

Ecosystem Function Analysis

Landscape Function Analysis: a Systems Approach to Assessing Rangeland Condition

Landscape Function Analysis is the core component of Ecosystem Function Analysis. The discussion paper below gives an outline of the procedure used.

- [Abstract](#)
- [Introduction](#)
- [Method Development](#)
- [Method in Operation](#)
- [Calculation of Indices](#)
- [Interpretational Framework](#)
- [References](#)

Abstract

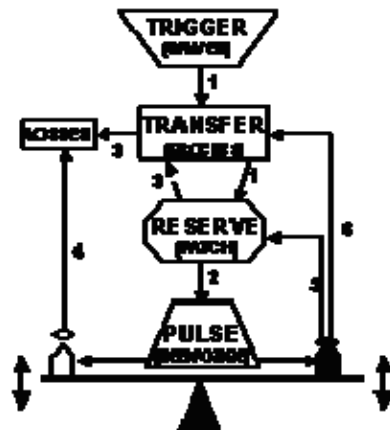
We propose a procedure for the assessment of rangeland function, comprised of three components: a conceptual framework, a field methodology and an interpretive framework. The conceptual framework treats landscapes as systems: defining how landscapes work in terms of the economics of vital resources. The field methodology uses rapidly assessed field indicators at landscape and patch scale to provide and structure information to satisfy the needs of the conceptual framework. The interpretational framework provides a process to identify critical thresholds in landscape function and thus provide a function-based state and transition landscape assessment. The approach is quick and simple in the field, is applicable to all range landscapes and amenable for use by a wide range of end-users.

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Introduction

Rangeland monitoring has typically been descriptive: restricted to evidence provided by a narrow range of biota or associated with theories of plant succession (Golley 1977). Methods have also been largely tied to pastoralism as the only land-use and pasture availability as the main output. This situation is now changing, with a broader societal use of rangelands. Monitoring and comparing landscapes on an inter-regional and national basis, for example the National Land and Water Audit, would be facilitated if the procedures were widely applicable and the data directly comparable. Walker (1996) called for an understanding of how rangelands function by building conceptual models. Ludwig and Tongway (1997) presented a systems-based framework (trigger-transfer-reserve-pulse - TTRP, Figure 1) for the way in which rangelands function, based on how landscapes function to conserve and utilise vital resources (sometimes now called “natural capital”). This framework also facilitated the development of more detailed simulation models (e.g. Ludwig and Marsden

1995), enabling the role of these models to be seen in a wider, landscape context.



Ref	Processes Involved
1	<ul style="list-style-type: none"> - Run-on - Storage/Capture - Deposition - Saltation capture
2	<ul style="list-style-type: none"> - Plant germination, growth - Uptake processes - Nutrient mineralisation
3	<ul style="list-style-type: none"> - Run-off into streams - Sheet erosion out of stream - Rill flow and erosion - Wind erosion out of system
4	<ul style="list-style-type: none"> - Herb array - Harvesting - Fire - Deep drainage
5	<ul style="list-style-type: none"> - Seed pool replenishment - Organic matter cycling/Decomposition processes - Harvest/Concentration by soil micro-fauna
6	<ul style="list-style-type: none"> - Physical obstruction/Absorption processes

Figure 1. The TTRP framework representing sequences of ecosystem processes and feedback loops. The table lists some of the processes operating at different locations in the framework.

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Method Development

The TTRP framework represents a comprehensive sequence of landscape processes and feedback loops, enabling the structuring of environmental information pertaining to functioning. Methods to assess soil productive potential linked to plant performance had been developed to a certain stage (Tongway and Smith 1989, Ludwig and Tongway 1992), but needed the spatial and inter-regional context to become more useful to potential stakeholders. The soil condition indicators were initially developed from geomorphic processes such as erosion, crust formation, litter decomposition and correlates observed in the field or measured under controlled conditions. The validity of these indicators was enhanced by laboratory experiments (Mucher et al. 1988, Greene et al. 1994) and field measurements (Tongway 1993,

Greene 1992). Spatial analysis of a number of landscape types (Ludwig and Tongway 1995) suggested a means by which the soil indicators could be packaged for use in different landscape types.

In 1992-1995, NSCP funding brokered by Ag WA facilitated the development of extensively applicable methods, integrating soil surface condition procedures with the emerging TTRP framework. This resulted in a nested hierarchical information system. The method was overtly linked to land system resource map bases (e.g. Mitchell et al. 1988; many others). Land units as sub-units within land systems were recognised, with the monitoring site located within the land unit. Australian standard methods (McDonald et al. 1990) were used to provide landform and slope characterisation.

