

Biological soil crusts and soil chemistry associated with distribution of the endangered Nichol's Turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*)

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The endangered Nichol's Turk's head cactus (*Echinocactus horizonthalonius* Lemaire var. *nicholii* L. Benson) occurs only in four small, isolated populations in the Sonoran Desert. Since 1995, we have characterized growth, flowering, recruitment, and mortality of a population in the Waterman Mountains of southeastern Arizona (Pima County, Ironwood Forest National Monument). Having documented a sharp and persistent population decline since 2008, in this study we examine soil characteristics that might influence the distribution of the species locally as well as their survival over time. In fall 2020, we compared frequency and coverage of biological soil crusts within and near six long-term study plots. We also compared 17 soil traits (including pH, conductivity, and soil micronutrients) from samples collected within plots and those from areas nearby with similar vegetation but without *E. horizonthalonius* var. *nicholii*.

Plots with *E. horizonthalonius* had significantly greater percent coverage of biocrust per quadrat (0.14 ± 0.2) than plots without (0.10 ± 0.2). However, within plots where the cactus occurs, crust coverage did not differ significantly between quadrats with vs. without the cactus. Among the 17 soil traits measured, only two differed between areas with and without *E. horizonthalonius*. Samples taken from within our study plots had significantly higher levels of boron (0.654 ± 0.024 ppm) and sulfate (4.71 ± 0.17 ppm) than samples taken outside our study plots in areas where the plants do not occur (boron: 0.433 ± 0.04 ppm; sulfate: 3.44 ± 0.23 ppm). In conclusion, the plants occur more frequently in soils with biocrusts, which in turn may be driven by differences in soil nutrients, water, or stability. With regard to soil chemistry, although it has long been observed that this cactus occurs on limestone-derived soils, these results suggest a specific chemical basis for this association. Further, the strength of the association suggests it is more of a requirement than a preference for the plant.