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Review of a regional scale grassland condition monitoring method

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Abstract

This paper outlines the review and development of site selection and field data collection protocols for enabling the continuation of the state government's Western Australian Rangeland Monitoring System (WARMS) beyond 2024. The primary purpose of WARMS remains to detect change in the condition and trend of the extensive rangelands across Western Australia. The Department of Primary Industries and Regional Development (DPIRD) aims to align WARMS with the move to risk-based monitoring and assessment outlined in DPIRD's Framework for Sustainable Pastoral Land Management.

Regular reviews of monitoring methods, collaboration with industry stakeholders and governing bodies are required to ensure the system's robustness and relevance for management of public lands.

A revision of DPIRD's grassland field site-selection and data collection protocols is presented with two main goals: (1) to improve monitoring effectiveness by aligning sites with key pastures and broad ecosystem types identified in ecological State and Transition models (Richards et al. 2023), and reducing the total number of sites monitored; and (2) to modify site spatial configuration and align data collection with national standards for fractional cover data collection, while maintaining longitudinal continuity with the WARMS program. The co-location of nationally comparable sites with suitable WARMS sites would be an efficient way to provide the ground measured data needed for calibration of remotely sensed fractional cover estimates, if the changes in data collection protocols prove compatible with previous WARMS condition trend detection. Methods for using remote sensing data to directly monitor rangeland condition and degradation risk will be explored.

In 2024 we began a field program of monitoring pasture condition using the existing WARMS site layout in tandem with the star transect layout for cover measurement in the Kimberley region of Western Australia. Data from the two transect configurations will be analysed to assess the practicality of substituting the existing WARMS measurement layout for the star layout without compromising the long-term trend detection.

Introduction
A revision of DPIRD's grassland field site-selection and data collection protocols is required because of DPIRD's desire to assist with the collection of SLATS data for contribution to the national database (Barnetson et al. 2017, Sparrow et al. 2020). There is also recognition that maintaining continuity with the existing WARMS program and data within available resources is valuable and worthwhile (Watson et al. 2007, Reeves et al. 2023).

A variety of methods are used in Australia to access ecological conditions including: % or relative cover using remote sensing (Than et al 2022, Scarth 2012, Ali 2016, Barnetson et al. 2017); ecological monitoring/validation on a tiered system (i.e. some sites visited more frequently than others) (Sparrow et al. 2020); SLATS (QDES 2022), and; landscape function analysis (Tongway and Hindley 2004).

Using WARMS data, we can determine rangeland condition trend over time and tree/shrub crown cover across a range of ecosystems (or states) (Novelly et al. 2008). The major causes of condition change events are seasonality, grazing, fire and flood. Time since fire is also a factor, and not currently considered; however, if it was decided that it was of value, high-quality spatial fire scar data could be incorporated into this dataset.

Instances where we have been able to detect or infer condition change at WARMS sites are relatively rare. This is because condition change generally occurs over an extended time period and requires more than one driver (i.e grazing pressure and seasonal rainfall). We have a large existing dataset that could be used to estimate *how many* times an event is likely to occur within a given period of time. The results could be used to inform the revisit and reporting cycle required to detect those changes, but this cycle is likely to be more influenced by resource availability and timelines.

DPIRD is intending to improve the method for allocating monitoring sites with consideration of geographical distribution and stratified to be representative of key pastures as identified during the development of the Land Condition Standards. A link to remote sensing is envisaged, so that the existing sites are validation and ongoing on-ground monitoring sites as part of a (yet to be developed) remotely sensed cover/condition system.

We have set out to ensure that the new data collection system will be comparable with the previous system by using initial measurements of collected at WARMS sites using both WARMS and SLATS transect layouts (Craig and Thomas 2008, Muir et al. 2012) to assess if the datasets are comparable or if there is a step change in the frequency of perennial pasture species occurrence.

Our objectives are:

- to improve monitoring effectiveness by aligning WARMS sites with key pastures and broad ecosystem types identified in in ecological State and Transition models
- to modify site spatial configuration and align data collection with national standards for fractional cover data collection, while maintaining longitudinal continuity with the WARMS program
- reduce the total number of long-term sites monitored, where possible without compromising the longitudinal data

Methods
The method and practicalities were discussed internally prior to collecting data from WARMS transects and SLATS star transect at 13 sites in 2024. We grouped the existing Kimberley grassland sites to determine

the number of sites for statistically robust analyses of key and non-key pasture groups identified during the development of the Kimberley Land Condition Standards (Fletcher et al. 2022).