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The Method in Operation

"Landscape organisation" is the initial LFA data acquisition step and collects information at the hillslope scale. Data are collected on a line transect oriented in the direction of resource flow (a gradsect, usually down slope, but aeolian landscapes would use wind direction). Landscape features that interrupt divert or absorb runoff and transported materials are characterised as "patches" and recorded according to protocols outlined in the technical methods manual (Tongway 1994, Tongway and Hindley 1995, 2004). Typically, zones of resource loss (inter-patches) are distinguished from zones of resource gain (patches) and their sizes measured. Several indices of landscape organisation are calculated from these data with a spreadsheet supplied with the Manual. In addition, the data provides a "map" of the transect. This data is useful when assessing trend over time at a coarse or hillslope scale. In the second step, each zone type, 10 soil surface variables, plus soil texture are assessed, using the methods in the manual. These observations are both simple and quick after a little practice. In an extended version of LFA, vegetation parameters (such as density, species composition, size) can also be collected from the same transect by plotless, distance measuring techniques (Bonham 1979), as well as indicators of habitat complexity for mammals and birds (Newsome and Catling 1979).

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Calculation of Indices

The soil surface data are combined in different combinations to reflect three major soil habitat quality indices: **stability** or resistance to erosion, **infiltration/runoff** and **nutrient cycling** (Figure 2). The data are presented in a 0 to 100 scale .

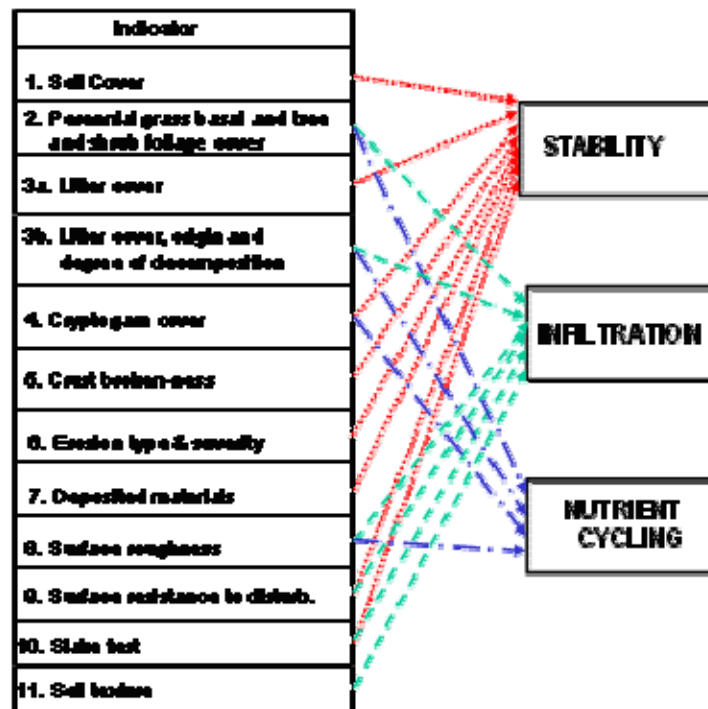


Figure 2: The combination of Soil Condition Classes to derive indices of Stability, Infiltration, and Nutrient Cycling.

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Interpretational Framework

The tabulated values need to be interpreted in the landscape context to make the most use of their information potential. With extensive experience, one might be able to place useful interpretations on each of the index values, but this would be a drawn-out process. The most recent development in LFA is the process whereby a response surface in the form of a sigmoidal curve is generated from field data (Tongway and Hindley 2000). The curve relates functional status versus stress and/or disturbance. To fit this curve, one needs data from both extremes of the available data space as well as the study sites encountered in monitoring which will have values somewhere between the extremes. The response surface (Figure 3) recognizes the upper asymptote as the biogeochemical potential of the site limited by climate and parent material and the lower asymptote as the lower limit of function under the existing land use stress. The slope of the line joining the asymptotes reflects the "robustness" or "fragility" of the system. The point X_0, b is located at the inflexion point of the curve, and represents a point of potential concern in terms of self-sustainability of the landscape in terms of its response to major stress and/or disturbance if its function is in that vicinity.

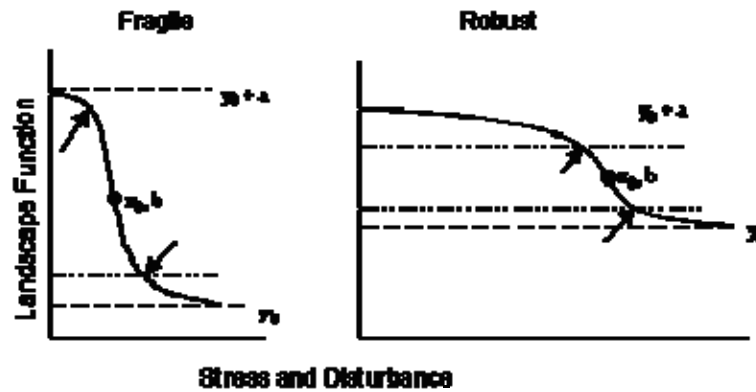


Figure 3. Examples of response curves for fragile and robust landscapes. The initial response of landscape function to stress and/or disturbance is markedly different. The fragile landscape deteriorates with low stress and has a much lower base line y_0 than the more robust landscape. Four-parameter sigmoid curves of the form:

$$y = (y_0 + a) / 1 + e^{-(x-x_0)/b}$$

provide four practical values reflecting the nature of the landscape. Critical thresholds (arrows) for each of the indices can be determined from field data.

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<< [EFA Home](#)

[▲TOP](#)

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