INTEGRATED LAND CONDITION MONITORING FOR REEF CATCHMENTS: A NEW ERA

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ABSTRACT
Land condition monitoring information supports the strategic management of grazing land and better understanding of ecosystem processes. Yet for policy makers and those land managers whose properties are situated within Queensland's Great Barrier Reef catchments, there has been a general lack of geospatial land monitoring information – until recently. This paper provides an overview of results from three components of integrated land monitoring activity since 2004 in two of the largest GBR catchments. This collaborative work has used remote sensing technologies in producing sophisticated monitoring information for assessing land condition at both property and regional scale.

INTRODUCTION

For the extensive Burdekin Dry Tropics and Fitzroy Basin catchments (133,000km^2 & 144,000km^2 respectively) that border Australia's iconic Great Barrier Reef (GBR) effective management of grazing land is an important issue, with consequences that not only impact individual enterprise profitability, but the larger marine ecosystem itself. There is no single agency or legislative act responsible for decreasing sediment laden run-off from grazing land flowing into the GBR. Even so a number of agencies take part in research and undertake activities to encourage adoption of better management practice for minimising off-farm outputs (e.g. under the Queensland and Commonwealth Government Reef Water Quality Protection Plan – 'Reefplan'). Yet for targeting activities with respect to improving land condition, there has been little objective information on whether land condition is improving or declining at the scales necessary for regional or property level decisions. Through support from regional bodies Burdekin Dry Tropics NRM (BDTNRM) and Fitzroy Basin Association (FBA) – and Queensland Government agency partners Department of Primary Industries and Fisheries (DPI&F), Natural Resources and Water (NRW), and the CSIRO – new products for decision-makers in Reef catchments have been developed. The acquisition and calibration of 20+ years of annual Landsat TM satellite data by NRW has been fundamental in product development. This satellite data in combination with other spatial data and ground assessment has set new standards in the assessment of land condition for focussing on ways to minimise grazing impact on the natural resource.

METHODS

Remote sensing
Knowledge of where and when changes in vegetation have occurred is fundamental to monitoring grazing land and management impacts in rangelands (Wallace *et al.* 2006). The ability to monitor change at greater spatial and temporal scales can also greatly improve efficiencies of ground monitoring systems. The Landsat series of Earth observation satellites provides this ability; through detecting vegetation change at multiple spatial and temporal scales over 30+ years, and by helping reinforce the learnings and principles observed at sites to the broader landscape. For the GBR catchments in northern Australia, Landsat TM and ETM+ images were acquired when groundcover was normally senescent (e.g. Jul-Nov). Images were geometrically and radiometrically corrected, and incorporated into the SLATS data archive, resampled to 25m (Statewide Landcover and Trees Study - http://www.nrm.qld.gov.au/slats/). The Ground Cover Index (GCI) is a multiple regression satellite cover index developed by NRW (Scarth *et al.* 2006) used for estimating total organic groundcover in areas having less than 20% woody Foliage Projected Cover (FPC) – approx. 8 m^2/ha basal area or <40% canopy cover. Approximately 30% of the Burdekin Dry Tropics (BDT) and 42% of the Fitzroy

Basin (FB) has woody foliage cover greater than 20%; where a reliance on-ground monitoring is needed. It is important to appreciate that GCI estimates are not absolute for a given year (i.e. not a 1:1 relationship with groundcover), having an associated residual error. Yet repeated measurements of the same area (i.e. same 25m pixels) provide insight into groundcover trend to enable judgement on conditions of that area, especially when coupled with ground validation and knowledge of the system.

Identifying very poor condition – D-condition

The ABCD condition framework of Chilcott *et al*. (2003) provides differentiation between grazing land condition classes that has gained wide acceptance. Similarly, the ABCD concept was used here as a basis for mapping very poor condition, or D-Condition. Mapping areas of persistent bare ground was undertaken because: rehabilitating very poor land condition was linked to NRM resource condition targets; it was a feature normally associated with very poor condition and sediment loss; and it was a realistic option using remote sensing data, for identifying a land condition end member at the regional scale. A threshold value of <40% groundcover on the 11-year Landsat GCI time-series 1996-2006 was used for determining persistent bare ground as a surrogate of very poor condition or D-Condition (Abbott *et al.* 2008; also in these proceedings). D-condition was identified as a combination of either:

- low 11-year mean GCI of <40% *(persistent low cover D-condition)*
- medium mean GCI 40-60% with a declining cover trend *(marginal cover D-condition)*
- SPOT 5 PAN bare ground *(chronic D-condition).*

