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RETROSPECTIVE ANALYSIS: RAPID APPRAISAL OF SATELLITE DERIVED COVER INDICES

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INTRODUCTION

Satellite data are increasingly used to assess trends in rangeland cover (Grech *et al.* 2003; Karfs 2002), and a variety of indices have been derived from satellite data to assess land condition or cover (e.g. Brock *et al.* 2001; Scarth *et al.* 2006). Among the rangeland monitoring methods they provide the greatest spatial, and often temporal, coverage, rendering them attractive monitoring options.

At present, there is no universal satellite-derived CI for the Australian rangelands. As such, agencies wishing to assess rangeland cover from imagery in areas where a trialled index is unavailable must use an index transplanted from other locations. In this case, the index should be validated locally to understand its applicability, as the validity of the index is fundamental to the success of the monitoring system. Traditionally, ground cover indices are validated by correlating on-ground measures of cover with satellite index values collected simultaneously (e.g. Bastin *et al.* 1993; Karfs 2002). Whilst robust, this technique is very time-consuming, and cannot provide feedback on the index until a number of years of ground data have been collected.

We have trialled a set of alternative methods for validating a CI. Unlike formal ground measurement sites, it provides almost immediate feedback on the performance of the cover index. We call these approaches 'retrospective analysis', since they collate the historical records and observations of land managers regarding the location of noticeable temporal and spatial variance in ground cover. These records are then compared to historical cover index data for those locations to assess the capacity of the index to reflect changes in groundcover.

This paper provides an outline of retrospective analysis. We outline methods for gathering the data, describe potential case studies for analysis, and discuss the relative merits of each type of analysis.

METHODS

Analyses were conducted on 15 pastoral properties scattered across approximately 6 000 000 km^2 of western Queensland where we were trialling delivery and use of satellite assessments of land condition. Properties were selected on the basis of owner interest and to encompass a range of representative land types for each region.

Retrospective analysis refers to the process of comparing historical data regarding land condition and ground cover with a satellite-derived cover index (CI), to test the CI in mapped polygons across the property. This process is outlined in Figure 1. We identified six different types of retrospective analysis that might be used to assess the performance of a CI on each property (Table 1). We conducted a semi-structured interview with each property manager, focussing discussion around potential locations for each analysis on the property. We then inspected these locations and collected descriptive data for each site including vegetation and erosion descriptions, notes on important nearby infrastructure and photographs. Coordinates were also recorded with a GPS and used to map polygons around each site.

Once polygons were mapped in a GIS, we extracted average CI values for each polygon in each year of our satellite record (1988-2006 depending on location). We used inverted Landsat TM Band 3 data as a CI, masking out areas of high woody vegetation cover to reduce confusion of woody and herbaceous cover. The time traces for the CI in each polygon were then assessed against management descriptions to determine the adequacy of the index to indicate cover levels.

