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BIOGEOGRAPHY AND BIODIVERSITY OF BIOLOGICAL SOIL CRUSTS ACROSS QUEENSLAND

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ABSTRACT

Recent field research has established that biological soil crust communities (cyanobacteria, lichens, liverworts and mosses) are widespread across the rangelands of Queensland. Our survey has covered many national parks and reserves or private properties where necessary, to take in changes in rainfall gradients, vegetation communities and soils. We document for the first time, well-established and extensive cyanobacteria-dominated soil crusts occurring throughout much of the gulf-savannah. An ecologically important biological crust system was found across a fragile dune and flood plain near Skull Hole, Bladensburg NP. Other noteworthy biological crusts with significant biodiversity and cover were found in the jump-ups Diamantina NP; Spinifex ridges, Minerva Hills NP; Grey Range (west of Thargomindah); Sturt Stony Desert (Arrabury region); Stony plains (Coorabulka, Windorah Rd) and Arcadia Valley (Old Towrie). There were considerable and diverse cyanobacteria-dominated soil crusts found south-east of Cunnamulla (Glencoban), Currawinya NP, Bindegolly NP, Boodjamulla NP (Lawn Hill Gorge and Riversleigh sections), sand dunes (various sites, far western QLD) and in the estuarine sand-flats around Karumba. Across western QLD several mesas were surveyed. There were also good representations of hypolithic (cyanobacteria - under quartz, Boulia-Djarra Rd), epilithic (cyanobacteria and lichens) and endolithic (cyanobacteria) communities on various granite or sandstone rocky outcrops. Early results clearly show these biogenic soil crusts are unique in their biodiversity, structure and function. There are exceptional and rare community ecosystems, particularly those recorded at Bladensburg, Diamantina and Boodjamulla NP's that deserve special protection and more detailed study. We are continuing to expand the sample sites to include the Cape and other national parks. To date, this research has resulted in exciting new discoveries that are unique to the Australian rangelands and significant on an international basis.

Key words: *biological soil crusts, cyanobacterial soil crusts, lichens, cyanobacteria, biodiversity.*

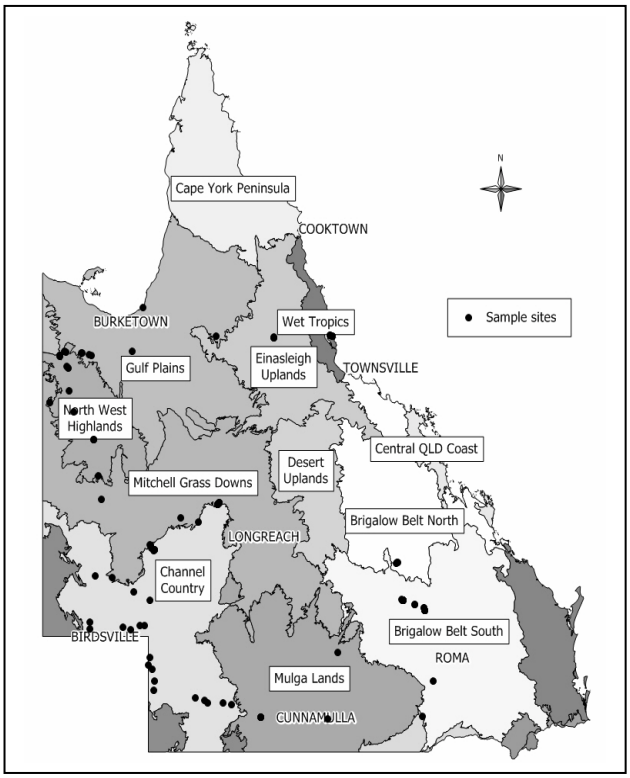
INTRODUCTION

Australian records of biological soil crusts have focused on the arid to semi-arid regions of NSW and SA including a number of localised studies (Eldridge 2001; Büdel 2002). There are also several studies specifically directed towards soil lichen biodiversity and most recently a comprehensive report on lichens across a 1500 km transect from the sub-tropical coast near Brisbane to Lake Eyre in central Australia (Rogers, 2006). Currently, the known distribution of biological soil crust extends into the southern border regions of QLD (Eldridge, 2001) and has been the subject of ongoing research in south western QLD, including good descriptions of cyanobacteria-dominated soil crusts (Hodgins and Rogers, 1997).

This research is a pilot study investigating the biogeographical occurrence and diversity of biofilms (on rock and soil), and biological soil crusts, across arid and semi-arid regions, including the gulf-savannah of QLD.