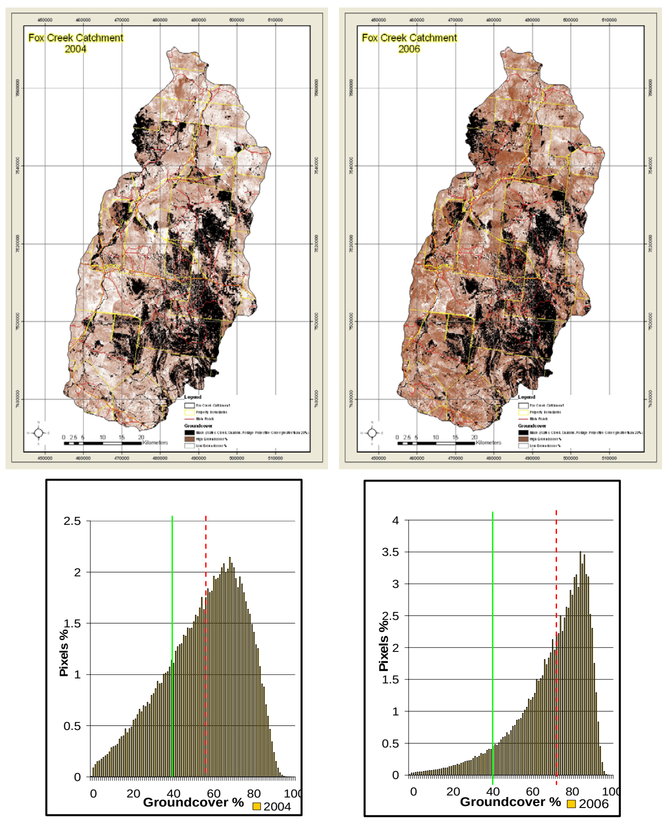
The 'marginal cover D-condition' class is likely to include a significant proportion of 'C' (poor) condition that behaves similarly to D-condition landscapes, albeit with relatively more 3P grasses (grass that is perennial, palatable and productive). For mapping small areas of bare ground, not detected from 25m Landsat pixels due to spectral mixing with surroundings, very high resolution 2.5m panchromatic (PAN) band SPOT 5 satellite data was employed – acquired in 2006 through joint NRM/Govt acquisition. Segregating minor natural features such as rock outcrop from bare ground was considered too problematic, therefore not attempted. Analysis of areas > 20% FPC though Bayesian Modelling are discussed in Abbott *et al.* (2008; also in these proceedings).

Rapid Condition Assessment (RCA)

Collecting ground-based scientific data within a relatively short period (e.g. months) for representing contemporaneous conditions over country 10,000s to 100,000s km^2 in area, is both resource intensive and difficult to achieve. Therefore to augment sparsely located yet highly precise scientific sites, methods for subjective rapid condition assessment (RCA) have been developed. RCA refers to the visual appraisal of biophysical attributes over a specified site from a moving vehicle and assigning an ABCD condition score. These data are particularly useful when analysed with other units of spatial data, for example, remote sensing, land type or cadastre boundary for detecting patterns in condition over a wide area. The sites can be revisited if further more detailed investigation is required. The RCA approach was modelled after Hassett *et al.* (2000) and Karfs (2002). RCA is a 'free' survey as opposed to a grid or random survey, with sites recorded as changes in condition or land type were encountered or as points along extended intervals of similar landscape character. Site data were captured using commercial navigational software. The positional accuracy of the Garmin GPS was <15m, 95% typical. On-screen background rasters were used for helping anticipate changes in the landscape and target field investigation en route. As a general rule there was one site recorded for every 1-2 km travelled along route. From 2004-2007, officers from DPI&F have collected some 11,380 observations. Assessments were made of uniform areas, out 75m-125m to the side of the road nominated, focussing on the average condition of a 1-2ha area. Frequent stopping for roadside inspections was done as a means to confirm condition classes or identify vegetation species or soil condition. Selective roadside photography was also taken and geo-referenced for future consideration. No formal measurements to calibrate RCA observations were undertaken.

RESULTS AND DISCUSSION

The changes in groundcover at subcatchment scales are helpful for understanding the wider affects of climate over time, while patterns within the subcatchment may be of further significance. An example of groundcover change in the BDT (from Milne and Scarth 2008) is shown in Fig. 1. Two maps clipped to the Fox Creek subcatchment boundary (3,205km^2) show overall GCI values, representing 0-100% cover, increasing from 2004 (left) to 2006 (right). The increase of overall GCI values in 2006 is particularly evident in histogram analysis between the two dates. As groundcover increases the histogram gets skewed to the right towards high GCI values. Also the portion of total pixels below the 40% cover threshold decreased noticeably from 20% in 2004 to 7% in 2006. Assessment of wet season rainfall totals (1 Oct to 30 Apr) were similar for the subcatchment in each year (~400mm), yet rainfall after 15 February was dramatically different in 2004 (39.4mm) from 2006 (212mm). Hence a shorter wet season in 2004 may have contributed to lower residual groundcover expressed on imagery captured six-months later in August (11 Aug 04 and 2 Aug 06 respectively). Underlying trends in range condition however require identification of consistent patterns of change over much longer periods.



after Milne and Scarth 2008

Figure 1 – Fox Creek subcatchment BDT: change in GCI 2004 (left) to 2006 (right). High GCI depicted in dark brown; low GCI white to beige. FPC >20% mask in black. GCI subcatchment histograms: solid line = 40%; dashed line = mean.

