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LANDSCAPE LEAKINESS IN THE GRAZED RANGELANDS OF THE BURDEKIN

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ABSTRACT
Landscape leakiness describes the extent to which landscapes have lost their capacity to regulate rainwater and soil nutrients. We demonstrate a remote sensing-based index for monitoring changes in leakiness for sub-catchments of the Burdekin River near Charters Towers. This index is based on the amount and spatial arrangement of persistent cover (e.g. 3P grasses). Index values are validated with ground data for a smaller area within these sub-catchments. Leakiness increased to very high levels in the mid 1990s in sub-catchments dominated by Indian couch. Grazing strategies that encourage native perennial grasses to re-establish, and that maintain higher levels of persistent cover, should reduce leakiness in future drier years.

INTRODUCTION

Landscape leakiness describes the extent to which landscapes have lost their capacity to regulate rainwater and soil nutrients, the vital resources for plant growth and related livestock production (Ludwig *et al*. 2002). In the grazed rangelands of the Burdekin catchment, north east Queensland, functional (i.e. non leaky) landscapes maintain a good cover of palatable, perennial and productive (3P) grasses. Less functional (leaky) landscapes are generally dominated by either Indian couch (*Bothriochloa pertusa*) or ephemeral herbage species. While Indian couch provides reasonable ground cover in better seasons and is palatable to stock, its ability to protect the soil surface and reduce runoff and erosion diminishes in years of lower wet-season rainfall.

CSIRO has developed an index and calculator for monitoring changes in landscape leakiness over time (Ludwig *et al*. 2007). This Leakiness Index (LI) is based on the amount and spatial arrangement of persistent cover, particularly perennial grasses (including 3P species). Leakiness is calculated from a digital elevation model (DEM) and remotely-sensed measures of vegetation cover. As such, LI allows landscape function to be monitored at larger scale than is possible with ground-based assessment. A computer program calculates the relative leakiness of defined areas (sub-catchments, paddocks, sub-catchments within paddock) for each image date that cover data are derived from.

This poster paper illustrates change over time in cover and calculated leakiness for functional and relatively leaky landscapes. We also validate leakiness index values for part of the selected areas with available ground data.

METHOD

The study area of 900 km^2 was focussed on sub-catchments of the Fanning River, a major tributary of the Burdekin River, north east of Charters Towers. Estimated ground cover in the mid to late dry-season of most years between 1986 and 2005 were provided by the Queensland Government's Bare Ground Index (Scarth *et al*. 2006, percent ground cover = 100 – BGI). This index is derived from Landsat TM data and pixel size is 25 m. Digital elevation data were sourced from the Shuttle Radar Topographic Mission and pit filling routines (Cacetta 1999) used to produce a hydrologically sound DEM (i.e. where water flows through all sub-catchments in a sensible manner). The DEM was then used to define the boundaries of 39 sub-catchments of the Fanning River with sub-catchments varying between <1 km^2 and 31.8 km^2 in area. Average percent ground cover and relative leakiness were calculated for larger sub-catchments (>1 km^2) using the Leakiness Calculator (Ludwig *et al*. 2007).

Leakiness results were validated with higher resolution (5 m) data from paddocks at Virginia Park within the study area. These paddocks are dominated by Indian couch. Patch type, ground and litter cover, and soil stability data were collected at 250 4 m^2 quadrats across three small sub-catchments of the Weany Creek in November 2003. These data were used to assign a numerical functionality score to each point using PATCKEY patch-types (Corfield *et al*. 2006). The mean cover level and PATCHKEY functionality score for each sub-catchment were compared with estimates of landscape leakiness calculated from a high resolution (5-m) DEM and vegetation cover derived from a December 2003 Quickbird satellite image (pixel size 2.4 m re-sampled to 5 m).

RESULTS

A sub-catchment known to be dominated by native 3P tussock-grasses had relatively high and stable levels of average ground cover between 1986 and 2005 (Fig. 1) and very low landscape leakiness compared with a sub-catchment dominated by the stoloniferous exotic Indian couch (Fig. 2). Mean ground cover was lowest in both sub-catchments in the mid 1990s, and substantially more so for the Indian couch sub-catchment (3P dominant sub-catchment, 52.2%; Indian couch sub-catchment, 28.6% in 1996). The mid 1990s was a period of much below-median rainfall. Significantly, calculated leakiness for the Indian couch sub-catchment was much greater than for the 3P-dominant sub-catchment at this time. Also significantly, continuing similarly-stepped declines in average cover between late 1994 and 1996 resulted in much greater increases in leakiness due to the spatial concentration of low-cover areas within the poorer condition sub-catchment (Fig. 2). The spatial arrangement of cover, in addition to amount, is critical to the hydrological functioning of landscapes and this factor is included in the calculation of landscape leakiness.

