Project Plan SP 2021-011

Novel methods combining ground-based monitoring and remotely sensed observations to inform management and measurement of ecosystem condition in the rangelands

Remote Sensing and Spatial Analysis

Project Core Team

Supervising Scientist	Katherine Zdunic
Data Custodian	Katherine Zdunic
Site Custodian	

Project status as of June 14, 2021, 1:27 p.m.

Approved and active

Document endorsements and approvals as of June 14, 2021, 1:27 p.m.

Project Team	granted
Program Leader	granted
Directorate	granted
Biometrician	granted
Herbarium Curator	not required
Animal Ethics Committee	not required

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Biodiversity and Conservation Science Program

Remote Sensing and Spatial Analysis

Departmental Service

Service 6: Conserving Habitats, Species and Communities

Project Staff

Role	Person	Time allocation (FTE)
Research Scientist	Gerald Page	1.0
Supervising Scientist	Katherine Zdunic	0.05

Related Science Projects

Proposed period of the project

June 8, 2020 – July 8, 2025

Relevance and Outcomes

Background

The mulga rangelands of the Midwest have experienced long-term degradation from the cumulative impact of 150 years of pastoral activity (Curry, Hennig, Blood and Leighton 1994). Changing precipitation regimes and increasing temperatures also threaten to further modify the trajectory of ecological condition in these ecosystems (Nano et al. 2017), with the impact of vegetation mortality and invasive species both likely to become more pronounced in future decades. However, while the extent of degradation is widely acknowledged, it is not known whether these ecosystems have the ecological capacity to naturally recover when agricultural grazing pressures are removed or how resilient they might be to future climatic extremes.

Long-term monitoring datasets are crucial for identifying changes in ecosystem condition and evaluating the impact of management interventions. To this end, a range of field-based ecological data has been collected from long term monitoring plots in the WA rangelands over the past several decades, the most comprehensive being the Western Australian Rangeland Monitoring System (WARMS; Watson et al. 2007, Novelly et al. 2008). However, to-date little progress has been made in synthesizing these data with other long-term datasets, including remotely-sensed data, to understand past changes in rangeland condition, the diversity of present conditions and predict likely future changes. Furthermore, past monitoring programs like WARMS have been necessarily focussed the most agriculturally productive landscapes in the rangelands, rather than for the purposes of biodiversity conservation across the landscape more broadly. Therefore, this project proposes to compile a database of existing on-ground monitoring data to be used as validation data for a landscape-wide analysis of the 33-year archive of Landsat satellite imagery and other remotely sensed data.

This project will establish a joint research program between CSIRO and DBCA focusing on ecological monitoring and restoration technologies in the WA rangelands. DBCA legislated lands in the WA rangelands (the Carnarvon, Coolgardie, Gascoyne, Murchison and Yalgoo IBRA regions) currently totals 8.82 million hectares including a management interest over 5.62 million hectares of land outside of the current reserve system. CSIRO now also manages 350,000 hectares on Boolardy Station in the Midwest for the purposes of operating the Murchison Radioastronomy Observatory and constructing the Square Kilometre Array radio telescope. These properties contain extensive tracts of degraded ecosystems presenting an ongoing management challenge. Therefore, both DBCA and CSIRO have an urgent need to understand the spatial extent of degradation across their combined property estates and the ecological trajectory of these systems.

Aims

- Deliver new insights into the functioning of rangeland ecosystems in WA, as well as tools to undertake future monitoring and evaluation of these ecosystems.
- Develop a method to relate remote-sensing based measurement of ecosystem condition to on-ground monitoring datasets.
- Integrate new remote sensing technologies into assessments of rangeland condition and change detection.
- Determine the recovery potential of degraded rangeland ecosystems in Western Australia.

Expected outcome

This project will produce an archive of remote sensing products (1988 – present) that will be used to evaluate the ecological condition of vegetation communities across CSIRO and DBCA properties in the West Australian rangelands. Remotely sensed satellite imagery will be combined with high-resolution terrain data and other satellite data (synthetic aperture radar, LiDAR), climate records and management histories to make assessments of the spatial distribution of vegetation condition and disentangle the complex interactions between landform, climate and management actions. This project will also produce an analysis of long-term field monitoring data, principally WARMS data, across all DBCA and CSIRO properties in the mid-west region. This analysis will help us to provide locally-derived estimates of growth rate, recruitment and mortality for a range of long-lived woody perennial species that are key to the ongoing management of rangeland ecosystems and also directly relevant for many HIR projects in the region, including potential future HIR projects on DBCA and CSIRO properties.

Knowledge transfer

A series of peer-reviewed publications along with conference and meeting presentations will be delivered. Presentations will also be given internally at DBCA as well as through working groups such as Land Monitor. Collaboration among a wide group of land managers, traditional owners and science agencies has been built into the project plan. Ongoing engagement with an advisory group, comprised of experts at CSIRO, DPIRD, Curtin University and DBCA, is scheduled for 6-monthly updates, and regional outreach through workshops and annual meetings has been included in the project budget. An end-of-project workshop is also scheduled to occur at Boolardy Station, where research findings along with methods and tools will be demonstrated to CSIRO staff and Wajarri representatives, along with any other interested stakeholders from the midwest region.

Tasks and Milestones

The project is split into 6 key components that will be delivered over three years. The outcome of each of these components will be either a peer-reviewed publication or a workshop. Below is a list of milestones by year.

2020 - 2021

- Project establishment and planning.
- Acquire on-ground datasets, including WARMS database from DPIRD.
- Create a remote sensing database of woody vegetation cover at Boolardy and potentially at other mid-west properties.
- Networking and outreach activities with CSIRO, DPIRD.
- Field data collection at Boolardy to validate remote sensing products.

