RECOVERY OF POPULATIONS OF THE SOIL LICHEN *PSORA CRENATA* AFTER DISTURBANCE IN ARID SOUTH AUSTRALIA

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Abstract

Measurements were made of density, size and shape of colonies of the soil lichen *Psora crenata* at sites with varying disturbance histories at Maralinga in arid South Australia. Lichens were measured along transects at 10 sites with recovery intervals ranging from 3 to 42 years, and on four undisturbed control sites. As the time since disturbance increased, the number of lichen colonies increased markedly, colony size declined, but colony shape remained unchanged. We tentatively suggest that at least 60 years is required for disturbed sites to approach the condition of undisturbed sites. These results reinforce the notion that lichen recovery is very slow, and suggest that colony density of *Psora* could be a useful indicator of recovery after disturbance in rangelands where crusts are a common component of the soil surface.

Keywords: *Psora crenata*, rangelands, soil crusts, cryptogams, rangeland health

Introduction

*Psora crenata* (Taylor) Reinke is a common squamulose lichen in arid Australia. It occurs in circular to sub-circular colonies with other squamulose and crustose lichens as a component of cryptogamic (microphytic) soil crust communities (Eldridge 1998a). Along with *Psora decipiens* (Hedwig) Hoffm., it is probably the most conspicuous lichen in arid Australia, and is easily recognised by the large, pink to pinkish-white squamules with deeply crenulate margins. At Maralinga in north-western South Australia, *Psora crenata* is one of the most common soil lichens.

The landscape in the vicinity of Maralinga comprises a mosaic of woodland and low shrubland underlain by Tertiary limestone. The soils are dominated by weakly developed brown calcareous earths with high pH levels. The massive, unstructured soils means that they are susceptible to wind erosion (Johnston *et al.* 1993). Maralinga lies between the Nullarbor Plain and the Great Victoria Desert approximately 900 km north-west of Adelaide in South Australia. In the 1950s and early 1960s Maralinga was used for nuclear testing, and access to the area has been restricted. Apart from a cleanup operation carried out by the British government in 1967, and studies conducted in the mid 1980s preparatory to the present cleanup (Cooper *et al.* 1997, Rawson *et al.* 1997), the area has remained virtually uninhabited. Beyond the limited area adjacent to the nuclear test sites, the general landscape has been altered very little by Europeans, largely due to the absence of sheep and cattle grazing.

The combination of winter-dominant rainfall, highly calcareous soils and low levels of disturbance, has resulted in the growth and establishment of an extensive microphytic crust cover over large areas of the Maralinga landscape. The crusted surface protects the soil against wind and water erosion (Williams *et al.* 1995, Eldridge and Kinnell 1997), and is essential for the maintenance of vital soil and ecological processes (West 1990, Eldridge and Greene 1994). Biological crusts contribute to the biodiversity of arid systems, and play significant roles in nitrogen fixation, biomass production, soil fertility, microrelief and infiltration (Eldridge and Tozer 1997, West 1990). Consequently, microphytic soil crusts are useful indicators of landscape health (Eldridge and Koen 1998).
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Within the area used for nuclear testing are a large number of sites with varying histories of disturbance. Many of these are old tracks, construction camps or airstrips that were cleared of vegetation and up to 20 cm of the topsoil was removed by grading. These sites, which were subsequently abandoned and allowed to regenerate, provided us with an excellent opportunity to examine the recovery of crust communities after disturbance.

Our observations of soil crusts at sites with varying disturbance histories indicated that *Psora crenata* tended to be more common on relatively undisturbed sites, and, conversely, absent from disturbed sites. We selected all available sites for which we had a reliable estimate of time since disturbance, to examine changes in density and size of *Psora crenata* in relation to disturbance.

**Field measurements**

At Maralinga, *Psora crenata* was widely distributed on calcareous loams dominated by *Casuarina cristata* and *Alectryon oleifolius* (Eldridge 1998a). We selected 14 sites on calcareous soils for detailed measurements of density, size and shape of *Psora crenata* colonies. Four sites were chosen as undisturbed controls, and although these were assigned a nominal period of 100 years since disturbance, it is possible that they may never have been disturbed markedly by humans. Apart from the undisturbed controls (100 years; n=4), we were able to find sites with 3 (n=1), 29 (n=6), 35 (n=1), 39 (n=1) and 42 (n=1) years since disturbance. We visited Maralinga in August 1996, during the early stages of the Maralinga cleanup which commenced in 1995 (Rawson et al. 1997). At that time, we were not able to access more than the one recently disturbed site.

At each site up to three 26 m transects were established with 1 m² quadrats placed every 5 m along each transect. Depending on the density of *Psora crenata* colonies, we examined between 5 and 19 quadrats at each site. For each colony, defined as an aggregation of lichen squamules, we measured the longest diameter, and a second diameter through the centre, perpendicular to the first measurement. Colony size was calculated according to the area of an ellipse, and the ratio of longest diameter to the second diameter was used as an index of colony shape.

