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BIOLOGICAL SOIL CRUST COVER AS AN INDICATOR OF RANGELAND CONDITION

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ABSTRACT

Biological Soil Crust (BSC) can potentially be used to estimate grazing pressure, which in turn can be used as an indicator of rangeland condition. BSC is easily disturbed by hard-footed animals such as sheep. Two BSC-based indicators, species composition and cover, have already been suggested as useful indicators for rangeland condition assessment. There is strong agreement that BSC species composition is a good indicator of rangeland condition; however, there is less agreement that BSC cover alone is a good indicator. The percentage cover of BSC was measured at a series of sites at different distances from watering points in five paddocks at Middleback Field Center, north-west of Whyalla in South Australia. Results showed that there is indeed a direct relationship between distances from watering point and the percentage cover of BSC, indicating that BSC cover could be used as an indicator of rangeland condition.

INTRODUCTION

BSC, consisting of nonvascular photosynthetic ground flora, is a complex mosaic of cyanobacteria (blue-green algae), eukaryotic green algae, lichens, mosses, microfungi, and other bacteria in different combinations, where are well developed on the soil surface in the interspaces of open shrubland, grassland and woodland communities of arid, semi-arid and arctic ecosystems (Belnap *et al.*, 2001b). They live within, or immediately on top of, the uppermost layer (1 to 50 mm) of soil (Belnap *et al.*, 2001a). BSC and their constituent organisms are common components of landscapes in semi-arid and arid Australia (Rogers, 1982; Eldridge, 2001). BSC are generally restricted to rangelands, which occupy nearly three-quarters of the land area of Australia (Eldridge, 2001). They contribute to the biodiversity of arid systems, and play significant roles in soil stability, nitrogen fixation, biomass production, soil fertility, microrelief and infiltration (West, 1990; Belnap *et al.*, 2001b).

BSC have been identified as an important indicator of rangeland condition (Klopatek, 1992; Eldridge & Koen, 1998). Two BSC-based indicators, species composition and cover, have already been concluded to be useful as indicators for rangeland condition assessment (Rogers & Lange, 1971; Klopatek, 1992; Eldridge & Koen, 1998). There is a strong agreement that BSC species composition is a good indicator of rangeland condition (Rogers & Lange, 1971; Eldridge & Koen, 1998). However, there is not agreement that BSC cover alone is a good indicator of land degradation and some researchers concluded that BSC cover is a weak indicator (Eldridge & Koen, 1998). Although these studies have employed some pre-assessment techniques such as classification of morphological groups, or consideration of seasonality patterns by wetting, some other issues such as site stratification and sampling method selection has been less considered. The main important issues of pre-assessment are: what to measure (rangeland surface components plus definition of morphological groups of

BSC); where to measure (site stratification); how to measure (suitable method selection); and when to measure (seasonal pattern and phenelogical events) and have been less considered. The main objective of this study was to examine the significance of cover variation of BSC at different distances from watering points, which considered to be correlated to grazing and trampling pressure (Lange, 1969), as a preliminary to using remotely-sensed data to detect them. If BSC cover is a good indicator of grazing gradients, then employing remotely-sensed methods to detect BSC cover could be a suitable tool for rangeland condition assessment.

METHODS

The Study Area and Data Collection

This study was conducted at Middleback Field Center (MFC), in five replicate paddocks, in the pastoral region of the South Australian chenopod shrublands, approximately 400 km north-west of Adelaide and 15 km north-west of Whyalla. Data were collected at six distances from watering points in five replicate paddocks with a 100 m line-intercept method. Sites were stratified to only include shrubland and shrub-woodland physiognomic communities.

Data Analysis

The significance of any relationships between cover of BSC and distances from water was tested using analysis of variance and general mixed models using S Plus v6.2 for Windows (Insightful Corporation, 2003). In the analyses, distance from water was assumed as the independent variable and the cover of various groups of BSC as dependent variables in a two-way table indexed by five paddocks and six distances.

Having decided on the model for the variances and correlations, the investigation of the relationship between mean cover and distance was conducted and is based on general mixed models, if unequal variances were required, and on the analysis of variance, if equal variances were considered appropriate. The logistic or sigmoidal model of Graetz and Ludwig (1978), is not suitable for these data because the collected data did not display a lower asymptote, possibly because the distances at which observations were made were some distance apart. Thus linear and exponential models were tested for the collected data. In the first step if a linear trend proved to be inadequate, then an exponential curve was investigated for describing the trend. The general equation of the exponential (or asymptotic) curve was:

$$Y_i = \alpha + \beta \times \rho^{\text{Distance}_i} \qquad \text{(Equation 1)}$$

where α is the asymptote (Payne *et al.*, 2000). In all cases where an exponential curve needed to be fitted, the model for the variances involved only equal variances for the distances and so the investigation of trend could be based on the analysis of variance.

