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A Conservation Planning Framework for South Australia's arid lands

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Abstract

Determining the level of investment and support needed to maintain biodiversity across vast areas is difficult. In response to this challenge the South Australian Department of Environment, Water and Natural Resources has developed an information synthesis and evaluation process known as the "*Aridlands Landscape Assessment Framework*" (ALAF), which attempts to provide a systematic basis for landscape-specific conservation planning and priority setting across the arid zone. The project is part of a broader scoping study that supports the development of the Trans-Australian Ecolink Initiative in South Australia (TAEL SA).

The ALAF is an analytical and conceptual framework that seeks to define ecosystem components and ecological processes operating at a landscape level. This requires a systematic process to name and identify plant communities that occur in distinct biophysical settings. The next, more difficult challenge is to document the dynamic processes that drive change within a landscape, to assist our understanding of how systems vary in space and time. The last step in the ALAF is to identify which components are most under threat, where and for what reasons.

Here we provide an outline of the ALAF process and snap-shot of current knowledge for Witjira National Park in northern South Australia. The most resilient ecosystem types appear to be those with physical attributes that limit soil erosion, retain water and support woody shrubs with low palatability during dry times. This is largely due to the ability of these systems to accumulate soil moisture, nutrients and biological propagules.

Introduction

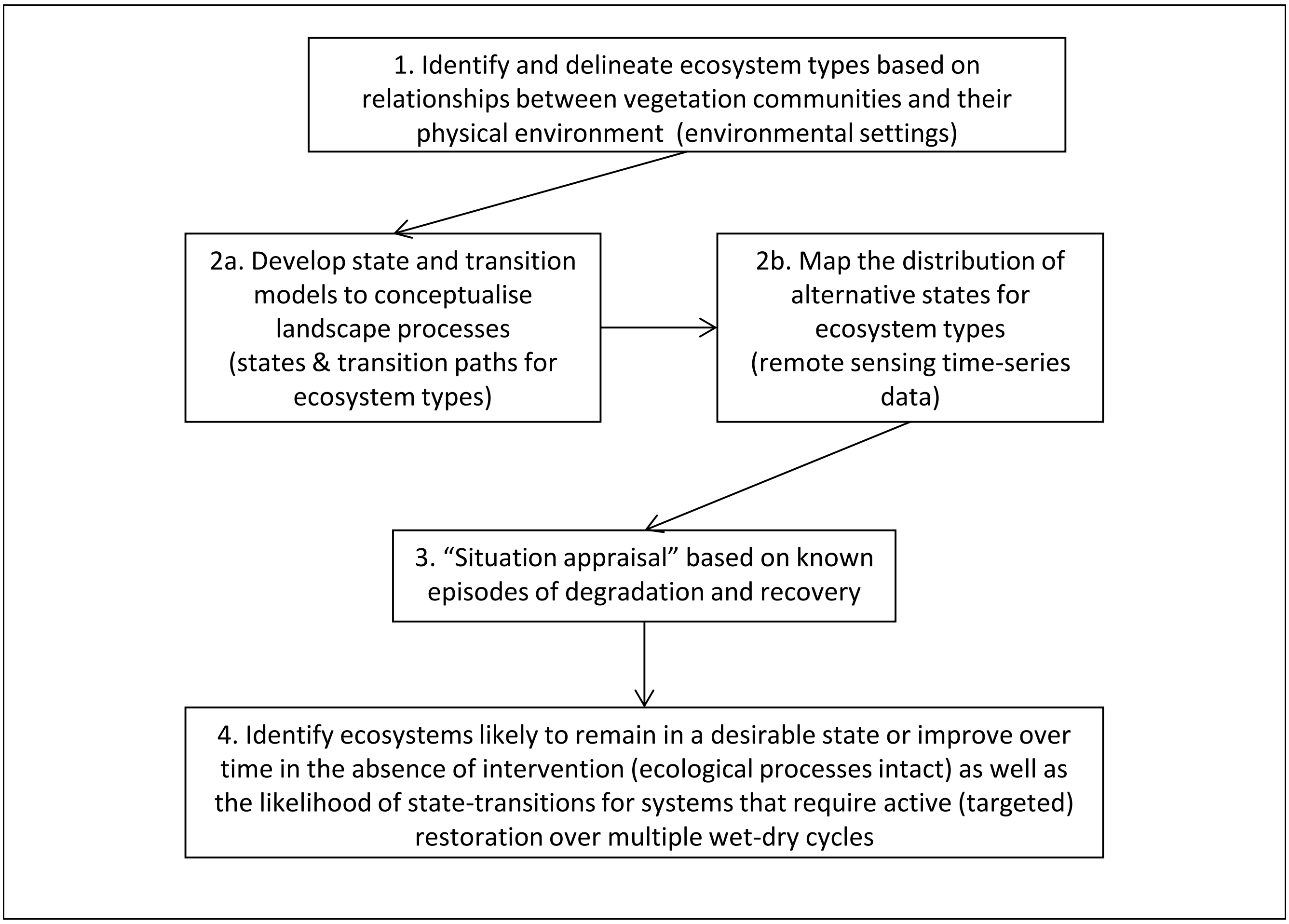
South Australia's arid lands are characterised by episodic wet and dry cycles (boom and bust), where prolonged dry periods are often broken by high-intensity rains. Vegetation pattern and change is driven primarily by climate variability, but is also strongly influenced by soil nutrients, fire and grazing (Morton et al. 1995). Some of the major issues affecting biodiversity include alterations to the availability of water and nutrients within a landscape (Ludwig et al. 2002, Pringle and Tinley 2003), alterations to the structure and composition of plant communities (Landsberg et al. 2003), and changes in the distribution and spread of pest plants and animals, and the impacts this has had on native biota (Newsome 1994).