**Results**

Detailed analyses of 50 *Psora crenata* colonies ranging in size from 12 to 355 squamules per colony revealed a strong relationship between the number of squamules and the area of individual colonies ($R^2=0.859$, $F_{1,48}=305.66$, $P<0.001$; Fig. 1). The lengths of the two diameters through the centre of *Psora* colonies predicted 86% of the variation in number of squamules per colony.

We recorded a total of 1044 *Psora crenata* colonies within 114 quadrats at the 14 sites. No *Psora crenata* squamules were recorded in the quadrats at four of these sites; one with 3 years recovery and three with 29 years recovery since disturbance. A small number of squamules were, however, found outside the transects in the 29 year group.

The number of *Psora crenata* colonies increased markedly with increases in time since disturbance (Fig. 2a). Whilst there was little variability in density up to 40 years after disturbance, colony density at undisturbed sites was highly variable (Fig. 2a). A t-test comparing mean colony density at sites disturbed 29 to 42 years previously ($n=9$) with mean densities found at undisturbed sites ($n=4$) showed that the two groups were significantly different ($t=-4.09$, $P=0.002$), with disturbed sites having a lower density of *Psora crenata* colonies even after 30 to 40 years recovery. Data were ln+1 transformed to reduce the difference in variance between the two groups to insignificant levels. Linear regression of frequency data (percentage of quadrats with *Psora* present) from known-age sites indicated
that at least 60 years would be required for these sites to approach the condition of undisturbed sites (Fig. 2b). Whilst the area of individual colonies declined with time since disturbance (Fig. 2c), colony shape changed very little (Fig. 2d).

Fig. 1. Relationship between the number of squamules in Psora crenata colonies and the area of individual colonies.

Fig. 2. Relationships between time since disturbance and a) mean density of Psora colonies, b) the percentage of quadrats with Psora present, c) mean colony area (mm²), and d) mean colony shape (length/width).
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**Discussion**

The results of this study indicated that density and frequency of *Psora crenata* colonies increased with the period of recovery following disturbance in a landscape dominated by soil crusts. Our results from arid South Australia suggest that some measures of the population structure of the *Psora* genus could be useful indicators of recovery after disturbance in rangelands where crusts are a common soil surface component. Our tentative estimate of at least 60 years for recovering sites to approach the condition of undisturbed sites, indicates that lichen recovery is very slow.

Over the past decade, attention has focused on the role of soil biota as bioindicators of landscape health. In Australia, methodologies have been developed to link the presence of soil crusts to landscape productivity (Tongway 1995), given their marked influence on soil and landscape processes such as infiltration and erosion (Eldridge and Greene 1994). Recent research from the semi-arid woodlands of eastern Australia has shown that the foliose lichens *Xanthoparmelia* spp. are closely associated with sites regarded as being stable, productive and in good rangeland condition (Eldridge and Tozer 1996, Eldridge and Koen 1998). This current work supports anecdotal evidence suggesting that large continuous colonies of soil lichens indicate periods of relative landscape stability. This is based on the premise that trampling and erosion break up areas of soil crust, preventing lichens such as *Psora* from growing in large colonies (Rogers and Lange 1971, Nash et al. 1977, Anderson et al. 1982, Jeffries and Klopatek 1987, Eldridge 1998b).

Whilst *Psora crenata* is restricted to the more arid areas of Northern Territory, South Australia and Western Australia (McCarthy 1991), the closely-related *Psora decipiens* is widely-distributed over most of arid and semi-arid Australia. Superficially the two species are often indistinguishable in the field, differing only in the extent of the crenulate margins and the degree of concavity in the thallus (McCune and Goward 1995). However, given their brightly coloured pinkish to pinkish-white squamules, these lichens are easily recognisable, even to the novice. Given their similar growth characteristics and basic morphology, it is likely that size and density of *P. decipiens* colonies display similar trends.

Although lichen and moss floristics has been used to evaluate the health of forested ecosystems (Cornelissen and ter Stegge 1989, Carleton 1990, McCune 1994, Scott and Hutchinson 1989), floristics has not to our knowledge been used to evaluate semi-arid systems. Along with foliose lichens (Eldridge and Koen 1998), *Psora* spp. are distinctive and therefore easily recognised. With very little training they could be used to complement traditional rangeland assessing techniques such as measurement of foliage cover of perennial plants and measurements of soil surface characteristics and erosion.

**Acknowledgements**

We thank Michael Apostolides for his tireless efforts in the field, the Department of Primary Industries and Energy for supporting our visit to Maralinga, and John Ludwig for comments on an earlier draft. Publication no. CNR99.025 of the Centre for Natural Resources, Department of Land and Water Conservation.

**References**


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Manuscript received 4 January 1999, accepted 2 July 1999.