WARMS grassland sites were shortlisted for field data collection early in 2024, targeting relatively stable sites categorised as Wet-dry tropical eucalypt woodlands of the Kimberley (Richards et al. 2023) or Pindan pastures (Craig and Thomas 2008, Ryan et al. 2013).

The orientation of SLATS transects is fixed, whereas existing WARMS sites may be any orientation. The layout for ratings of presence/absence of perennial species in 100 quadrats (0.49m^2) on the star transects is 33 on each transect, plus 1 random. Some sites did not include the 100th quadrat.

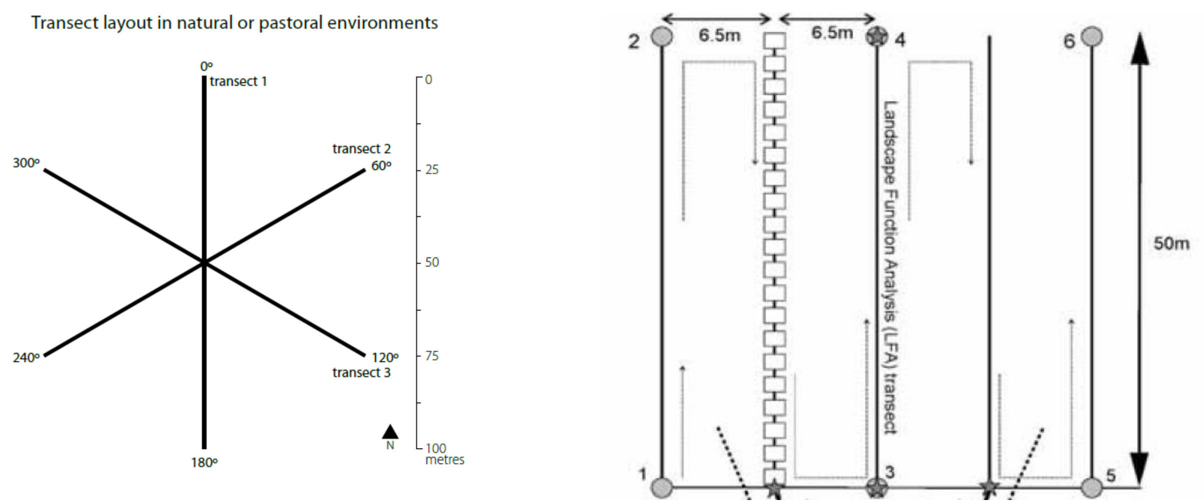

Figure 1. SLATS star transect layout with orientation (Muir et al 2012) (left) and WARMS transect layout (Craig and Thomas 2008) (right).

Data were collected from the WARMS transects then the SLATS transects were centred over the WARMS site and data collected from the SLATS transects.

Preliminary analysis of the data collected in 2024 is in progress using the Bray-Curtis method (K. Reeves pers. comm. 2024).

GIS and analysis of remotely sensed data will be used to select WARMS sites that meet the SLATS site criteria (P. Ramzi pers. comm. 2024), while maintaining longitudinal continuity with the WARMS program. Fractional cover data collected by DPIRD on pastoral leases cannot be displayed on the public TERN site without permission of the lessee, however, the applicable data collected are uploaded to the national TERN database for use in deidentified applications.

Quantifying a change in data collection methods involves several steps to ensure that the new method provides comparable and reliable data (Caughley and Sinclair 1994, Specht et al. 2015, Kaplan et al. 2021). Steps used in our approach are listed below:

1. **Baseline Establishment:** extensive data has been collected using the current WARMS method in rolling three-yearly assessments from 1994-2020. This will serve as the baseline for comparison. Parallel data collection is in progress using the SLATS site layout method and the current method during a transition period (2024-2025) that will be used to establish a preliminary dataset.

