Cyanobacteria in Arid Land Rehabilitation

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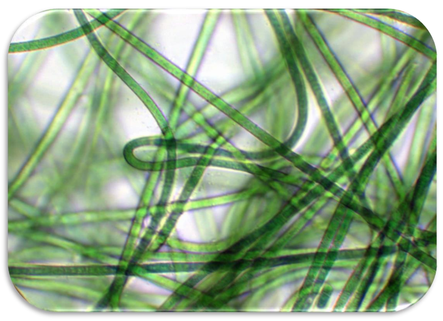
MINE REHAB CONFERENCE + BEST PRACTICE ECOLOGICAL REHABILITATION OF MINED LANDS

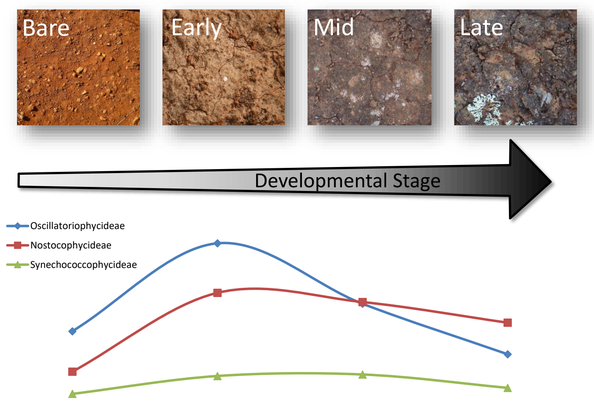
Cyanobacteria are a phylum of photosynthetic bacteria distributed globally in a wide range of habitats. In drylands, they form critical components of biocrusts – topsoil assemblages of microorganisms, mosses and lichens – that stabilise the surface and enrich the soil profile. Ecologically significant and well adapted to extreme arid conditions, biocrust cyanobacteria offer multifaceted solutions to several barriers currently limiting mining site rehabilitation. Presented here are three studies examining biocrusts and their cyanobacteria to develop and enhance rehabilitation strategies



Filamentous cyanobacteria from Australian biocrusts

Visually distinct biocrusts comprise significantly different bacterial communities[a]

Biocrusts perform critical ecosystem services within drylands - including carbon sequestration, nitrogen fixation, and protection against soil erosion - and are often used as indicators of ecosystem health. These factors increase with developmental stage and highlight biocrusts as valuable components in rehabilitation strategies. Understanding naturally occurring biocrusts is a first step in providing informed targets for their restoration in disturbed drylands, including mining sites.



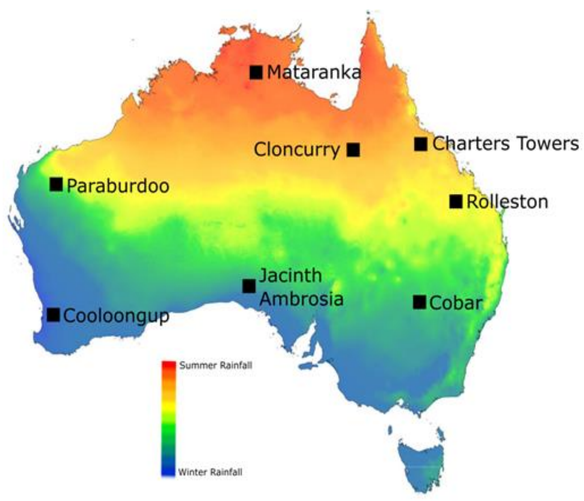
A dry bloom of cyanobacteria induces biocrust formation and promotes greater diversity in later stages

We examined distinct developmental stages of biocrusts from the same site and found cyanobacteria drove biocrust formation, resulting in distinct bacterial profiles. Specifically, we identified *Phormidium* as a keystone species. These findings establish that visually discernible biocrusts should be treated as different functional units and provides a frame of reference for monitoring their recovery.

Biocrusts vary on an intra-continental scale according to seasonality of precipitation

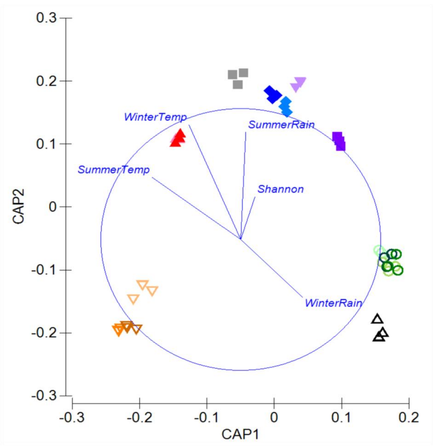
Australian drylands comprise multiple bioregions which vary according to climate, edaphic properties and vegetation types. We profiled the bacteria of biocrusts from across Australia to determine factors that affect biocrust distribution patterns.