RESULTS

Total BSC cover data were analyzed to determine if there was a significant change in BSC cover at different distances of water. A likelihood ratio test comparing the analysis of variance model with the heterogeneous variances model was not significant ($p = 0.200$) and so it was concluded there was no evidence for employing the heterogeneous variances model. As a result, an analysis of variance in which a straight line was fitted to the distance means was performed ($p<0.001$). From this result it was concluded that there were significant deviations from the linear trend ($p<0.031$). As a result an exponential curve was fitted to the trend (Figure 1). The extended analysis of variance shows that there were no significant deviations from the exponential curve ($p = 0.984$), thus the exponential curve was significant ($p < 0.004$). The equation of fitted curve is as Equation 2:

DISCUSSION

Comparison of Site Productivity Potential with BSC Cover Variation along the Transects

By considering the concept of site productivity potential (Tongway, 1994), we cannot expect 100% BSC cover, and the percentage cover of BSC was something between 30 to 45% in 73% of the sites at 2000 m to 4000 m. The cover in other 27% sites was between 19 to 30%. It should be noted that stratification was not 100% successful and nearly 13% of the sites were selected in woodland communities which have negative relationship with BSC distribution. Moreover, 43% of the sites were selected on mixed woodland-shrubland communities with relatively negative relationship with BSC distribution.

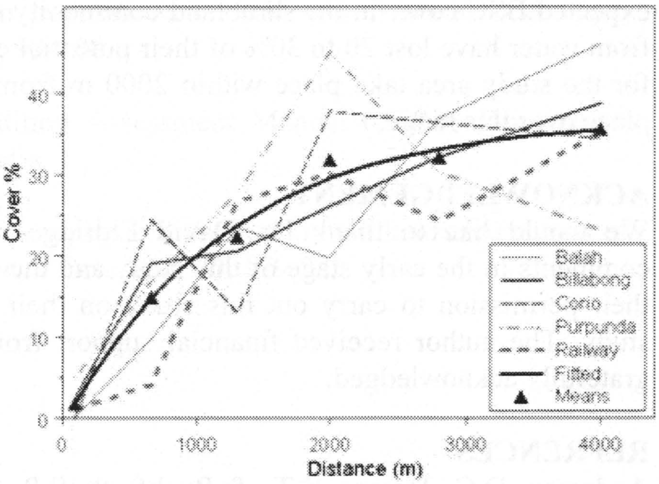

Figure 1: Profiles, means and fitted exponential curve ($p<0.004$) for total BSC cover along a piosphere gradient in five paddocks at MFC

A method of stratification which can further remove these environmental variations could increase the significance of relationships between BSC cover and degradation. Thus from these results, we can conclude that a productivity potential of the study paddocks for BSC cover is about 30 to 45% cover. On the other hand, at 100 m sites BSC cover ranged from 0.2 to 5%, which showed that their current condition is much less than their potential cover of BSC. Maximum BSC cover in the sacrifice zone is less than 10%, which confirms Graetz and Ludwig (1978). Thus sites at 100 m have lost 20 to 30% of their potential cover in comparison with the sites at 2000 to 4000 m.

BSC Cover is an Indicator of Rangeland Condition

BSC provide a beneficial role in the landscape, largely through the process they mediate, in particular nutrient cycling, infiltration and erosion (West, 1990; Eldridge & Koen, 1998). Consequently BSC cover might be expected to equate with a more stable landscape (Eldridge & Koen, 1998). Results of this study showed that total BSC cover have significant relationships with grazing pressure (trampling). These results were statistically significant in spite of some marked variation at some sites in the individual paddocks. Our results showed that BSC cover changes from almost 0% (around water) to over 30% in contrast to previous studies showing cover variance of BSC to be less than 10% in the piosphere (Anonymous cited in Rosentreter & Eldridge, 2002). My results support the results of Graetz and Ludwig (1978) who reported more than 15% BSC cover change at their piosphere patterns. These changes under grazing (trampling) pressure shows that BSC are a good indicator of rangeland degradation supporting other previous literature (Rogers & Lange, 1971; Anderson *et al.*, 1982; Klopatek, 1992). However, our results are in contrast to the some more recent literature concluding that BSC cover is a weak indicator of a grazing response (Eldridge & Koen, 1998). Whereas our study showed the BSC cover changes markedly with distance from water and is a robust indicator of rangeland condition.

CONCLUSIONS

BSC cover is a significant indicator of rangeland degradation. Total BSC increases significantly as distances increase from water. According to the soil productivity potential expected BSC cover in the shrubland community is about 30 to 45%. Sites at 100 m distance from water have lost 20 to 30% of their potential cover. Discernable grazing gradient patterns for the study area take place within 2000 m from water so BSC monitoring need only take place over this range.

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