Based on remote sensing analysis of time-series and very high resolution data, spatially explicit mapping of very poor land condition has been produced for the BDT region (see Abbott *et al.* these proceedings). Results indicate D-condition occupies up to 9% (~10,500 km²) of the BDT region – made up of 0.9% chronic, 2.6% persistent low cover and 5.5% marginal D-conditions. The combined percentages of chronic and persistent D-conditions, provides a lower limit of estimated D-condition of 3.5%. Thus the range of D-conditions estimated in the BDT region is between 3.5% and 9%.

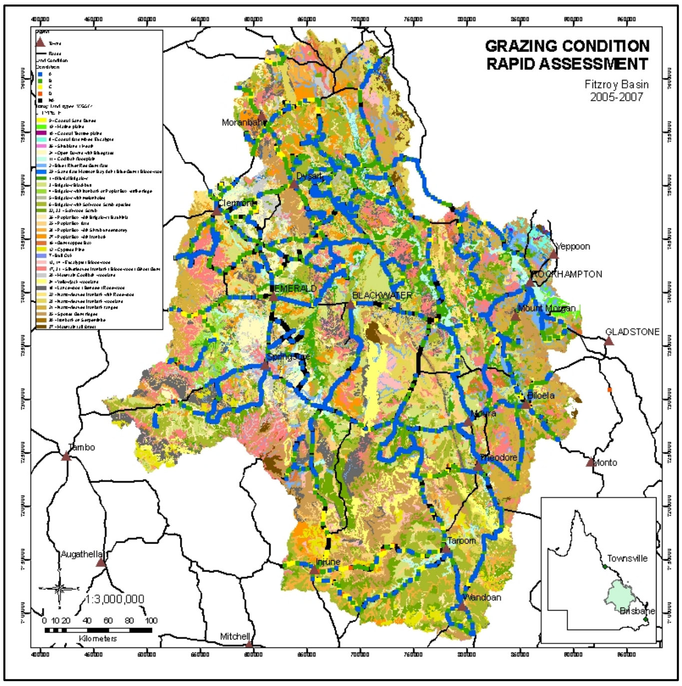


Figure 2 – RCA sites in the Fitzroy Basin from 2005-07 with major roads and land type shown.

In Fig. 2, the spatial distribution of 5,605 RCA sites collected in the Fitzroy Basin over three consecutive years from 2005-07 is shown. Major roads and land type layers complement the ABCD condition ratings on the map, while products presenting

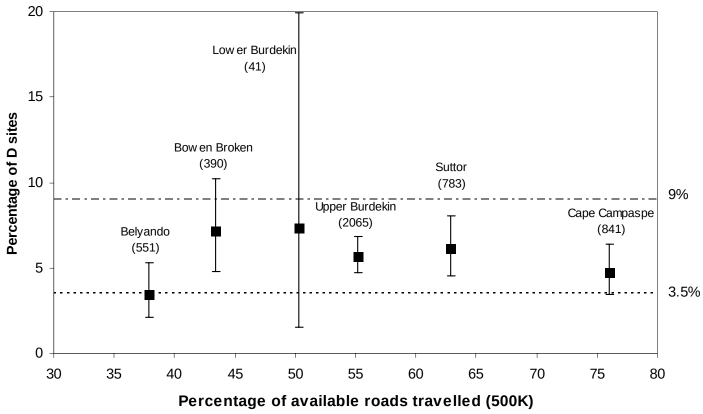


Figure 3 – Proportion of RCA D-condition sites compared to % of available roads travelled in six primary BDT subcatchments. Total RCA sites for each sub-catchment in brackets.

condition class per catchment or land type add further perspective (not shown). Integrating monitoring results can be used to explore similarities and test limitations of data. For example, Fig. 3 shows the proportion of D-condition RCA sites observed (y-axis) in six primary BDT subcatchments. The percentage of available roads travelled (x-axis), calculated by dividing the RCA track log by the Geosciences Australia 1:500k digital road coverage, indicates how much of a sub-catchment was 'seen'. In some cases significant numbers of RCA sites may represent only a small portion of a sub-catchment. Of the 4,074 condition sites recorded in the BDT, 7% were assessed as D-condition; also the proportion of D-condition sites observed in primary sub-catchments was consistent with overall remote sensing estimates of between 3.5% and 9% (dashed horizontal lines). Binominal distribution error associated with the proportion of D-condition RCA sites in sub-catchment samples are expressed as 95% confidence intervals.

CONCLUSION

This paper has presented methods and examples of new land monitoring information for GBR catchments, produced as a result of collaboration between agencies. We believe a better understanding of the broad picture, as provided by these data, will enhance the ability of policymakers and land managers to make strategic decisions; whether it for investing resources to reduce sediment loss at catchment scales or altering management of an enterprise to improve land condition and profitability.

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