Biocrusts can cover vast expanses of open inter-plant areas

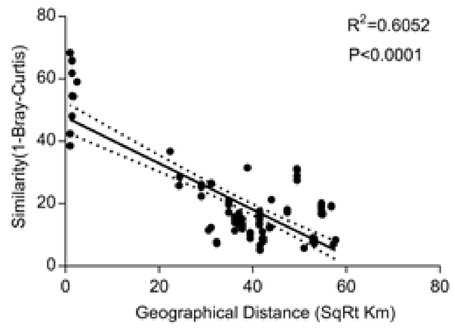


Sample sites locations with a seasonal precipitation gradient overlay

We found biocrusts grouped strongly according to site, with geographically close samples more related to each other than distant samples. Seasonality of precipitation was found to be a primary factor driving this pattern. These are important findings showing rehabilitation of disturbed top-soils using biocrusts will rely on employing endemic bacterial strains adapted to local conditions. This dataset serves as a practical framework to guide future work integrating biocrusts with current rehabilitation strategies for improved ecosystem outcomes.



Samples grouped according to sample site and were affected by seasonality of precipitation



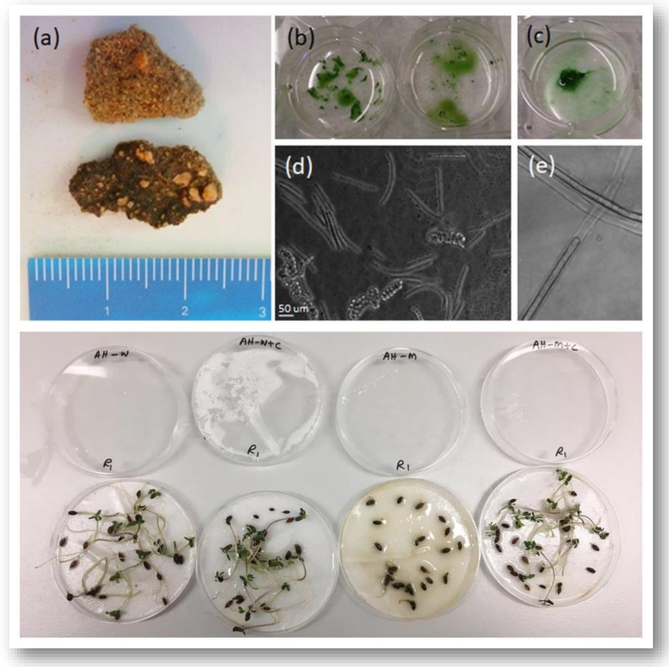
Samples were more closely related to geographically close than distant samples

Biopriming of native seeds with endemic cyanobacteria can promote germination and seedling growth[b]

In conjunction with next-generation sequencing efforts, we attained cyanobacterial isolates to perform microcosm experiments determining the effect of biocrust cyanobacteria on native vegetation. We used locally sourced biocrust cyanobacteria to bioprime native seeds from the Pilbara Region of Western Australia. We found significant positive effects on the germination and seedling growth of *Senna notabilis* and *Acacia hilliana* while showing no significant negative effects on three other species. These findings suggest the integration of cyanobacterial biopriming with current seed preparation strategies may improve vegetation outcomes for mining site rehabilitation.

Future Work

We aim to broaden our trials to include cyanobacteria and native seeds from a variety of bioregions to test these effects across Australia. We further seek to conduct landscape scale trials and test the effects of biopriming under environmentally relevant conditions.
Our findings presented here lay the foundations to develop tailored rehabilitation strategies for mining sites to deliver improved environmental outcomes.



Biocrust cyanobacteria used to bioprime native seeds showed positive germination effects for Acacia hiliana *and* Senna notabilis

(a) Pilbara biocrust, (b)–(e) biocrust cyanobacteria, lower photo shows A.hiliana *seedlings under different conditions*

[a]Chilton, AM, Neilan, BA and Eldridge, DJ (2017) Biocrust morphology is linked to marked differences in microbial community composition *Plant and Soil* https://doi.org/10.1007/s11104-017-3442-3

[b]Muñoz-Rojas, M, Chillton, AM, Liyanage, GS, Erickson, TE, Merritt, DJ, Neilan, BA and Ooi, MKJ (2018) Effects of indigenous soil cyanobacteria on seed germination and seedling growth of arid species used in restoration *Plant and Soil* https://doi.org/10.1007/s11104-018-3607-8