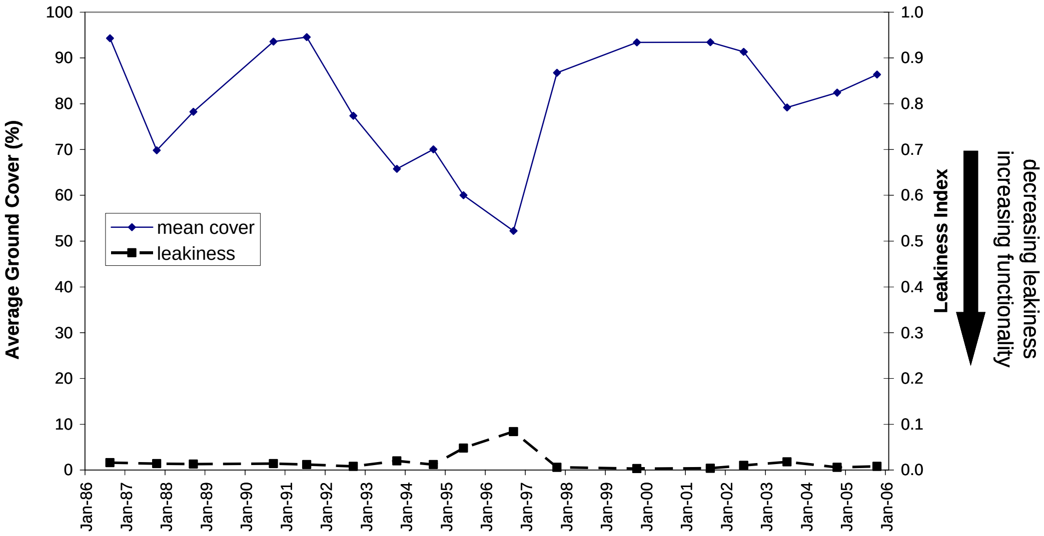

Figure 1. Mean cover and relative leakiness between 1986 and 2006 for a 259-ha sub-catchment of the Fanning River dominated by native 3P tussock-grasses.

Fine scale (~5 m) data for the smaller Weany Creek sub-catchments confirmed the pattern of decreasing leakiness (from remotely sensed data) with increasing levels of mean ground cover (estimated on the ground) (Fig. 3, dashed line). Trends in ground-based assessment of landscape function using PATCHKEY also conformed with LI values derived from remotely sensed cover data (Fig. 3, solid line).

DISCUSSION

Cover and its spatial arrangement are important in reducing runoff and loss of plant nutrients in water-borne sediments. The importance of both factors is demonstrated by the time series of computed LI for two sub-catchments in the Charters Towers region (Figs. 1 and 2). For the sub-catchment dominated by 3P grasses (Fig. 1), mean cover declined substantially (to a moderate level) in the mid 1990s but leakiness only increased slightly. Visual inspection of sequential cover images showed that cover was uniformly distributed throughout the sub-catchment until September 1994. In the June 1995 image, small areas of low cover had developed on ridges and hillslopes and these low-cover areas expanded in the following year (September 1996). Confinement of these bare areas to the higher parts of the landscape increased the LI value by a small amount in that year. Cover was restored to a uniformly high level the following year (October 1997) and indicated leakiness returned to a negligible value.

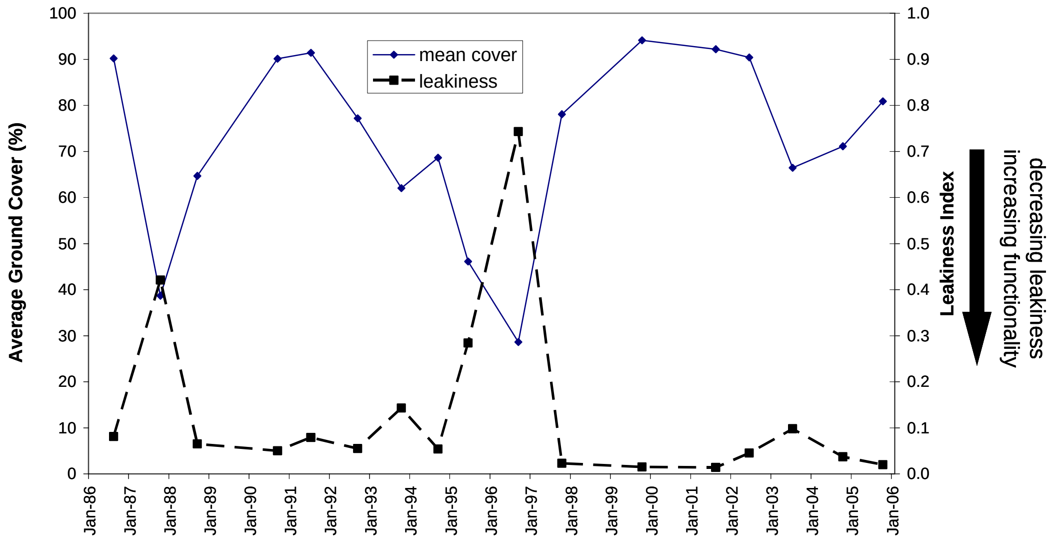

Figure 2. Mean cover and relative leakiness between 1986 and 2006 for a 185-ha sub-catchment of the Fanning River dominated by the stoloniferous grass, Indian couch (*B. pertusa*).