2. **Comparative Analysis:** A side-by-side comparison of data collected simultaneously by both methods is in progress and will be used to help identify systematic differences. Statistical tests (e.g. paired t-tests) will be used to determine if there are significant differences between the datasets from the two methods. Exploratory work is in progress.
3. **Calibration and Adjustment:** Calibration curves or adjustment factors will be developed to align the new method's data with the baseline data as required. Correction factors will be applied to the new data if systematic biases are identified.
4. **Error Analysis:** Error metrics such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Bias will be calculated, if necessary, to quantify the differences. The uncertainty associated with both methods will be assessed to ensure that the new method's uncertainty is within acceptable limits. The new method's uncertainty should not exceed that of the previous method unless justified by significant cost, time, or coverage advantages. For example, if the WARMS method has a standard error (SE) of 5%, the new method needs to be within this range or correctable using calibration models if biased. Acceptable MAE or RMSE might be ≤10% of the average quadrat counts in test sites.
5. **Validation:** Validating the new method with independent data sources or through external benchmarking will not be possible within the scope of this study, as the data are unique. Cross-validation by splitting the data into training and validation sets will be used to verify the robustness of the new method when enough data are collected to allow this.
6. **Longitudinal Studies:** Change detection techniques will be used to identify any significant deviations that might result from the method switch, if required.
7. **Documentation and Reporting:** The process, including the rationale for change, methods used for comparison, calibration, and error analysis will be documented and peer-reviewed internally and in scientific papers such as this to validate the approach and ensure transparency.
8. **Implementation of New Method:** Gradual implementation of the new method will not be possible, due to labour and expertise availability. The implementation of the new method is planned for completion in the WA grasslands in 2025, subject to DPIRD resources and priorities, and the results of a review of existing WARMS sites that are considered suitable for SLATS (in progress). Establishment of an ongoing regular data analysis system will be considered, so that issues arising from implementation of the new method are detected early and necessary adjustments can be made.

Results

Existing sites grouped according to pasture type

380 existing WARMS sites were considered and categorised according to key and non-key pasture groups set out during development of the Land Condition Standards for the Kimberley. One WARMS site was dropped from categorisation as it is the sole example of Lovegrass alluvial plain pasture in the dataset and lacks similarity to other pastures (Reeves et al. 2023). Pasture groups included in the development of state and transition models for the Kimberley included black soil plain pastures, frontage grass pastures and ribbon grass pastures. Pastoral value (categorised from very low (<2.5 cattle units (CU)/km^2) to high (>8 CU/km^2), fragility (after Craig and Thomas 2008) and suitability for remote sensing (Mundava et al. 2015, Ali et al. 2016) were discussed for each group. High pastoral value pastures suitable for remote sensing include marine plains and black soil plains, characterised by relatively low tree cover with generally good condition pastures that are fairly 'uniform'; low value examples include rocky and inaccessible country that is unlikely to be grazed by cattle Recommendations for consideration regarding the number of sites required for future monitoring are presented in Table 1.

Table 1. Existing WARMS sites grouped according to pasture characteristics

Pasture group	No. sites	Comment/s on pastoral value, fragility, other	Action to be considered
Hills/hard spinifex pastures	0	Low value, low fragility, suitable for remote sensing	None
Black soil plains pastures	137	High value, low fragility, suitable for remote sensing	Reduce, investigate which to keep and where to install under-represented 'states'
Frontage grass pastures	28	High value, high fragility	Increase to ~35
Ribbon grass pastures	99	Moderate value, high fragility	None
Coastal plains pastures	20	Range of values, range of fragility, localised, pastures in this group are very different from each other, some would be suitable for remote sensing	Investigate further
Pindan pastures	36	Low value, may be more fragile than previously published due to tussock grass component	None
Soft spinifex pastures	35	Low value, may be less fragile than previously published, suitable for remote sensing	None
Curly spinifex pastures	21	Low value, low fragility, probably suitable for remote sensing	Increase to ~30
Curly spinifex-annual sorghum hill pastures	3	Very low value, probably suitable for remote sensing	Drop entirely or increase

Summary of frequency data collected in 2024

Frequency data from 17 sites including that presented in Figure 2 below will be used for initial comparative statistical analysis. The clustered bar graph compares the frequency of desirable plant species, the frequency of quadrats without perennial plant species and the frequency of burnt quadrats, across the 17 sites assessed using both site layouts. The x-axis represents monitoring sites labelled sequentially, the y-axis indicates the frequency percentage (0 to 100) for the analysed variables, and the z-axis separates the data by variable and site layout. This set includes data from 4 sites collected in 2020, prior to method development discussions.

