LANDSAT TM IMAGES: SIMPLE YET PROFOUND TOOLS FOR OUTBACK ECOSYSTEM MANAGEMENT UNDERSTANDING

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Abstract

Satellite data have been important in expanding the scale at which landscape dynamics are researched and understood in rangelands globally. The data have usually been used by scientists and their technologists to apply local (fine resolution) models of ecosystem dynamics over larger than traditional site-based areas. In effect, this research has asked questions that are asked at ground-based sites, but over far greater areas. This approach has led to the development of broadscale models of within-landscape ("patch") dynamics. The research has improved our understanding of how local changes vary in space. Unfortunately, the dissociation of scientists from land managers in this research has not led to widespread improvement in the way land is managed.

The Ecosystem Management Understanding ("EMU") Project uses satellite data quite differently. We use relatively unsophisticated products but produce profound changes in management on the land. We use the opportunities presented by satellite imagery to address a range of questions related to how rangelands are structured and function and we involve land managers in assessing satellite products of the land they know intimately.

Typically, we use regional images for overviews and comparisons between regions in terms of landscape patterns and processes. We use district images for catchment, pest and weed management, property level images to identify critical issues for priority management and then local images for planning specific initiatives within properties.

While satellite imagery may need to be augmented by finer resolution aerial photographs for planning specific interventions within local projects, the imagery is incredibly versatile and an indispensable tool for addressing the multiple scales at which rangeland dysfunction is expressed. The imagery also has extraordinary value in engaging land managers who are often captivated by the opportunity to test their local knowledge against images and start to

develop a more hierarchical understanding of their properties and wider catchments. The images have been instrumental in developing cross-boundary and catchment-wide initiatives due to the expanded perspective they enable.

Ecological Understanding Has Not Kept Pace With Remote Sensing Technology

The commercial development of rangelands world-wide has left legacies of degradation (Milton et al. 1994, Rapport and Whitford 1999, Ratcliffe 1936, Sanford1983) that reflect a mis-match between the hierarchical organisation of pastoral industries and the hierarchical organisation of exploited ecosystems. Pastoralism was not developed to *fit* the patterns of landscapes and critical linking processes, such as the surface flow of water. Rather, commercial pastoralism was developed with a conquering philosophy, that *fought with* – and in too many cases damaged- ecosystem patterns and processes (Ludwig, Tongway et al. 1997, Pringle and Tinley 2003).

In essence, rangeland degradation has been viewed as a process driven by local denudation of perennial vegetation, exposure of soil to erosion and subsequent loss of productive capacity in a downward spiralling manner (Milton et al. 1994). In other words, rangeland degradation has been seen as a habitat/landscape/plant community level process; that is something that is readily visible. This has led us to believe that the causes and effects are manifest at our local, ocular scale of assessment. And consistently, the solutions are generally seen as needing to be local, whether in terms of grazing management (Dyksterhuis 1958, Heady 1975) or repairing damage (Whisenant 1999).

Satellite-based technology allowed us a new view of the rangelands, one that overcomes many of the theoretical deficiencies of site-based ground assessments (Eve et al. 1999, Pickup 1989). Indeed, some quite profound within-landscape models of patch dynamics have been developed (Bastin et al. 2002), providing much deeper insights into the broadscale dynamics of attributes we can observe visually in the field, but not over large areas as satellites can do. This progress has been a critical step towards addressing the problems of strictly site-based observation in extensive management systems such as rangelands.

However the scales of sampling (fractal dimensions of investigation) have not increased greatly despite the advent of remote sensing (although some insightful summary indices have resulted). While the scale of rangeland ecology has expanded, and some summary indices provide new insights (Bastin et al. 2002, Ludwig et al. 2004), the fractal dimension and therefore the ecological level of our understanding of rangeland patterns and processes has not kept pace. We are still locked into local attributes operating within and between patches (very small fractal dimensions in terms of the vastness of rangelands), albeit in a sophisticated and spatially extensive way now.

This failure to expand the fractal dimensions of our understanding of rangeland ecology is probably a result of most rangeland ecologists having a strong background in agriculture or botany. Some may have soil science to broaden their local understanding, but few would have geology, climatology, geomorphology and hydrology as core disciplines. Perhaps simplistically, these disciplines embrace the broadscale/slow variables of ecology and are often only referred in introductory, scene-setting sections of ecological publications.

We believe that in many instances, these broadscale/slower variables provide the framework within which more local and faster dynamics operate (Tinley 1987). Erroneously perhaps, there may be a general belief that these framework variables are so inert or slow changing that they do not exert much influence on the patch dynamics and so forth we use as the currency of degradation and repair. However, as any geomorphologist or hydrologist would attest, the framework is dynamic and is a major driver of ecosystem change (Cole 1963).