The South Australian Department of Environment, Water and Natural Resources (DEWNR) is responsible for the delivery of the Trans-Australian EcoLink Initiative (TAEL SA) and other regional conservation programs. In SA, the delivery of TAEL is focussed on the pastoral lands, particularly the more arid northern part of the Stony Plains Bioregion. Desired outcomes include the enhancement of sustainable property management initiatives such as EMU™, through partnerships with the pastoral community and NRM support agencies.

DEWNR has developed an information synthesis and evaluation framework referred to as the "*Aridlands Landscape Assessment Framework*" (ALAF), which attempts to provide a systematic basis for landscape-specific conservation planning and priority setting for the arid zone. The purpose of the ALAF is to bring together the relatively disparate sources of information into an integrated framework that focuses on the question "*can we identify which components of biodiversity are most under threat, where and for what reasons?*"

Figure 1 outlines the five steps in the ALAF process, as applied to Witjira National Park and its surrounds. The step-by-step process is designed to collate and interpret context-specific information about ecosystem condition and the drivers of change, which is essential to long-term conservation planning and prioritisation.

Figure 1: Aridlands Landscape Assessment Framework



Rationale behind the ALAF

Internationally, the need to understand complex, dynamic ecosystems has stimulated a wealth of ecological theory. The two most influential themes are probably hierarchy theory, which proposes that scale dependent levels of organisation exist in nature (Allen and Starr 1982, O'Neill et al. 1989), and literature centred on concepts of resilience and ecological thresholds.

Hierarchy theory provides a framework referred to as the Hierarchical Patch Dynamics Paradigm (HPDP), which is useful for constructing knowledge about complex systems (O'Neill et al. 1986). Heterogeneous landscapes can be described at any given level by identifying "patches" that represent spatially discrete entities whose internal structure and/or function is significantly different from that of their surroundings. Adjacent "patches" do not function independently from one another, but are instead connected by ecological flows and linkages, including the movement of water, nutrients and animals.

At a fundamental level, we assume that climate, geology and geomorphology have interacted over long time-frames to produce a range of characteristic vegetation communities that are associated with particular physical environments, and whose internal organisation suggests they are likely to respond to dynamic changes (either climate or management driven), in a similar way. Ecosystems also display different recognisable states and respond to disturbance in different ways. Perturbations can drive a system to an alternative state, as proposed under the "state-and-transition" framework (Westoby et al. 1989). A common question for land managers is whether a system is likely to recover from a disturbance event unaided, or is some form of active management and intervention needed. The resilience of a system can be measured in terms of its capacity to absorb and recover from disturbance without requiring intervention (Holling 1973).