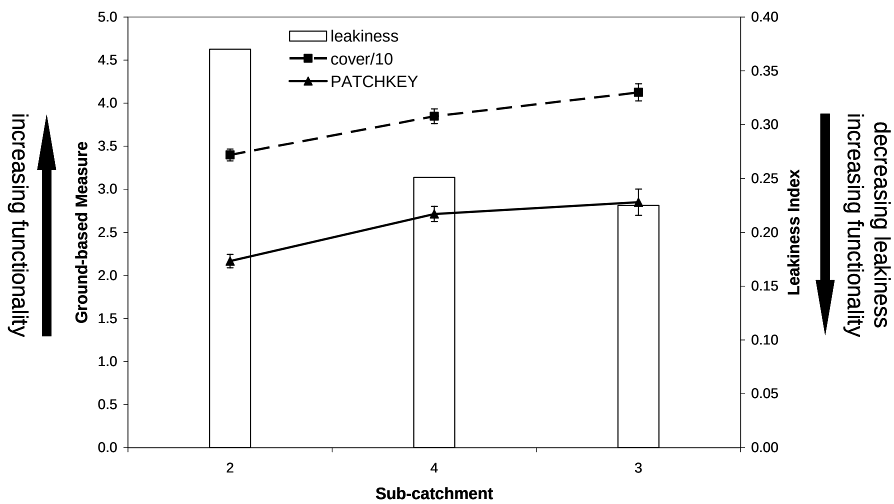

Figure 3. Ground-based estimates of mean cover and PATCHKEY functionality (lines), and remote sensing-derived landscape leakiness (vertical bars) for three sub-catchments of the Weany Creek. Note that cover estimates have been divided by 10 for scaling with PATCHKEY values on the vertical axis.

For the sub-catchment dominated by Indian couch, ridge lines and hillslopes had low to nil cover in mid 1995 and the bare areas expanded and coalesced in 1996 such that only riparian areas and some adjacent footslopes had better than low cover. Cover decreased incrementally between 1994 and 1996 but calculated LI increased substantially in the second year (Fig. 2). There was widespread anecdotal evidence that Indian couch disappeared from grazed paddocks in the mid 1990s leaving large areas of bare ground where this plant had previously dominated. Based on analysis of 30+ sub-catchments in the study area, we suggest that leakiness values greater than ~0.5 for the ‘goldfields’ land type in the Charters Towers region correspond with landscapes tending towards dysfunctional on a continuum of landscape function.

Mean cover returned to a very high level over the next two years in both sub-catchments and leakiness values were minimal. Leakiness has remained low in both sub-catchments since that time although mean cover again decreased in mid 2003. This suggests that based on remotely-sensed levels and locations of ground cover there has been no permanent decline in landscape function, particularly for the sub-catchment dominated by Indian couch. However additional PATCHKEY data and more general ground inspection may be required to confirm that landscape function is maintained in drier years because local experience suggests that remote sensing can over-estimate the 'effective' cover of residual Indian couch in these years.

It is probable that the cover of Indian couch will again decline to a very low level in future successive years of low wet-season rainfall leaving hillslopes vulnerable to increased runoff and erosion. The recent history of probable landscape leakiness available from archived Landsat imagery provides good evidence that grazing strategies that maintain higher levels of ground cover and help to re-establish 3P grasses (e.g. wet-season spelling) will decrease the risk of areas dominated by Indian couch becoming excessively leaky and unproductive during times of drought.

The spatial extent of ground data to validate landscape leakiness is limited. Available data for three sub-catchments of the Weany Creek, a tributary of the Fanning River, showed good agreement between calculated LI and mean cover measured on the ground (Fig. 3). Importantly, correspondence also extended to a quantitative score for landscape function derived from the type of cover (i.e. patch type), basal area of perennial grasses, litter cover, severity of erosion and extent of any deposition (Corfield *et* al. 2006). Abbott and Corfield (2006) had previously shown how PATCHKEY data related to classified patch types in a similar Quickbird imagery. Our validation provides increased confidence that the leakiness index reliably indicates landscape function of larger sub-catchments of the Fanning River based on remotely sensed ground cover and its spatial distribution.

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