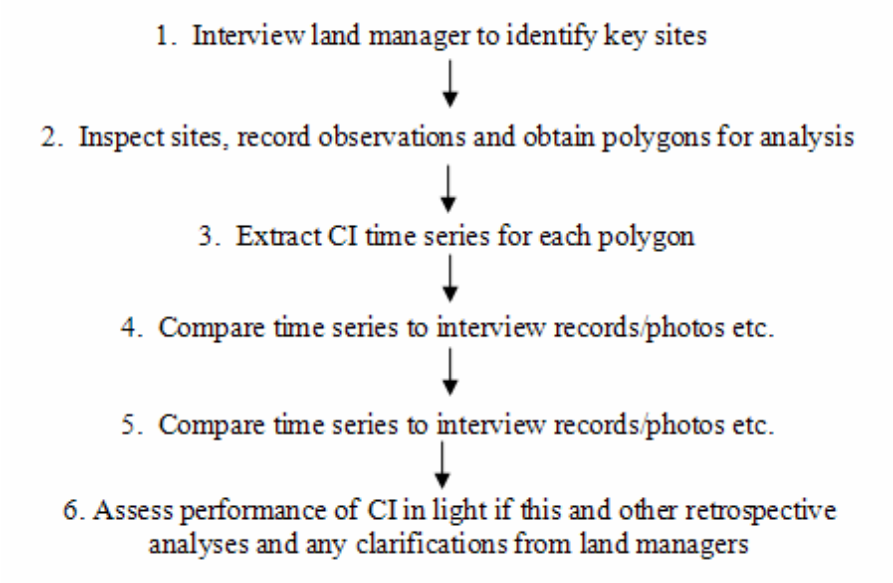

Figure 1 Retrospective analysis process

RESULTS AND DISCUSSION

Retrospective analysis allowed us to test the cover index across a wide range of land types and five NRM regions in a relatively rapid process. This would not have been possible using the more traditional approach of setting up monitoring sites, then progressively collecting and analysing data for several years. We examined a total of 66 retrospective sites across 28 land types in western Queensland. About 75% of case studies provided support for the groundcover index, while the remainder were inconclusive or identified potential problems with using the index in particular land types.

Retrospective analysis is neither new nor foolproof (see below), but it has several important advantages when applied to field testing cover indices in new circumstances, including capacity to

- deliver results across multiple land types;
- collect data outside the satellite overpass period, freeing up field time;
- assess polygons of various sizes, according to circumstance;
- triangulate on the question of "does this index work?" from a number of perspectives;
- involve land managers in the data collection better, giving them a sense of ownership in the process and introducing them to subsequent applications of the cover index for monitoring; and,
- utilise existing monitoring data, such as QGRAZE and rainfall data, fostering continuity of monitoring, which has not been a strong feature of rangeland monitoring in the past (Field *et al.* 2007).

While retrospective analysis proved useful, its limitations should be noted. Its most serious flaw is probably its capacity to produce false negative results, where the cover index data and management observations do not align. This can occur when the cover index really does not work, when management records are inaccurate, or when the effect identified by management is real, but too small for the index to detect. In any case of a single negative outcome, we cannot distinguish these possibilities. The likelihood of a false negative can however be reduced greatly by;

- focussing on case studies where the identified effect on ground cover is corroborated by multiple data sources (particularly historical monitoring data and/or photos), and avoiding cases studies where only verbal records are available;

Table 1. Six potential scenarios for retrospective analysis of a CI and their respective advantages and disadvantages.

Retrospective analysis scenario	Advantages	Disadvantages
Fence line contrasts Management differences such as stocking rate, infrastructure layout and grazing patterns (Orr 1979; Landsberg *et al.* 2003) across a fence line result in contrasting levels of ground cover.	Fence line contrasts are well recognised by rangeland managers, easy to find and their generally long standing nature provides a long series of dates over which to assess differences in cover.	More obvious contrasts more likely to be identified so CI may not be tested where subtler differences occur.
Established Monitoring Sites Pre-existing monitoring sites provide ground cover estimates at specific locations and times. Average CI values for each site are compared to ground measurements from the same times and locations.	Data from monitoring sites are often of high quality, and can include photographs.	Ground data collection dates may not match CI collection dates well. In some cases ground data may not include a direct measure of ground cover, though it may be inferred (eg from photos).
Grazing Gradients Differential grazing pressure results in predictable long term differences in ground cover at different distances from a water point. Average long term CI values along the gradient are compared between different parts of the gradient.	This analysis works best in more open and/or homogenous land types around well established waters.	It is generally harder to detect a gradient where tree and shrub cover is heterogeneous, land types are poorly mapped, gradients are short and/or water points are newly installed
Management interventions Changes of management practices (eg stocking strategy, infrastructure layout, ripping/contouring) impact on ground cover. These impacts on the CI are traced over time.	Interventions within the span of the time series are excellent since they should show the change from pre-intervention to post intervention conditions.	New interventions are harder to detect because impacts tend to accrue with time. Managers can also have inaccurate memories regarding the magnitude of changes due to management interventions.
Ground cover patches Differences in ground cover within the same paddock result from long-term grazing patterns, fire history or microtopography. Average CI values are compared between patches with known differences in ground cover.	Effective in testing the capacity of the index to distinguish between areas of very high and very low cover.	Differences can be difficult for managers to identify if drivers are difficult to observe (microtopography) or fluctuate through time (preferential grazing) or result from events unknown to manager (old fires).
Rainfall effects Rainfall patterns strongly influence long term patterns in ground cover. Annual estimates of average CI are compared to annual rainfall for a given area.	Rainfall data are available for many properties and are generally good indicators of gross annual rainfall.	Timing of rainfall within year affects ground cover also though, and this is harder to incorporate into any comparison with annual CI values.