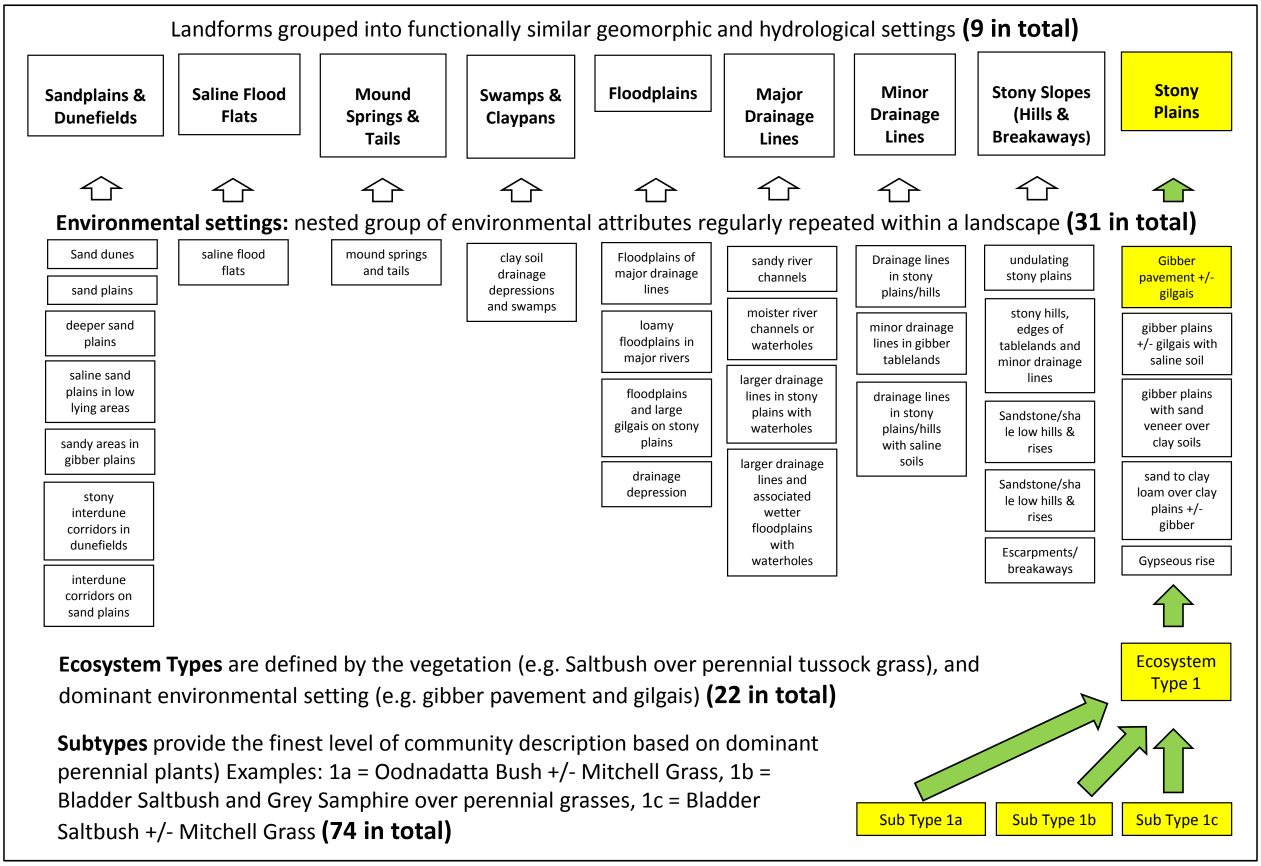
Conceptual models of ecosystem types

For many habitats across the Stony Plains Bioregion, ecological processes are considered to be largely intact when compared to highly fragmented agricultural parts of the state (Brandle 1998). Whilst habitat alteration and degradation has occurred throughout the region, its remoteness from settlement and biophysical properties such as the clay soils being unsuited to rabbit burrowing, have enabled many systems to remain essentially intact.

