Land systems, soils and vegetation survey of the southern Goldfields and Great Western Woodlands of Western Australia

Waddell, PA[1]; Galloway, PD[1]

[1] Department of Primary Industries and Regional Development;
Peter-Jon.Waddell@dpird.wa.gov.au; Paul.Galloway@dpird.wa.gov.au

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Abstract

The southern Goldfields region is ecologically significant as it closely aligns with the Great Western Woodlands– the world’s largest intact Mediterranean-climate woodland ecosystem, dominated by *Eucalyptus* species and encompassing diverse mosaics of woodlands, mallee, shrubland, and grassland. The region has been subjected to significant ecological perturbations since European colonisation. Despite multiple land-use pressures on a unique environment, the region is the last large area in Western Australia (WA) to be comprehensively surveyed for biophysical resource condition to promote sustainable use.

This survey presents a comprehensive assessment of the biophysical environment of WA's southern Goldfields region, covering 151,753 km². The survey maps land systems and refines soil-landscape zones at 1:250,000 scale. The accompanying report describes the geomorphology, soils and vegetation, offering new insights and revisions to existing physiographic data.

The survey advances prior studies by refining mapping in alignment with WA and national standards, thereby providing consistency in data presentation and analysis across regional and national scales and complementing the Interim Biogeographic Regionalisation for Australia. This survey’s integration into WA’s hierarchical soil-landscape mapping system enables data describing the southern Goldfields to be interpreted within broader regional, statewide, and national contexts. Key contributions are:

- complete biophysical mapping that meets national and state standards
- a multidisciplinary explanation of key aspects of landscape evolution
- revised physiographic mapping that reveals patterns of erosion, deposition, and landscape maturity
- defining 101 land systems and 88 habitat types that summarise key elements of landform, geology, geomorphology, soil and vegetation characteristics.

The survey’s hierarchical mapping framework and associated biophysical information provides comprehensive baseline data and improves understanding of the region’s ecological processes and environmental pressures. It thus constitutes a valuable resource for agencies, companies, and individuals involved in strategic land-use planning,

land management, monitoring, conservation and rehabilitation, and the sustainable use of rangeland habitats across the southern Goldfields region.

Introduction

The southern Goldfields region of Western Australia (WA) is ecologically significant as it closely aligns with the Great Western Woodlands–the world's largest intact Mediterranean-climate woodland ecosystem, dominated by *Eucalyptus* species and encompassing diverse mosaics of woodlands, mallee, shrubland, and grassland (Watson et al. 2008). The vegetation evolved over the Cenozoic from rainforest with a significant proteaceous element to become increasingly scleromorphic and then xeromorphic as southern WA aridified from the Late Miocene to present. The long history of isolation in a progressively drying climate resulted in a megadiverse vegetation suite adapted to fire (Martin 2006).

Prior to European colonisation the area was populated by indigenous inhabitants who used fire in patchwork mosaics to secure food and manage the vegetation and landscapes. Since then, the region has been subjected to significant ecological perturbations. Early European settlers extracted sandalwood. Gold was discovered in the region in the 1890's. Mining required structural wood and firewood to power steam engines for transport and water supply. Extensive areas were temporarily cleared for wood production until the late 1960's, and the wood-fired steam power increased the incidence of wildfire from ember strike. The combination of both pressures changed structural characteristics of vegetation. Pastoralism, based initially on wool production and more recently on cattle and opportunistic harvesting of feral species, has skewed vegetation composition by the preferential grazing habits of introduced herbivores. This highly mineralised region has extensive open pit mining and mineral exploration, because it contains world class deposits of gold, nickel, lithium and iron ore. Both mining and pastoralism require access, and the vehicular track network affects overland water flows, affecting vegetation growth and altering geomorphic processes (Raiter et al. 2018).

Since the 1950's, rangeland areas of WA have been progressively surveyed to document resources, identify condition, and promote sustainable use. Despite multiple land-use pressures on a unique environment, this southern Goldfields region is the penultimate WA pastoral area to be surveyed, with the final area still pending.