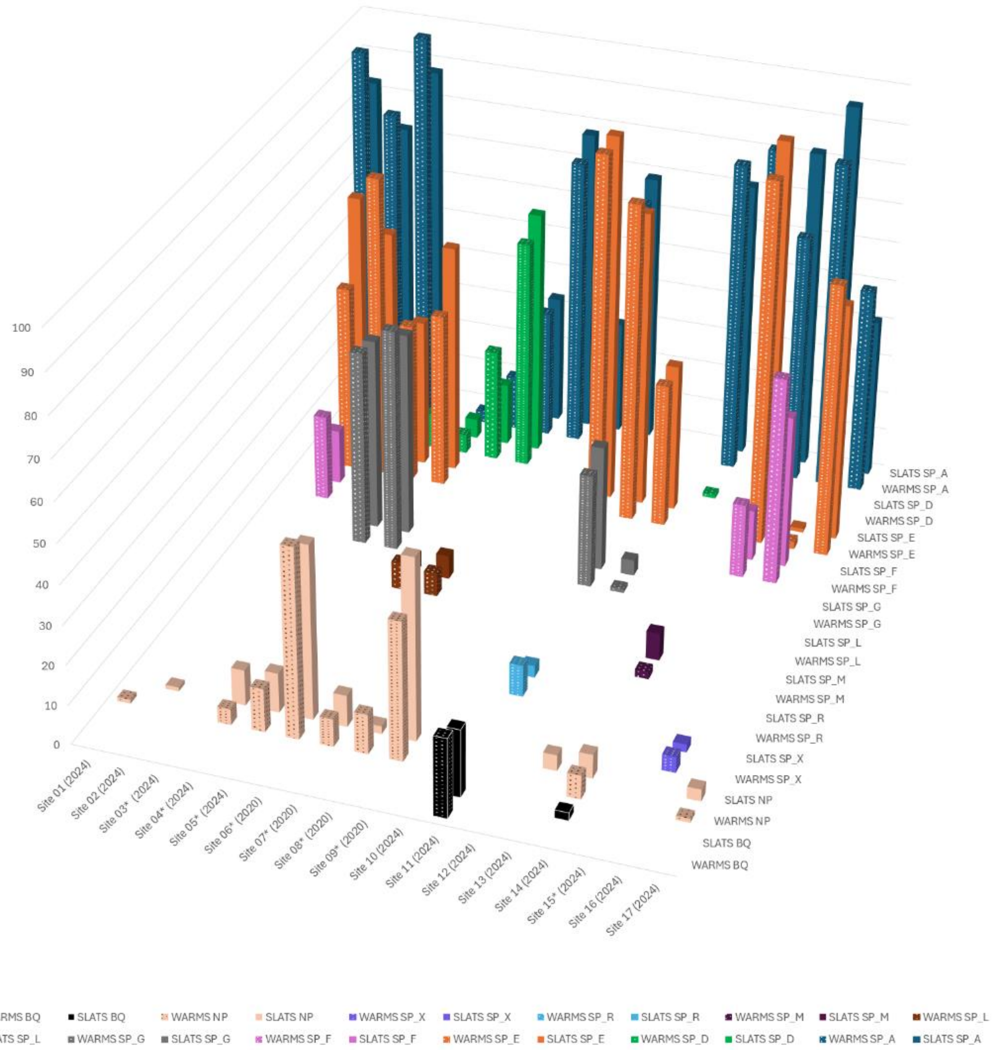

Figure 2. Comparative frequency data from sites assessed to date (*frequency data from 99 quadrats)

Discussion
We plan to collect additional data from shortlisted sites in 2025 to add to the comparative dataset.

Some SLATS star transect data may not be suitable for the TERN dataset, but will still be useful in this review and comparison with WARMS site data (P. Ramzi pers. comm. 2024).

Methods for using remote sensing data to complement on-ground monitoring of rangeland condition and degradation risk will be explored as part of this project, and may be useful in some pasture types for assessing the optimum number of on-ground data collection sites required and informing the optimum length of the epoch (revisit interval) required within our parameters to detect change.

The documentation of the change in the data collection method will allow the practicalities of substituting the existing WARMS measurement layout for the SLATS star layout without compromising the long-term trend detection to be quantified and analysed, which may assist other long-term ecological studies outside of the project area.

Establishment of an ongoing regular data analysis system is recommended to detect issues arising from implementation of the new method early, so that necessary adjustments can be made.