Conceptual models in parts 2a and 2b of the ALAF process (Fig. 1) attempt to explain how different ecosystems operate in terms of slow drivers (e.g. geology, topography and soils) that affect the limits to what can grow where, and dynamic drivers (rainfall, disturbance agents), which largely govern what and how much can grow at any point in time.

A hierarchical ecosystem classification was developed that delineates and describes different systems based on our understanding of the determinants of ecological variation and known drivers of change (Fig. 2).The term "environmental setting" was used to encompass a nested group of physical environmental attributes that are regularly repeated within a landscape, although they are not necessarily exclusive to the landscape. Ecosystem types are defined by their dominant perennial plant species and structure (e.g. *Eucalyptus* open Woodland) on a given environmental setting. Subtypes reflect a number of different functional or compositional states, which may be the product of different land-use histories and community assembly processes.

Figure 2: Proposed ecological hierarchy for Witjira National Park



The conceptual basis for state and transition models (STMs)

Plant communities are constantly changing in response to variations in climate, particularly rainfall. At the simplest level, the dynamics of a system are driven by annual cycles of growth and senescence, while more complex changes are associated with climatic extremes. This can cause ephemeral plants to differ in species composition from one year to the next and perennial plants to undergo infrequent, but widespread recruitment (or death) from time to time.

Land-use history is also an important determinant of ecosystem type expression. The Stony Plains has a long history of pastoral production with livestock grazing being a key driver of change. The nature (cattle/sheep) and intensity of this driver is variable across space and time, and continues to change. The legacy effects of past grazing practices can be deduced (to some degree) from reading a landscape in situ, but this information needs to be interpreted in the context of all available knowledge. This can be local knowledge from landholders themselves, or at the very least an assessment of change via repeat photo-points, aerial photography and/or time-series remote sensing. Any of these methods can be used to formulate hypotheses about the factors driving change. However, the results should be interpreted cautiously, as many drivers influence ecosystem dynamics beyond the property scale, and understanding how each of these interact, is always a difficult challenge.

STMs are developed to capture information on the types and rates of change in ecosystems that should be useful in a management context. For a given system, a local rainfall event will produce its own vegetation response and prolonged dry conditions are are much more likely to influence the character of the vegetation than a series of 'average' seasons. Thus, understanding the impacts of extreme environmental events and their combined interactions with grazing and fire is critical to interpreting and managing vegetation health and productivity in rangelands.

Examples from the Witjira Case Study

Ecosystem types and environmental settings

Floristic and structural information was used to assign177 sites to 74 vegetation assemblages based on the dominant perennial species. These were further refined into broad vegetation alliances, which were used to characterise ecosystem types (ET), each closely aligned to a particular environmental setting as presented in Fig. 2. At the broadest level in the hierarchy, ecosystem types and environmental settings were aggregated into one of nine functionally similar geomorphic and hydrological settings. At the finest level, ETs were divided into Ecosystem Subtypes (ESTs) based on slow geomorphic and dynamic drivers. Table 1 provides examples of subtypes for ET 1: *Atriplex* low shrubs with perennial tussock grasses on stony plains.

Table 1: Subtypes associated with *Atriplex* low shrubs with perennial tussock grasses on stony plains

Subtype 1a: *Atriplex nummularia* ssp. *omissa* +/- *Astrebla pectinata* on gibber pavement with gilgais of the Cordillo Silcrete.

Subtype 1b: *Atriplex vesicaria*, *Tecticornia medullosa*, *Tripogon loliiformis*, *Frankenia* spp. on gibber plains +/- gilgais with saline soil found low in the landscape.

Subtype 1c: *Atriplex vesicaria* and *Astrebla pectinata* on gibber plains with sand veneer over clay soils proximate to Quaternary sand deposits.

Subtype 1d: *Astrebla pectinata*, *Atriplex* spp., *Sclerolaena* spp. on gibber pavement of Pedirka Formation or deep, red clay soils with soft carbonate.

