory, they could be consistent with a scenario in which photosynthetic capacity acclimates to rising atmospheric carbon dioxide, such that the full increase in water-use efficiency is achieved, but it is accompanied by only a rather modest increase in photosynthetic rates. We tested this idea by growing six tropical tree species in glass domes in the Republic of Panama, in which three domes had elevated carbon dioxide concentrations and three had near ambient carbon dioxide concentrations. We observed acclimation of the photosynthetic process under elevated carbon dioxide, consistent with a theoretical framework that allows for steeply increasing water-use efficiency, accompanied by only a modest increase in photosynthetic rates. The results provide new insight into how tropical trees are likely to respond to future increases in the atmospheric carbon dioxide concentration.

Modernised Profile BREB for accurate, low-cost measurement of vapour fluxes

Dr Simon Kelderman[1]

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The Bowen Ratio Energy Balance (BREB) is a micrometeorological technique for determining vapour fluxes from water and terrestrial surfaces. There are two main approaches to BREB: (1) Have vapour pressure (e) and air temperature (T) sensors at each of two heights above a ground surface, and repeatedly exchange the sensors between the two heights; or (2) Aspirate air, in an alternating fashion, from air inlets at two heights above the ground to a common set of e and T sensors. In these exchange-mechanism approaches, the objective is to mitigate the effect of inevitable slight differences in sensor biases which can have profound impact on the results of BREB. There is another, less common, approach to BREB which effectively avoids many of the problems that arise from exchange-mechanism BREB. 'Profile BREB' consists of having fixed pairs of e and T sensors at multiple heights in a vertical profile above the ground (e.g. at 1.0m, 2.0m, 3.0m, 4.0m, and 5.0m above the ground). The (e,T) data pairs are plotted and the Bowen Ratio is calculated using the slope of the line-of-best-fit. There is historical precedent for Profile BREB but it was generally considered impractical due to the limitations of the instrumentation and a need to manually inspect the data when line-fitting. Recently, however, a modernised Profile BREB has been developed that features low-maintenance, precision sensors and a computer algorithm that objectively assessed, based on sensors' inherent measurement uncertainties, which of the data to include/exclude before creating a line-of-best-fit. Trial results showed that the modern Profile BREB could accurately measure latent heat flux in broadacre cropping and fallow sites. Furthermore, the system cost was less than one third of an eddy covariance system.

Session 8

Insights into the multi-scale environmental drivers of soil carbon in the Australian rangelands

Dr Mingxi Zhang[1], Prof Raphael Viscarra Rossel[1]

[1]Curtin university, Perth, Australia

Soil organic carbon (SOC) is vital for maintaining healthy ecosystems and providing a range of benefits beyond climate change mitigation. These benefits include supporting biodiversity, enhancing nutrient cycling, improving soil fertility and soil structure. This study aims to investigate the drivers of SOC content and composition across the vast Australian rangelands. We present robust methods that can be used with transect data, small sample sizes and high-dimensional predictors. Soil samples representing 280 sites across the rangelands were sampled by the Terrestrial Ecosystem Research Network (TERN), using the standardised sampling methodology following AusPlots Survey Protocols at three depths (0–10cm, 10–20cm, and 20–30cm). The SOC content and composition were measured by dry combustion following a physical fractionation and Fourier Transform Infrared Spectroscopy (FTIR). A total of 100 environmental soil and environmental variables were considered as potential drivers of SOC. We described the SOC state as a function of factors that describe the soil, climate, biota, topography, and parent material. We then used a comprehensive set of environmental variables as proxies for these five factors. To gain insights into the multi-scale drivers of SOC, we used three complementary methods to model the relationships between predictors and soil carbon fractions: (1) Least Absolute Shrinkage Selection Optimization (LASSO) regression and Redundancy analysis (RDA), (2) Spatial Linear Mixed Models (SPLMM), and (3) Bayesian Model Average. These approaches enabled us to identify relatively important predictors and confirm the significance of the predictors selected by each method. We then used a Partial Least Squares Structural Equation Modelling (PLS-SEM) to elucidate the direct and indirect effects of factors on SOC fractions. The results of this study provide new insights into the multi-scale drivers of SOC fractions in rangeland, Australia. Our findings could serve to develop strategies for long-term SOC monitoring in TERN.

Acknowledgements

2023 TERN Biennial Science Symposium Contributors

Deep appreciation is expressed to all participants and attendees, both in person and online.

A special thanks and recognition to our Science Symposium Patron, Professor Andrew Campbell, TERN's Advisory Board Chair, Professor Hugh Possingham, and keynote speaker, Professor Bronwyn Harch.

We are indebted to our session chairs for their generous participation. These are Distinguished Professor Belinda Medlyn, Professor Megan Lewis, Dr Tim Wardlaw, Dr Matthew Luskin, Dr Will Woodgate, Dr Tim Clancy, Adjunct Professor Mike Grundy and Dr Jamie Cleverly.

We specifically thank and acknowledge the contributions and participation of our exhibitors: Australian Access Federation (AAF), Australian National Fabrication Facility (ANFF), Australian Research Data Commons (ARDC), EcoCommons and ICT International.

The 2023 Science Symposium organising committee at TERN comprised Mark Grant, Peter Brady, Jayden Hausfeld, Nicolas Rakotopare, Mindy Gilling, Eleanor Velasquez, Sandy Heggie and Beryl Morris.

Wes Cooper, Jo Owens, Laura Sotomayor and Mohammad Taghadosi were the 2023 recipients of TERN's Science Symposium Student Stipends and we congratulate them on their project presentations.

ISBN 978-1-74272-414-0 (epub)
Version 1.1

TERN 2023 Science Symposium Book of Abstracts
Morris, Beryl, editor
Grant, Mark, editor

Available from TERN, The University of Queensland 4072, Australia

www.tern.org.au

Cover and layout design by Mindy Gilling

Maps and Wayfinding

Figure 1. An annotated aerial representation of the Queensland State Library venue in relation to the George Williams Hotel and Ibis Hotel, both within 10-15 minutes walking distance of the Queensland State Library.

Queensland State Library
Stanley Place, South Brisbane
Queensland 4101, Australia

George Williams Hotel
317/325 George St, Brisbane City
Queensland 4000, Australia

Ibis Hotel
40 Elizabeth St, Brisbane City
Queensland 4000, Australia

Key

- Venue and nearby hotels
- Walking Route
- Roads
- Brisbane River
- Parklands

Venue Map

Figure 2. A schematic of the Queensland State Library showing the level 2 Auditorium and Terrace.