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CYANOBACTERIA – SILENT SURVIVORS DURING DROUGHTS

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INTRODUCTION

Cyanobacteria are well renowned for their survival strategies in harsh environments and can tolerate long periods of desiccation resulting from acute water deficiency (Wynn-Williams 2000). Cyanobacteria in soil crusts play a crucial role in maintaining soil surface stability (Danin *et al.* 1989), particularly when other vegetation is absent. Many cyanobacteria are capable of fixing atmospheric nitrogen (West 1990), contributing significant nutrient to the surrounding substrate which is readily taken up by vascular plants, fungi, actinomycetes and bacteria (Belnap 2003).

The recent drought in Australia has resulted in some of the most devastating pastoral conditions during the past century. Over the past two years I have been monitoring the cyanobacteria-dominated biological soil crusts at 'Glencoban' in south-western Queensland. The 2000 ha paddock normally carries a mix of cattle and sheep but was completely destocked in early 2003 due to severe drought conditions. Early in 2002, a distinct gradient was observed in the distribution of biological soil crusts, expressed as a significant increase in soil crust cover with increasing distance away from water points (Williams, unpublished, 2002). This gradient of crust cover was attributed to grazing pressure. Since that time a gradual decline in crust cover has been recorded along these transects. At some points however, crust cover has increased.

Early in 2003 rainfall runoff from local thunderstorms washed sand downslope, exposing substantial portions of the biological soil crust that had been previously covered by sand. The exposure of the cyanobacteria beneath the sand suggested that the amount of soil crust visible was not a true reflection of the total amount present. In order to improve methods for the detection of crust cover, a series of transects were used to determine whether there were predictable differences between the exposed cyanobacterial soil crust and layers of crust covered by sand.

METHODS AND RESULTS

Six 10-m transects were located adjacent to established transects in run-off zones. Many of the extremely rocky zones had not trapped or retained sand cover, so the transects were located somewhere between these rocky ridgelines and mulga grove run-on zones. These regions appeared to be where sand deposits, transported into the area predominantly by wind and water, were most abundant. The cyanobacterial soil crust that was visible on the surface was recorded along each transect. Following this, the sand was brushed away to expose any further soil crust surviving underneath and once again the crust cover was recorded.

The average cyanobacterial crust cover, exposed and visible on the surface, from six 10-m transects was 8.5% (se = 3.1). On these same transects the average crust cover found underneath the sand was 37.2% (se = 2.6). Using a paired *t*-test, the average difference of 28.7% (se = 3.4) was highly significant ($p < 0.001$).

Visually, the cyanobacterial crust underneath the sand appeared to be faded and not as robust in structure compared to photographic records of the same crusts taken in the early stages of the drought. Erosion or ablation had reduced the crust continuity previously observed. Subsequently, following significant rainfall, cyanobacteria and the other crust organisms in both the exposed areas and areas that had been covered by sand have been extremely active, as indicated by their ability to photosynthesise.

DISCUSSION

In this erosionally active landscape where sand is continually being moved throughout the region by wind and water, these results indicate why estimates of cyanobacterial crust cover vary widely over short time spans. Some of the decline in cover recorded may merely reflect the deposition of sand gradually covering the exposed cyanobacterial crusts. It would seem reasonable to suggest that the majority of the cyanobacterial crust structure has remained intact throughout the drought. The cyanobacterial soil crusts are physically fragile and easily broken up by stock trampling. The destocking of this paddock occurred at a crucial time, preventing further damage to these crusts.

Cyanobacteria are important for the long-term sustainability of rangelands. Growth, photosynthesis and nitrogen production in cyanobacteria are triggered by even small rainfall events (Lange *et al.* 1998). Cyanobacteria are capable of photosynthesis in extremely low light conditions (Lange 2003). It is quite possible that the sand cover is not extinguishing, but merely slowing, the photosynthetic processes. Small amounts of light have been shown to penetrate sand cover of up to three cm in depth (Williams, unpublished data). When combined with moisture from dew or small rain events cyanobacteria may remain sporadically active even during extended drought conditions.

The fact that substantial patches of cyanobacteria dominated soil crust have survived under layers of sand over the past two years of severe drought indicates that cyanobacteria are well adapted to survive periods of frequent sand inundation. Although microscopic, cyanobacteria in soil crusts play a crucial role in providing soil surface stability. In times when environmental stresses impact on the bare ground during drought the cyanobacterial crusts act as a biophysical barrier. Consequently, it is paramount that the monitoring and management of these biological soil crusts should be integrated into land management practices. For example, the integrity of biological soil crusts should be a factor in determining the appropriate time to de-stock during long dry periods.

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