- only selecting case study sites where there *is* a difference, not where there *should be* a difference;
- using longer-term comparisons where possible;
- testing the index across multiple contexts and looking at the range of results; and,
- seeking feedback from managers on results. This produces mixed results, but sometimes managers provide important clarifying information missed in the original interview.

CONCLUSIONS

Retrospective analysis is not a new approach to understanding trends in rangeland health or to validating an index of rangeland condition such as a CI. Most of the kinds of analyses that we've presented have been used implicitly or explicitly in prior research. What has occurred here though is a fairly exhaustive summation of the sorts of retrospective analyses that can be conducted. It should provide a useful guide for future applicants of this technique.

Retrospective testing and validation of a CI cannot replace validation via permanent ground site data. Its lesser robustness means it works best as an adjunct to site monitoring. However, it has core advantages that make it a useful tool. It is an excellent means of engaging managers in research. It is also an excellent means of tapping into their valuable local knowledge. Finally it provides a useful and speedy first look at the performance of any CI, and should clarify the accuracy of any CI as it is trialled in new regions.

REFERENCES

Bastin, G.N., Sparrow, A.D. & Pearce, G. (1993). Grazing gradients in central Australian rangelands: ground verification of remote sensing-based approaches. *Rangeland Journal*, 15(2): 217-33.

Brock, A., Tynan, R. & Fleming, M. (2001), *Indices of change in ecosystem function (cover) for northern South Australia using Landsat TM*. Final Report to National Land & Water Resources Audit (January 2001).

Field, S.A., O'Connor, P.J., Tyre, A.J. & Possingham, H.P. (2007). Making monitoring meaningful, *Austral Ecology*, 32: 485-491.

Grech, A., Ostendorf, B. & Lewis, M. (2003). *Land Condition Monitoring: Integrating Ground Surveys, Aussie GRASS and Satellite Remote Sensing – Final Report*. University of Adelaide, South Australia.

James, C.D. (2003). Responses of vertebrates to fenceline contrasts in grazing intensity in semi-arid woodlands of eastern Australia. *Austral Ecology*, 28: 137-51.

Karfs, R.A. (2002). *Rangeland Monitoring in Tropical Savanna Grasslands, Northern Territory, Australia: Relationships Between Temporal Satellite Data and Ground Data*, Masters Thesis, James Cook University, Townsville.

Landsberg, J., James, C.D., Morton, S.R., Muller, W.J. & Stol, J. (2003). Abundance and composition of plant species along grazing gradients in Australia's rangelands. *Journal of Applied Ecology*, 40(6): 1008-1024.

Orr, D.M. (1979). *Effect of Sheep Grazing* Astrebla *Grasslands in Central-Western Queensland*, Master of Agricultural Science Thesis, University of Queensland.

Scarth, P., Byrne, M., Danaher, T., Henry, B., Hassett, R., Carter, J., Timmers, P. (2006). State of the paddock: monitoring condition and trend in ground cover across Queensland. Paper to *The 13th Australasian Remote Sensing and Photogrammetry Conference.* Canberra, Australia.