State and transition models as a means to conceptualise landscape processes

Conceptual models were used to describe relationships between subtypes, their environmental setting and drivers of change. An example of the influence of micro-topographic and soil characteristics on ecosystem subtype expression is presented in Figure 3. Figure 4 illustrates the responses of sub-types to rainfall, soil moisture and salinity levels. Figure 5 illustrates how rainfall seasonality and drought can drive transitions in ecosystem type expression.

Figure 3: Conceptual models for effect of microtopography in determining subtypes for the *Atriplex* spp. with perennial tussock grass on stony plains ecosystem type.

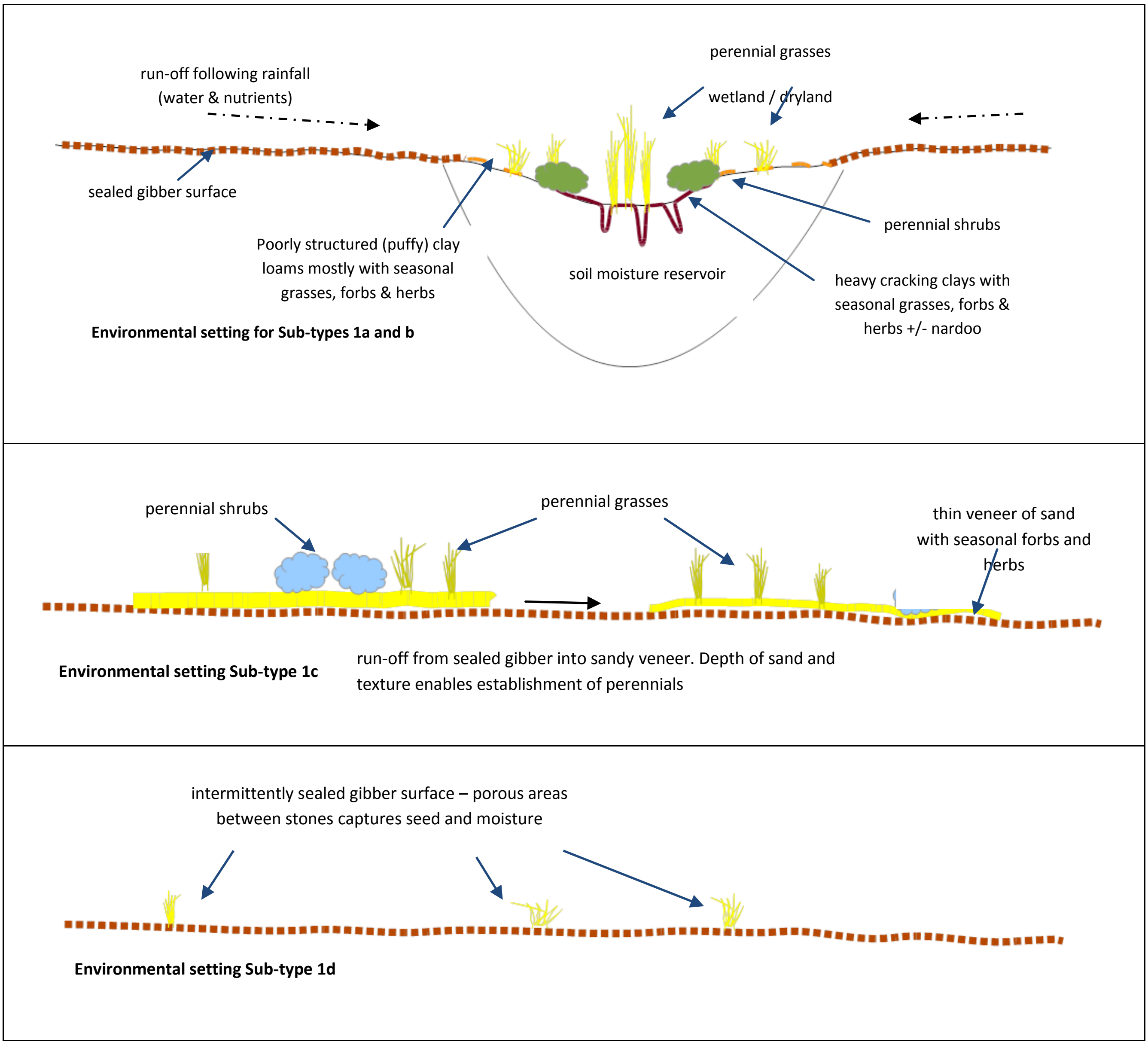


Figure 4: Transition pathways ecosystem subtypes displayed in Figure 3 driven by the interaction micro-topography, soil type and salinity and their influence moisture.