RESULTS

To date we have sampled 129 sites covering 9 bioregions that focus on National Parks but also include reserves and private properties (Figure 1). Thus far we have recorded a biodiversity of 116 species that has included 57 lichens, 37 cyanobacteria, 9 mosses, 10 liverworts, 2 algae and the common rock-dwelling micro-fungi *Lichenothelia*. These results are summarised in Table 1. An account of 3 contrasting landscapes exemplifying unique biodiversity or form follows:



Bladensburg National Park – Skull Hole

This site was characterised by shallow gravely soils interspersed with low sandy shrub-hummocks and broad expanses of bare ground that was almost entirely covered by unbroken biological soil crust (Figure 3). The range of genera within this 1-2 cm thick crusted surface was made up of 8 lichens, 4 liverworts, 6 cyanobacteria and 2 mosses, and represented a long-established ecosystem that would be extremely effective in erosion control of an otherwise fragile landscape. We observed some areas of erosion damage (causes unknown) where new crust had re-established across the eroded area (Figure 3). The sandy hummocks were lightly vegetated by small shrubs and tussock grasses with a soil surface biofilm dominated by cyanobacteria (Figure 3). A more detailed survey of this region will most certainly reveal a greater biodiversity than presented here. This habitat is clearly visible in satellite imagery and is estimated to be about 1000 hectares in area.

Figure 1 (above). Sample sites across bioregional map of QLD.

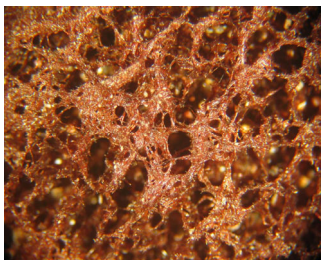


Figure 2. (above) Cyanobacteria filaments form web-like structure on soil surface found at Boodjamulla NP and Burke & Wills (40x magnification)

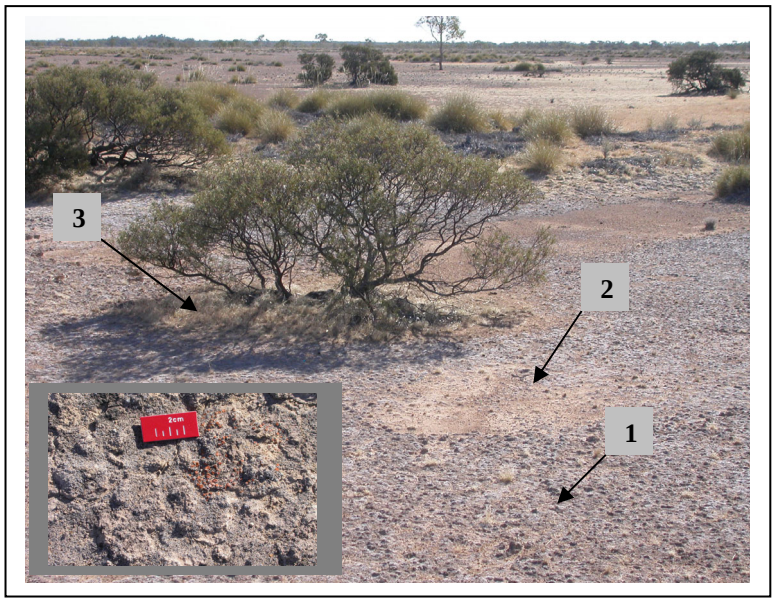


Figure 3. (left) Biological soil crusts (BSC) at Skull Hole, Bladensburg NP. (Arrows) 1: BSC covering bare ground, 2: eroded regions with BSC, 3: shrub hummock with cyanobacteria dominated crusts. Inset: Close up view (2 cm bar) of BSC including lichen *Psora decipiens*

Cyanobacteria-dominated soil crusts from the Gulf-Savannah

Currently 13 sites have been sampled from Boodjamulla NP (Lawn Hill and Riversleigh), Gregory Downs and north of Burke and Wills Roadhouse (photo left) to Karumba. Soil crusts at these sites were dominated by cyanobacteria. We have recorded a number of new cyanobacteria species for Australia. Sites (excluding the cracking clay floodplains) had cyanobacterial colonies with specialist adaptations to the high summer rainfalls – this included intricate web-like structures (Figure 2 and left-inset) and tufted filaments that would act to enhance water drainage. CO_2 exchange data indicates lower respiratory responses to saturation (see Williams *et al.*, conference proceedings) thus the general adaptation of form to survive saturation. At the site 70 km north of Burke and Wills Roadhouse we found the lichen *Peltula boletiformis* (Hue) Henssen & Büdel and we believe this is the first record for Australia. We are also investigating several lichen species in more detail that may represent new records or range extensions.

