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## Changes in range condition in the arid shrublands of Western Australia : application of spatial and temporal analysis to long-term monitoring data

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**Key words :** monitoring, grazing, range condition, shrublands, GIS, WARMS

**Introduction** The effects of climate, herbivore grazing, fire and other natural and anthropogenic disturbances are reflected by changes in range condition, driven by changes in soil and vegetation condition. When range condition is used in an ecological context, an improving trend implies an improvement in ecological or ecosystem integrity. In contrast, a declining trend implies a reduction in integrity, otherwise known as natural resource degradation. This study integrated soil and vegetation condition attributes into a quantitative index of range condition and mapped its variation through time across the shrublands of Western Australia, covering a total area of approximately 760,000 km<sup>2</sup>.

**Methods and materials** The analysis is based on a hierarchical suite of soil and vegetation indices derived from transect field metrics acquired by the Western Australian Rangeland Monitoring System (WARMS). WARMS is an extensive, long-term, ground-based system established in 1981 to monitor range condition change in the pastoral rangelands and is operated by the Department of Agriculture and Food Western Australia (DAFWA). By the end of 2006, 980 sites located on 377 pastoral leases existed at an average density of one site per 77,780 hectares of pastoral shrubland. Data collection protocol has remained essentially unchanged since 1992 and new data is captured at each site on a 5-year cycle (Watson, Novelly & Thomas 2007). The Shrubland Range Condition (SRC) index and sub-indices were partitioned into 4-year time-slices based on data capture date and then spatio-temporal maps showing relative range condition for each time-slice and change between time-slices, each classified into five classes, were produced using Geographic Information System (GIS) techniques. Change maps utilised an Inverse Distance Weighted (IDW) analysis technique to identify clusters of sites displaying similar change behaviour.

**Results and discussion** Local, regional and shrubland-wide patterns of change are evident. In the northwest of the shrublands, change in range condition is generally more spatially and temporally variable, greater in magnitude and involves larger clusters of sites compared to areas in the southeast. Many clusters of sites show alternate improvement and decline between time-slices whilst several clusters in the Ashburton and Murchison catchments continued to decline over the last 15 years or so. For most sites showing negative change, causal agent(s) of change, usually high grazing pressure but also fire and flood, could be inferred. Only two clusters of sites, located in the upper reaches of the Gascoyne River, steadily improved over the same period. Most sites are in "Fair" condition in the Goldfields region and in "Poor" condition in the Nullarbor region, however, the concern is that most of these sites in both regions also showed little or no change in range condition, despite a 10-year sequence of average or above average rainfall throughout much of the shrublands. The ecological response to grazing and other disturbances across the shrublands, reflected by change in the SRC index, appears to be related, at least in part, to drainage type. In general, monitoring sites located in endorheic and arheic basins exhibit less change in range condition compared to sites located in exorheic catchments. This is interpreted to reflect differences in rates of incision and soil erosion fundamentally related to ultimate and local drainage base levels. The regional insight provided by this study supports local field observations made by Pringle and Tinley (2003) of certain critical hydrogeomorphic processes involved in land degradation.

**Conclusions** The combination of hierarchical index framework, use of time-slices and GIS mapping techniques provides a potent analysis platform for the elucidation of spatial and temporal change in range condition or ecological integrity at WARMS sites. The study has shown that natural resources in exorheic catchments are more susceptible to degradation. In this particular catchment type, but also throughout the endorheic and arheic basins, much more ecologically benign land use practices must be implemented to reverse range degradation in the shrublands of Western Australia.

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