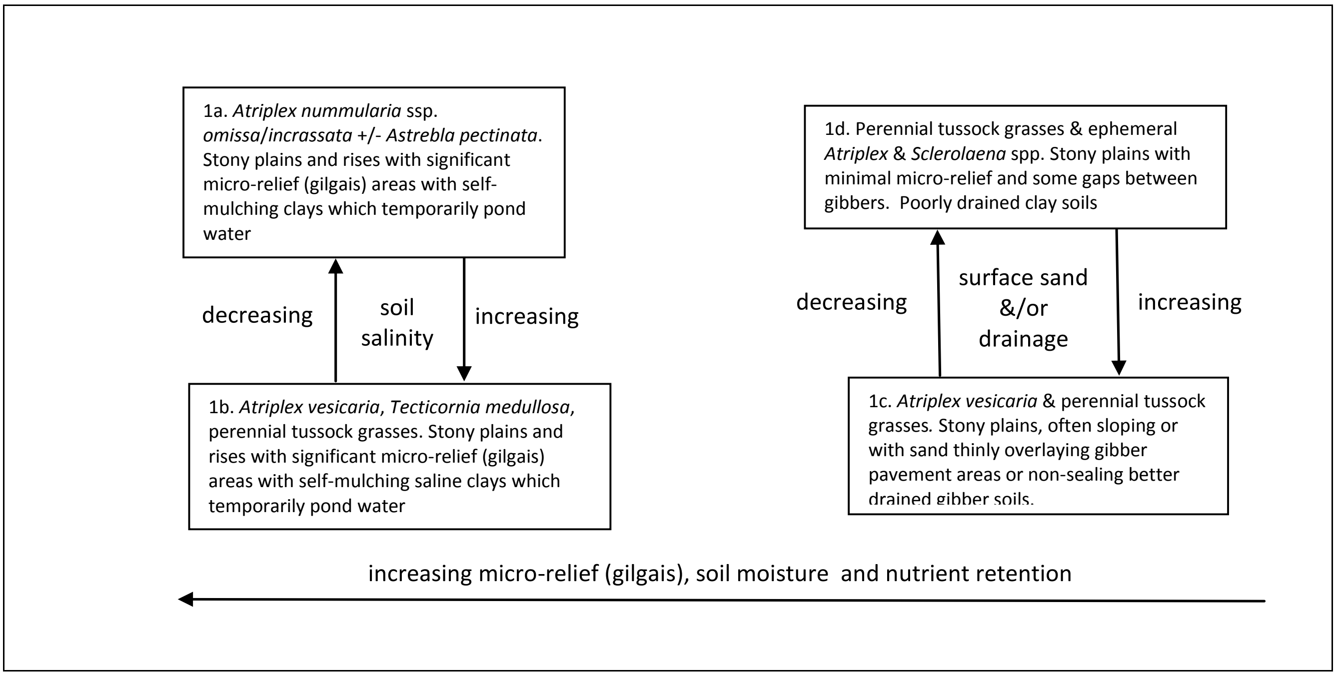
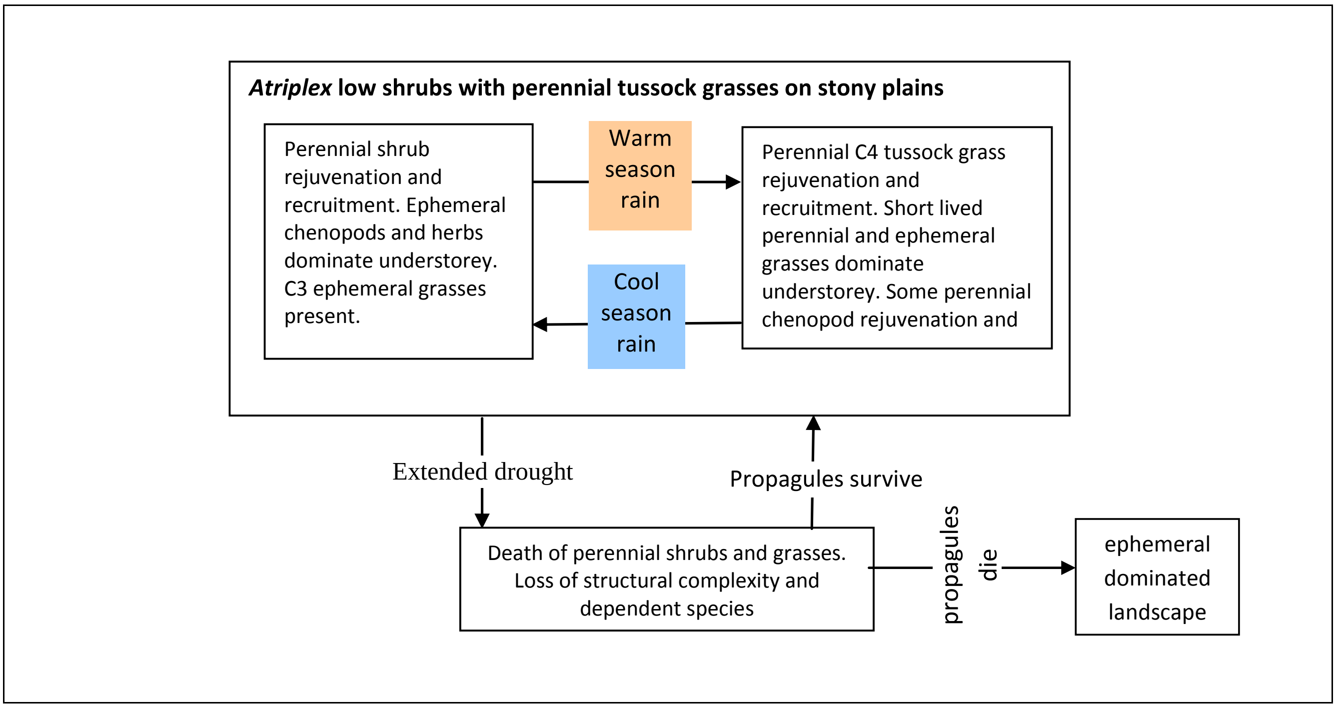