Cyanobacteria biofilms from dunes

A number of dunes have been surveyed (Table 1) and in most cases we found a webbed network of cyanobacteria filaments just below the surface (photo left). This sub-surface refuge undoubtedly protects the cyanobacteria from the harsh environmental conditions and, with some degree of mobility, provides a means of moving towards or away from light. The grey dunes at Bindegolly NP and Moonda Lake sandhills had well-developed surface biofilms primarily consisting of *Scytonema* sp.

CONCLUDING COMMENTS

This pilot study has clearly identified that biological soil crusts extend well beyond that which has previously been recorded Each ecosystem has its own unique form that contributes not only to biodiversity but will also significantly contribute to landscape function (Büdel, 2002). It is important that this research is expanded at both local and regional levels in order to more fully document these communities Research should also be carried out using ecological models to determine possible distribution of species and communities and to predict changes to nutrient flows resulting from expected changes in rainfall gradients associated with global climate change.

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Table 1. Biogeographical records of biodiversity of biological soil crusts and rock biofilms across QLD survey sites.
Landscape notes – sites marked * were dominated by landscape featured but also included other landscape types in sample set.

Bioregion	Location	Sites/samples	Rainfall	Landscape	Total biodiversity	Cyano-bacteria	Lichen	Moss	Liverwort	Algae
Brigalow Belt South	Arcadia Valley	3(23)	600-800	Woodland	32	10	10	6	5	1
Brigalow Belt South	Carnarvon Gorge NP	3(10)	600-800	Woodland	15	7	4	3		1
Brigalow Belt South	Surat rocky scrub	2(23)	600-800	Woodland	32	9	20	1	1	1
Brigalow Belt North	Minerva NP	3(23)	600-800	Spinifex*	40	11	15	6	6	2
Mulga Lands	Bindegolly NP	4(15)	300-400	Sandfire*	17	9	4	1	3	
Mulga Lands	Gidgee dry creek	1(3)	200-300	Woodland	16	5	7	1	3	
Mulga Lands	Charleville - mulga	2(76)	400-500	Woodland	26	7	13	2	4	
Mulga Lands	Cunnamulla - banded mulga	36(180)	300-400	Woodland	47	16	17	6	6	2
Mitchell Grass Downs	Bladensburg NP	2(12)	300-400	Floodplains	12	9		1	2	
Mitchell Grass Downs	Diamantina NP Mitchell Grass	3(10)	200-300	Floodplains	5	5				
Mitchell Grass Downs	Cravens Peak Reserve	8(18)	300-400	Dunes*	11	6	5			
Channel Country	Bladensburg Skull Hole	5(10)	300-400	Floodplain	20	6	8	2	4	
Channel Country	Diamantina NP Floodplains	2(7)	200-300	Floodplain	4	4				
Channel Country	Diamantina NP Jump ups	3(13)	200-300	Mesas*	19	5	12		2	
Channel Country	Grey Range region	2(12)	200-300	Mesa*	33	10	17	2	4	
Channel Country	Nockatunga region	3(10)	200-300	Stony plains	31	11	16	1	3	
Channel Country	Moonda Lake sandhills	3(6)	<200	Dunes*	10	10				
Channel Country	Annes mesa	3(9)	200-300	Mesa*	19	8	11			
Channel Country	Strezlecki dry lake	2(4)	200-300	Floodplain	6	5			1	
Channel Country	Strezlecki dunes	1(2)	200-300	Dunes	2	2				
Channel Country	Arrabury Station	2(5)	200-300	Stony plains	14	8	6			
Channel Country	Sturt Stony Desert	2(14)	200-300	Stony plains	25	5	20			
Channel Country	Diamantina Channels & Plains	5(6)	<200	Floodplain*	13	13				
Channel Country	Bedourie dunes	3(5)	<200	Dune	7	7				
Channel Country	Coorabulka stony plains	1(5)	<200	Stony plains	16	7	7		2	
Channel Country	Lookout Hill Betoota	2(8)	200-300	Mesa	20	13	6	1		
Channel Country	Monkira mesa	4(13)	<200	Mesa	16	7	9			
Mount Isa Inlier	Mt Isa-Camooweal districts	5(24)	300-500	Plains*	20	7	3	3	5	2
Mount Isa Inlier	Boodjamulla - Riversleigh	3(10)	400-500	Savannah	10	5	4		1	
Gulf Fall and Uplands	Boodjamulla - Lawn Hill Gorge	5(10)	500-600	Spinifex	20	7	10	1	2	
Gulf Plains	Gregory Downs	3(7)	500-600	Floodplain	7	5	1		1	
Gulf Plains	Burke & Wills Roadhouse 70k N	1(13)	600-800	Savannah	24	10	10	1	3	
Gulf Plains	Karumba- tidal wetlands	1(7)	800-1000	Wetland	8	8				
Einasleigh Uplands	Undarra NP	1(3)	600-800	Woodland	16	7	3	2	3	1