2021 - 2022

- Collect spatial datasets for Boolardy Station and other mid-west properties.
- Collect on-ground validation data for remote sensing products and analyses.
- Collate additional and emerging remote sensing datasets (Sentinal-1 SAR, GEDI, DESIS)
- Develop manuscript: "A method to produce maps of vegetation density/ projective foliar cover from Landsat satellite imagery (1989 – present)."
- Develop manuscript: "A model to predict ecological dynamics and recovery in mulga rangelands."

2022 - 2023

- Develop manuscript: "Towards vegetation mapping at Boolardy: Estimating vegetation height and structure from Sentinal-1 SAR, validated against 12.5cm & 45cm point-cloud and TERN plots."

- Develop manuscript: "Understanding shrub dynamics for rangeland restoration: recruitment, growth rate and mortality of mulga and other key woody species in the mulga rangelands."
- Develop manuscript: "Towards monitoring ecological condition from space: a comparison of on-ground ecological data with satellite data."
- Conduct end-of-project workshop.

References

Curry P., Hennig P., Blood D. & Leighton K. (1994) *An inventory and condition survey of the Murchison River catchment, Western Australia*. Department of Agriculture Western Australia.

Nano C., Jobson P. & Wardle G.M. (2017) Arid Shrublands and Open Woodlands of Inland Australia. In *Australian Vegetation*, 3rd ed. pp. 626–650. Cambridge University Press, Cambridge.

Novelly P.E., Watson I.W., Thomas P.W.E. & Duckett N.J. (2008) The Western Australian Rangeland Monitoring System (WARMS) – operating a regional scale monitoring system. *The Rangeland Journal* **30**, 271–281.

Watson I.W., Novelly P.E. & Thomas P.W.E. (2007) Monitoring changes in pastoral rangelands - the Western Australian Rangeland Monitoring System (WARMS). *The Rangeland Journal* **29**, 191.

Study design

Methodology

1. *A method to produce maps of vegetation density/ projective foliar cover from Landsat satellite imagery (1989 – present).*

We will develop a method to estimate projective foliar cover at 25m spatial resolution from Landsat satellite imagery. By training a machine-learning regression model with high-resolution imagery derived from either satellite or remotely piloted aircraft (RPA), we will be able to estimate projective foliar cover (PFC) from Landsat imagery. Initially, maps of PFC for all of Boolardy will be produced using annual dry-season Landsat mosaics, with the resulting maps and methodology published as a stand-alone peer-reviewed paper. Once completed, we will then apply this method to imagery captured at a higher temporal frequency (16 days or monthly) at Boolardy as well as the other DBCA managed properties in the mid-west region.

2. *A model to predict ecological dynamics and recovery in mulga rangelands*

We will use the time-series maps of vegetation cover (produced above) at Boolardy and potentially other properties to determine the drivers of change in projective foliar cover (PFC) over time. The importance of precipitation and terrain attributes along with initial (starting) cover on the year-to-year change in PFC will be tested using mixed-effects and regression-tree models. Analyses will be stratified by land system. This analysis will help us to identify areas that are showing evidence of natural recovery and determine how responsive landscape positions and/or vegetation communities are to seasonal variation.

3. *Towards vegetation mapping at Boolardy: Estimating vegetation height and structure from Sentinal-1 SAR, validated against 12.5cm & 45cm point-cloud and TERN plots.*

Maps of projective foliar cover (PFC) are limited to estimating two-dimensional structure of vegetation communities, as optical satellite remote sensing does not provide any information on the vegetation height or other measures of structural diversity. We will test the capability of using Synthetic Aperture Radar (SAR) data from the Sentinal-1 satellite platform to estimate the structure of vegetation communities at Boolardy Station. Satellite data will be validated against 45cm and 12.5cm point-cloud data obtained from CSIRO as well as field-collected data from WARMS and Ausplot sites. If successful, this approach will help us to distinguish among vegetation communities based on both PFC and structural attributes using satellite remote sensing.

4. *Understanding shrub dynamics for rangeland restoration: recruitment, growth rate and mortality of mulga and other key woody species in the mulga rangelands.*

Long-term datasets that measure the growth of individual plants in the rangelands are exceptionally rare. Furthermore, estimates of potential growth rates for individual species are typically based on sparse observations, sometimes from regions and locations far removed from specific sites of interest. Current interest in the regeneration of *Acacia* woodlands and shrublands in the West Australian rangelands, including Human Induced Regeneration (HIR) projects, are predicated on an assumption that these ecosystems can achieve height-based thresholds. The WARMS database for sites located on DBCA and CSIRO properties will help us to provide locally-derived estimates of growth rate for a range of long-lived woody perennial species that are directly relevant for many HIR projects in the region, including potential future HIR projects on DBCA and CSIRO properties.

Biometrician's Endorsement

granted

Data management

No. specimens

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

not required

Data management

Metadata will be stored on the DBCA data catalogue. Published datasets will be archived on Zenodo.org and R code will be archived at Zenodo.org once papers are published, and a code base maintained on Github.

Budget

Consolidated Funds

Source	Year 1	Year 2	Year 3
FTE Scientist			
FTE Technical			
Equipment			
Vehicle			
Travel			
Other	50000		
Total			

External Funds

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime	100000	110000	110000

Source	Year 1	Year 2	Year 3
Overheads			
Equipment			
Vehicle			
Travel	10000	10000	10000
Other			
Total			