Figure 5: Response of ecosystem type 1 to seasonal rains and extended drought.



Situation appraisal based on known episodes of degradation and recovery

Witjira National Park was proclaimed in 1985. Prior to this the area known as Mount Dare Pastoral Lease was grazed by domestic stock (sheep then cattle) for more than 100 years. Although grazing by cattle has officially ceased, much of the reserve remains unfenced, and cattle are free to move into the park from neighbouring leases.

Historic photos and photo-points from 1956, 1979, 1986 and 1993-95 were used to assess change using perennial plant cover/abundance under reduced grazing pressure during 2011 at 45 locations. A further 8 off-park locations were similarly assessed.

The data showed that in 55 individual cases, plant species increased their density across alluvial floodplains and drainage channels (n=13 sites). In contrast, the stony plains had only 36 instances of density increase from 20 sites. The most obvious species trend on stony plains was density increases in *Astrebla pectinata* which were attributed to the recent influence of above average summer rains.

Trends for *Atriplex nummularia* ssp. *omissa* showed little change, while *Atriplex vesicaria* had increased at 8 sites where it was noted, and declined at 3 sites. Creeks registered the most substantial changes in terms of species diversity and abundance, particularly the development of a shrub understorey where previously absent, as well as a substantial increase in cover-abundance of canopy species. The re-appearance of palatable species such as *Chenopodium auricomum*, *Atriplex nummularia* ssp *nummularia* and *Maireana aphylla* suggests a wide-spread relaxation of grazing pressure. There was also a slight trend for establishment of trees on flood and alluvial plains.

