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# RECOVERY RATES OF CRYPTOBIOTIC CRUSTS: INOCULANT USE AND ASSESSMENT METHODS

Jayne Belnap[1]

ABSTRACT.—Recovery rates of cyanobacterial-lichen soil crusts from disturbance were examined. Plots were either undisturbed or scalped, and scalped plots were either inoculated with surrounding biological crust material or left to recover naturally. Natural recovery rates were found to be very slow. Inoculation significantly hastened recovery for the cyanobacterial/green algal component, lichen cover, lichen species richness, and moss cover. Even with inoculation, however, lichen and moss recovery was minimal. Traditional techniques of assessing recovery visually were found to underestimate time for total recovery. Other techniques, such as extraction of chlorophyll *a* from surface soil and measurement of sheath material accumulation, were used and are discussed.

*Key words: cyanobacteria, soil algae, cryptobiotic crusts, cryptogamic crusts, recovery, disturbance, reclamation, innoculation,* Microcoleus vaginatus.

Cyanobacterial soil crusts occur in semiarid and arid regions throughout the world. Studies of these crusts have documented the importance of the role they play in these ecosystems. This role includes the stabilization of soils (Belnap 1990, Harper and Marble 1988, Marathe 1972), improved nutrient status of vascular plants growing in the crust (Belnap and Harper unpublished), and improved soil structure (Metting and Rayburn 1983).

For the National Park Service, maintaining the biota and visual aesthetics of undisturbed landscapes is a central concern. Since cryptobiotic crusts are widespread throughout parks on the Colorado Plateau and damage to them is highly visible, finding methods to hasten the recovery of disturbed crusts is of importance to this agency. The use of inoculants to speed up recovery of these crusts has been reported by several authors (Ashley and Rushforth 1984, Lewin 1977, St. Clair et al. 1986, Tiedemann et al. 1980).

Traditionally, assessment of recovery rates of cryptobiotic soil crusts after disturbance has been based on visual measurements only. Generally, such measurements have included percent cover of the cyanobacterial/green algal, lichen, and moss components; presence of pediceled soil surfaces; and number of moss and lichen species observed (Anderson, Harper, and Holmgren 1982, Anderson, Harper, and Rushforth 1982, Brotherson et al. 1983, Cole 1990). Unfortunately, visual measurements cannot quantify the amount of the cyanobacteria/green algae present, since filaments and cells ramify through several millimeters of surface soils. The few studies that have attempted to quantify the amount of cyanobacteria and green algae tissue present have used fluorescence optics or culturing (Ashley and Rushforth 1984, Johansen and Rushforth 1985). Both methods have problems associated with them: fluorescence optics is very time consuming, and culturing may give misleading results. Recently, Beymer and Klopatek (1992) used chlorophyll *a* to estimate cyanobacterial and green algal tisue in recovering crusts.

Another aspect of crust recovery should also be considered. *Microcoleus vaginatus*, the cyanobacterium that makes up the bulk of crustal organisms in the semiarid environments considered here, may contribute up to 95% of the crust biomass (Belnap personal observation). This cyanobacterium secretes a thick, extracellular gelatinous sheath around the living filaments. This sticky sheath material adheres to soil particles, thereby aggregating them into larger, less erodible particles (Belnap and Gardner 1993, Harper and Marble 1988). When moistened, the filaments of *Microcoleus* are partially extruded from the colonial sheaths; the filaments

[1]National Park Service, 125 W. 200 South, Moab, Utah 84532.