This communication summarises key findings of a recently completed comprehensive assessment of the biophysical environment of the southern Goldfields region. The survey covers 151,753 km² and extends from latitude 30°00'S to 33°00'S and from longitude 118°00'E to 124°00'E. The survey maps the region's land systems and characterises the geomorphology, soils and vegetation, offering new insights and revisions to existing physiographic data. This survey, together with adjacent rangeland surveys (see 'Methods' chapter in Waddell and Galloway 2023), provides mapping at a land system scale of 1:250,000. Together these surveys describe the biophysical features of the Great Western Woodlands, except their southernmost extremities.

The bulletin and accompanying land systems maps provide a reference for land managers, advisers and administrators, the people most involved in planning and implementing land management practices. They also provide a baseline reference on landscape resources of the region. Land system surveys also enable recognition and location of land systems and landforms with particular habitat or conservation values for land use planning.

The survey advances prior studies by refining vegetation, soil, and physiographic mapping in alignment with WA and national standards, thereby providing consistency in data presentation and analysis across regional and national scales and complementing the Interim Biogeographic Regionalisation for Australia. This survey's integration into the State's hierarchical soil-landscape mapping system enables data describing the southern Goldfields to be interpreted within broader regional, statewide, and national contexts (Schoknecht et al 2004). A notable contribution is the revision of physiographic descriptions and soil-landscape zones of Tille (2006). These zones are based on geological and geomorphic criteria that reveal patterns of erosion, deposition, and landscape maturity, facilitating understanding of the region's evolution and environmental processes.

Accompanying the land system map is a report in two volumes. The climate chapter provides a synopsis of past and present climates with reference to the vegetation and geomorphic evolution. The landscape evolution chapter describes the region's geology, relevant tectonic processes and geomorphology, then discusses how the landforms formed and are distributed. These chapters contextualise evolution of landscape and vegetation.

The remaining chapters detail the region's biophysical features relating to soils, vegetation and ecology, and land systems. They provide information on landforms, soil and vegetation and, used in conjunction with the maps, provide a comprehensive description of biophysical resources. Included within these chapters are references to the impacts of certain management practices on the soils and vegetation, which are directed towards land managers to provide general information to assist in land use planning.

Methods

A detailed description of the methods and the types of data collected during the survey is provided in the 'Methods' chapter in Waddell and Galloway (2023).

Results

Our investigations at 606 inventory sites sampled during the survey and data from another 57 inventory sites from previous work in the area augmented knowledge of the region's biophysical features. Using this data, we were able to assimilate our comprehensive literature review of the geology (petrology and tectonics), geomorphology, and paleoclimate to interpret the landscape in an interdisciplinary manner.

At inventory sites we identified 69 WA Soil Groups and 88 habitat types. This great diversity reflects the complexity and diversity of the landscapes and vegetation associations present. The 88 habitat types, being combinations of landforms, soil types and plant communities, were clustered into 13 broader groups to aggregate ecologically similar types in topographically comparable positions. Forty-nine habitat types were described for the first time.

We identified 101 land systems in the survey area: 62 are described for the first time and the other 39 were previously described in adjacent surveys. The descriptions of some land systems identified in the adjacent rangeland surveys were modified to account for vegetation changes associated with the southerly transition from the Great Victoria Desert, Murchison, Nullarbor and Yalgoo bioregions into the Coolgardie bioregion.

We grouped the land systems into soil-landscape zones defined by geomorphologic or geological criteria, suitable for regional perspectives. Where existing physiographic mapping was inadequate (see discussion in Tille 2006), we identified and mapped 4 new zones and modified 6 others using the 'bottom-up' hierarchical approach of Schoknecht et al. (2004). We described zones using a combination of Pain et al. (2011), Tille (2006) and new information from this survey. Our new physiographic zones correlate to all prior mapping.

Discussion

The addition of the southern Goldfields rangeland survey to the long-running program of describing WA's rangeland biophysical features, with accompanying land system and zone mapping, has many benefits. Primarily this is through detailed information on landforms, soil and vegetation with references to the impacts of certain land use practices on the soils, surface hydrology and vegetation.