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References

Ali I, Cawkwell F, Dwyer E, Barrett B, and Green S (2016) Satellite remote sensing of grasslands: from observation to management, *Journal of Plant Ecology* 9- 6, 649–671 https://doi.org/10.1093/jpe/rtw005

Barnetson J, Phinn S, Scarth P, and Denham R (2017) Assessing Landsat Fractional Ground-Cover Time Series across Australia's Arid Rangelands: Separating Grazing Impacts from Climate Variability. 10.20944/preprints201703.0236.v1

Caughley G, and Sinclair ARE (1994) 'Wildlife ecology and management', (Blackwell Scientific Publications: Boston)

Craig A, and Thomas P (2008) Western Australian rangeland monitoring system for grasslands: field manual. Department of Primary Industries and Regional Development, Western Australia, Perth. Bulletin 4741

Fletcher R, Sudmeyer R, Ryan K, Fletcher M, Holmes K, Thomas P, Barker D, Fletcher W, Ramzi P and Penny N (2022) Pastoral land condition standards: Conceptual basis and West Kimberley region case study – Draft October 2022, Department of Primary Industries and Regional Development, Western Australian Government.

Kaplan N, Baker K, and Karasti H (2021) Long live the data! Embedded data management at a long-term ecological research site *Ecosphere* 12. 10.1002/ecs2.3493.

Muir J, Schmidt M, Tindall D, Trevithick R, Scarth P, and Stewart JB (2011) Field measurement of fractional ground cover.

Mundava C, Schut AGT, Helmholz P, Stovold R, Donald G, Lamb DW (2015) A novel protocol for assessment of aboveground biomass in rangeland environments. *The Rangeland Journal* 37, 157-167. https://doi.org/10.1071/RJ14072

Novelly P, Watson I, Thomas P, and Duckett N, (2008) The Western Australian Rangeland Monitoring System (WARMS) – operating a regional scale monitoring system. *The Rangeland Journal* 30. 10.1071/RJ07047.

Queensland Department of Environment and Science. 2022. Statewide Landcover and Trees Study – Methodology Overview v1.1. Queensland Government, Brisbane.

Reeves KL, Ryan K, Hetherington C, Thomas P, and Sudmeyer RA (2023) Simple classification tree models to predict pasture condition In 'Proceedings 22nd Australian Rangeland Society Biennial Conference'. https://austrangesoc.com.au/biennial-conference/22nd-biennial-conference-2023/

Richards A, Abbott B, Prober S, Hayward J, Sudmeyer R, Fletcher M, Ryan K, Hetherington C, Ramzi P, Thomas P, Reeves K, and Fletcher W (2023) State and transition models for tussock grasslands and woodlands of the Kimberley. Australia: CSIRO; 2023. csiro:EP2023-0758. https://doi.org/10.25919/n876-4v88

Scarth P (2012). Tracking Grazing Pressure and Climate Interaction - The Role of Landsat Fractional Cover in Time Series Analysis. figshare. Journal contribution. https://doi.org/10.6084/m9.figshare.94250.v1

Sparrow BD, Edwards W, Munroe SEM, Wardle GM, Guerin GR, Bastin JF, Morris B, Christensen R., Phinn S, and Lowe AJ (2020) Effective ecosystem monitoring requires a multi-scaled approach. *Biol Rev* 95, 1706-1719. https://doi.org/10.1111/brv.12636

Specht A, Guru S, Houghton L, Keniger L, Driver P, Ritchie EG, Lai K, and Treloar A (2015) Data management challenges in analysis and synthesis in the ecosystem sciences. *Science of The Total Environment* 534, 144-158, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2015.03.092

Than MS, Williams WJ, Schmidt S, Potgieter A, Cowley R, Mellor V, Driscoll C, and Zhao Y (2022) Using digital photography to monitor changes in biocrusts and ground cover in a savanna rangeland. *The Rangeland Journal* 44, 263-278. https://doi.org/10.1071/RJ22019

Tongway D, and Hindley N (2004). Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes - with Special Reference to Minesites and Rangelands. CSIRO Sustainable Ecosystems.

Watson I, and Novelly P (2004) Making the biodiversity monitoring system sustainable: Design issues for large-scale monitoring systems. *Austral Ecology* 29, 16-30. https://doi.org/10.1111/j.1442-9993.2004.01350.x

Watson I, Novelly P, and Thomas P (2007) Monitoring changes in pastoral rangelands – the Western Australian Rangeland Monitoring System (WARMS). *The Rangeland Journal* 29. 10.1071/RJ07008.