The Ecosystem Management Understanding (EMU) story

Hugh Pringle and Ken Tinley started the EMU Project with pastoralists as part of the Gascoyne-Murchison Strategy's Regional Environmental Management Program in 2000 (Pringle et al. 2003). Many pastoral leases exceed 200,000 ha with individual paddocks of 10,000 ha and integrated catchment projects that may readily exceed a million hectares in area.

The project's primary focus has been on enlightening pastoralists as to the extent and nature of the legacy of degradation they have inherited from previous managers and the Government landlord, and enabling and empowering them to address the challenges that are most important and can be overcome (i.e. are feasible). The most important of these is to lose no more healthy land to the insidious degradation processes driven by inappropriate infrastructure and overgrazing. There are other core foci in the project, such as regionally important conservation values, but in this paper we focus on catchment and landscape function issues. A major feature of the project is the initial capture of pastoralists' considerable local knowledge on clear overlays over a coloured land system (country type) and infrastructure map of their properties (see www.emuproject.org).

We started the project without remotely sensed images (Pringle and Tinley 2001). While we found it easy to talk about broadscale processes, such as major drainage features and processes, we found it difficult to diagnose higher level catchment dysfunction without any picture of stations. We had to rely on seeing something in the field that sounded alarm bells to us (such as a sharply incised channel in what should be a calm part of a catchment, indicating that something was geomorphically wrong with a drainage system) to find "big picture" problems. We also had no capacity to anticipate possible threats to most intact areas and with limited time on-site, we weren't as efficient as we are now.

Partnership with the Department of Land Information, Leeuwin Remote Sensing Centre

Then came our partnership with the Department of Land Information staff, Peter Sanders and Ross Dodds, at the Leeuwin Remote Sensing Centre (and critically, their Landsat TM products). They provided us with regional overviews in which we could locate neighbouring managers and they could identify important linkages between their properties, management and future prospects (the catchment management perspective). Ross Dodds also provided us with excellent 1: 100, 000 images of individual properties. The key catchment control points (Pringle and Tinley 2003) are obvious when you view such an image of a property, and this helps us work with pastoralists on the areas that are most important; but not necessarily most degraded. Thanks to our LANDSAT images, we spend our time on the ground efficiently, putting local observations into their catchment context and developing simple, but profound "big picture" solutions to what are usually broadscale problems.

The Landsat images show us both potential problems and solutions. Sometimes the problems we see are just a legacy of extraordinary grazing pressure that leaves the land simplified, leaking and unproductive. But at least as often, we can see critical drainage controls that aren't working anymore (as a result of infrastructure as much as stocking rates we believe) and that might be restored or substituted to help the catchment do what it used to do (Pringle and Tinley 2003).

Another tool helps us greatly; high-winged aircraft with which we fly traverses at about 100-200 metres above ground based on interpretation of pastoralists' overlayed information of key features and assessment of the satellite images (Tinley and Pringle 2002). We take digital photographs of key features and can then play them back on a television on landing. We frequently switch focus between the TV's digital photos (the detailed view) and the LANDSAT image (the broader context), quickly developing a deep, hierarchical understanding of critical patterns and processes (even before we set out in vehicles to inspect the areas that this dual assessment has allowed). We would then spend at least another full day visiting the areas where we had collectively decided our attention should focus. In less than two days, we can identify, diagnose and commence planning for what really matters thanks to the context provided by the Landsat images and the aerial traverses.

When we become involved in any major interventions with pastoralists we get good quality Landsat TM images at 1:50,000 to clarify what needs to be done and where, within the plans we have constructed together. We might also then spend time looking at the best available aerial photography, if the drainage patterns are complex.

Concluding comments

The EMU Project depends on high quality remotely sensed images as a key tool in understanding the complex, hierarchical and broadscale dysfunction of rangelands and what is required to repair or protect them. The images graphically reveal the patterns and processes surrounding an area of particular interest, helping us to develop management solutions that are contextualised and holistic.

The images play a critical role in building pastoralists' own capacity to understand their properties as parts of catchments with critical control points that determine whether rain is harvested locally and produces vegetation, or escapes with topsoil to the sea or salt lake. Thus the images are fundamental to our capacity building as well as the efficiency with which we diagnose problems and build solutions. They provide a simple but profound means to enter into conversation of ecologically sustainable land management with local managers.

Landscapes are dynamic, even at catchment scales (Pringle and Tinley 2003). Therefore, we hope that our partners at the Department of Land Information will continue to be able to supply us with the high quality, recently captured imagery which they have done over the last few years. That way we will have the best imagery with which to take on the challenge of ecosystem management in the Outback.

In a way, our simple but profound use of satellite images represents a return to the "pure" use of the medium as a means of seeing patterns and processes beyond those readily viewed by the human eye in the field. We use this capacity (which was not available to our predecessors) to develop better understanding of broadscale patterns and processes at higher levels of the ecological hierarchy. Indeed, the simplicity of our use of remotely sensed data may be a critical success factor in developing this better understanding of the hierarchical complexity of the real world.

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