Implications for unified data

Inventory site data, land system maps and descriptions of their unmapped components meet State and National standards (and is the first WA Rangeland survey to do so). The data can be transferred to the publicly available

Australian National Soil Information System, and it therefore contributes to current and future research efforts to improve the resolution of soil, physiographic and other environmental mapping using 'big data'. A particularly promising research use for the baseline data generated during this survey is the estimation of carbon stocks for better modelling of global carbon storage to assess greenhouse induced climate cascades.

Adhering to standards enabled correlation of the southern Goldfields maps to soil-landscape maps of the adjoining agricultural region and existing mapping for the rest of WA (Schoknecht et al. 2004; Tille 2006). Such correlation simplifies the generation of derivative land suitability, land capability and land degradation maps that are seamless and comparable across WA's agricultural and southern Goldfields areas. These derivative products are invaluable for the land use and management implications described below.

The hierarchical nature and standardisation of our mapping permits application across scales for regional and property perspectives. The land zone mapping provides the spatial context for our explanations of regional scale geomorphic features that are present due to the interlinked evolutionary history of geology, paleoclimate, vegetation, weathering, erosion and deposition, and tectonic processes at continental, regional and local scales.

Implications for land use

Information curated enables government to administer pastoral leases and prevent or minimise land degradation. In WA, the Valuer General's Office sets pastoral lease annual rental charges based on potential carrying capacities. Carrying capacity figures derive from land system mapping in conjunction with habitat type analysis. Baseline information from rangeland survey informs rangeland assessment staff about the resource condition of habitats, enabling them to report on land degradation on pastoral leases and administer actions under the Soil and Land Conservation Act (1945; Waddell et al. 2023).

Some areas within the pastoral estate may be suited to alternative land uses. The ability to apply standard land evaluation criteria permits a regional scale 'first pass' mapping that allows a like-for-like comparison, even across diverse land uses. For example, maps could be created to identify areas best suited to sandalwood re-establishment, native animal re-introductions, or potential water supply.

Though assessments of vegetation condition are primarily relevant to a pastoral context, evaluation of community composition and physiognomy is determined in intact, ungrazed states (where possible), so they do not preclude condition assessment from an ecological context and are useful in determining (or as surrogates for determining) conservation value of vegetation and habitat (Pringle and Tinley 2001; Brandis 2008), state and transition modelling, status of carbon stocks and identifying the potential for carbon sequestration in rangeland landscapes (Williams et al. 2023).

The survey identified areas subjected to increased land use pressure. A pertinent example is the identification of stressed vegetation surrounding a gold roasting plant. Soil characterisation at an affected inventory site identified an acidic soil profile under vegetation that traditionally inhabits alkaline soil types. In other respects, the soil had morphological characteristics of the alkaline soil. The regional nature of the survey precluded a detailed study, but it identifies a potential problem and provides the basis for future research. Elsewhere a common observation was where tracks and fencelines disrupt natural water flow, altering moisture levels across the landscapes. Some areas pond water while others are water-starved and contribute to degradation.

The survey identified vegetation suites that indicate a change in state to lower production. Some locations affected by historic overgrazing have undergone a step-change in ecological state due to altered species composition, soil loss or both stressors combined. The introduction of non-native herbivores has resulted in some areas becoming degraded with reduced vegetation cover, decreased species diversity, encroachment by unpalatable perennial shrubs, weed proliferation and erosion. The condition of some habitats preferred for grazing has declined – the extent of palatable species has been reduced or totally lost. Survey data provides a baseline description of habitats facilitating the strategic location of monitoring sites (Pringle et al. 2006), restoration strategies (Tinley and Pringle 2014), and mapping supports the placement of infrastructure (e.g. tracks, fencing, watering points) and facilitate weed control programs to economically target priorities.

The inclusion of the land zone hierarchy in our southern Goldfields mapping provided a spatial context for our explanations of regional geomorphology, which enhanced our explanations of general distribution of ecological communities, plants and soil characteristics. These broad geomorphic patterns are responsible for environmental processes that exert a significant influence on all land uses. While the aspects of landscape evolution discussed are provided with evidence, where possible, the paucity of paleo-information means some ideas remain speculative and are ripe for further study. We hope the new information and mapping presented will assist and support management strategies and future management of the southern Goldfields region.

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