Mapping the distribution ecosystem types and alternative states

While the production of suitable products to map the extent and condition of ecosystem types is still in its development phase, a range of promising methods have been trialled and the results presented in the accompanying Conference poster. A multi-temporal image classification approach was trialled as a tool to discriminate different ecosystem types. Using a sequence of 15 Landsat 5™ images between 2003 and 2011, it was possible to classify vegetation in to units based on the different growth and decay responses of vegetation across a series of wet-dry cycles.

Discussion

DEWNR has developed a methodology and provided examples within the Witjira Pilot region of a conservation planning framework that 1) defines landscapes and their components, and 2) links dynamic processes to these components allowing us to understand how they vary and can be managed. The assessment attempts to model real trends in actual dynamics to better understand vegetation states and transition processes within them.

Conservation priorities at a paddock and station level cannot be identified through the ALAF alone, and need to be informed by the goals and aspirations of landholders. Programs like EMU™ start with local knowledge as their ethical foundation. EMU™ is partnership of knowledge sharing within an ethical, nurturing framework that supports land managers to act on issues they know need specific attention (Janet Walton, Pers. Comm.). The process of learning to read and understand landscape processes is done in situ, while on the ground (or in the air) with the help of EMU™ staff, but can be infused with landscape-specific insights and knowledge from the ALAF. It is important that any information from the ALAF, if it is to be of use to the landholder, is processed and distilled in the correct local context. This may require a re-evaluation of existing maps and outputs through a process of reciprocal learning. In this regard, we view the ALAF as an iterative planning framework designed to inform a range of stakeholders and end users of the "big picture" landscape issues that require consideration beyond the level of an individual property.

Conclusions

The ability to track dynamic changes in natural systems is central to the effective management of biodiversity. Because natural systems are complex and constantly changing, it is often difficult to differentiate between 'natural' variation and anthropogenic impacts. Thus, the detection of management-related trends in the presence of inter-annual climatic variability is extremely challenging. In this project, we have tried to find innovative ways to confront this challenge, and in the process come up with a framework that provides a fresh new approach to NRM planning across South Australia's rangelands, that is based on resilience concepts and thinking.

References

Allen, T. F. H. and T. B. Starr. 1982. Hierarchy, perspectives for ecological complexity University of Chicago Press, Chicago.

Brandle, R. 1998. A Biological Survey of the Stony Deserts, South Australia, 1994-1997. Department for Environment and Heritage South Australia.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics **4**:1-23.

Landsberg, J., C. D. James, S. R. Morton, W. J. Muller, and J. Stol. 2003. Abundance and composition of plant species along grazing gradients in Australian rangelands. Journal of Applied Ecology **40**:1008-1024.

Ludwig, J. A., R. W. Eager, G. N. Bastin, V. H. Chewings, and A. C. Liedloff. 2002. A leakiness index for assessing landscape function using remote sensing. Landscape Ecology **17**:157-171.

Morton, S. R., D. M. Stafford Smith, M. H. Friedel, G. F. Griffin, and G. Pickup. 1995. The Stewardship of Arid Australia - Ecology and Landscape Management. Journal of Environmental Management **43**:195-+.

Newsome, A. E. 1994. Vertebrate pests versus wildlife conservation in semi-arid New South Wales: A profound imbalance. Pages 43-51 Transactions of the Royal Zoological Society of New South Wales; Future of the fauna of western New South Wales.

O'Neill, R. V., A. R. Johnson, and A. W. King. 1989. A hierarchical framework for the analysis of scale. Landscape Ecology **3**:193-205.

Pringle, H. and K. Tinley. 2003. Are we overlooking critical geomorphic determinants of landscape change in Australian rangelands? Ecological Management & Restoration **4**:180-186.

Westoby, M., B. H. Walker, and I. Noy-Meir. 1989. Oportunistic management for rangelands not at equilibrium. Journal of Range Management **42**:265-273.