Soil Biology & Biochemistry 65 (2013) 168–171

Contents lists available at SciVerse ScienceDirect

Soil Biology & Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Short communication

Biological soil crust community types differ in key ecological functions

Nicole Pietrasiak [a,*], John U. Regus [b], Jeffrey R. Johansen [c,e], David Lam [a], Joel L. Sachs [b], Louis S. Santiago [d]

[a] University of California, Riverside, Soil and Water Sciences Program, Department of Environmental Sciences, 2258 Geology Building, Riverside, CA 92521, USA
[b] University of California, Riverside, Department of Biology, University of California, Riverside, CA 92521, USA
[c] Biology Department, John Carroll University, 1 John Carroll Blvd., University Heights, OH 44118, USA
[d] University of California, Riverside, Botany & Plant Sciences Department, 3113 Bachelor Hall, Riverside, CA 92521, USA
[e] Department of Botany, Faculty of Science, University of South Bohemia, Branisovska 31, 370 05 Ceske Budejovice, Czech Republic

ARTICLE INFO

Article history:
Received 22 February 2013
Received in revised form
17 May 2013
Accepted 18 May 2013
Available online 7 June 2013

Keywords:
Biological soil crust
Mojave Desert
Nitrogen fixation
Carbon fixation
Soil stability

ABSTRACT

Soil stability, nitrogen and carbon fixation were assessed for eight biological soil crust community types within a Mojave Desert wilderness site. Cyanolichen crust outperformed all other crusts in multi-functionality whereas incipient crust had the poorest performance. A finely divided classification of biological soil crust communities improves estimation of ecosystem function and strengthens the accuracy of landscape-scale assessments.

Biological soil crusts carry out essential ecological roles in desert ecosystems (Evans and Johansen, 1999; Belnap et al., 2003). However, soil crust community types differ in the degree to which they contribute to ecosystem functions (Belnap, 2002; Housman et al., 2006; Strauss et al., 2012). In past studies, crust community types were often simplistically characterized (e.g. light vs. dark, moss vs. lichen). This resulted in difficulties for cross-investigator or cross-regional comparisons. More importantly, simplistic categories mask functional differences in crust types contributing to errors in estimates of ecosystem function. Consequently, ecologists need to refine classifications for crust communities and determine ecosystem function.

The Mojave Desert is rich in crust communities (Pietrasiak et al., 2011a, 2011b; Pietrasiak, 2012) compared to community types reported from other deserts (Pietrasiak, 2012). This study classifies ten biological soil crust community types in the Mojave Desert (Table 1) and evaluates three ecosystem functions: carbon fixation, nitrogen fixation, and soil aggregate stability for eight of these community types.

Our study area is within the Mojave Desert physiographic province (ca. 35.50° N, 115.68° W). The climate is arid, with a mean annual precipitation of 145 mm and a mean annual temperature of 17 °C (Turk, 2012). Annual rain events are variable and bimodal (Osborn, 1983). Soil parent material is Mesozoic dolomite alluvium. The vegetation is dominated by *Larrea tridentata* and *Ambrosia dumosa*. Within a 2 km^2 area, ten crust community types were identified (Table 1), with eight prevalent enough for study. Five replicates per crust type were sampled in the field to conduct the field stability test following Herrick et al. (2001). Ten replicates per crust type were collected for laboratory studies of nitrogen and carbon fixation (Fig. 1).

Nitrogen fixation varied significantly ($p < 0.0001$) among crust types (Fig. 1A). Incorporation of ^{15}N into crust ranged from below detection to over 100 μmol N_2 m^{-2} h^{-1}. Cyanolichen crusts had significantly higher nitrogen fixation rates than all other crust types. Hairy moss, darkened moss, and green algal lichen crusts also showed relatively high fixation rates. Two trends were also notable. First, fixation rates were very consistent within crust community type (Fig. 1A). Second, untransformed data varied by

* Corresponding author. Present address: Biology Department, John Carroll University, 1 John Carroll Blvd., University Heights, OH 44118, USA. Tel.: +1 216 397 3077; fax: +1 216 397 4482.

E-mail addresses: npiet001@ucr.edu, npietrasiak@jcu.edu (N. Pietrasiak), john.regus@ucr.edu (J.U. Regus), johansen@jcu.edu (J.R. Johansen), dlam010@ucr.edu (D. Lam), joels@ucr.edu (J.L. Sachs), santiago@ucr.edu (L.S. Santiago).

0038-0717/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.soilbio.2013.05.011

Table 1
Descriptions of the ten biological soil crust communities identified in the Mojave Desert based upon morphology and dominant taxonomic group as visible in the field with the naked eye, or in some cases, a hand lens. These crust community types are found throughout the arid west and include all types we have observed except the liverwort-dominated crusts found in the coastal sage-scrub.

Crust type code	Crust type identification	Description
IC	Incipient algal/fungal crust	Weakly consolidated, soft crust that breaks apart easily but displays fungal hyphae or cyanobacterial filaments, dominant components are fungi and/or non-heterocytous cyanobacteria (*Microcoleus* spp., *Leptolyngbya* spp.); ubiquitous
FC	Fungal crust	Embedded underneath shrub litter or a sand layer in the open, fungal hyphae clearly visible, dominant components are fungi
LAC	Light algal crust	Inconspicuous colored crust dominantly composed of cyanobacteria (mostly *Microcoleus* spp. and *Pseudanabaenaceae* spp.) and eukaryotic algae (e.g. *Bracteacoccus*, *Chlorosarcinopsis*, *Scenedesmus*, *Chlorella*); ubiquitous
DAC	Dark algal crust	Dark-colored crust dominantly composed of cyanobacteria (colored by surface-growing heterocytous taxa in *Nostoc*, *Scytonema*, and *Hassallia*); present but too rare for study in our site, commonly found on granitic soils elsewhere in the Mojave Desert
CLC	Cyanolichen crust	Lichens that have cyanobacterial photobionts, e.g. *Collema*; broadly distributed in intershrub spaces
GLC	Green algal lichen crust	Lichens that have green algal photobionts, e.g. *Placidium*; broadly distributed in intershrub spaces
SMC	Smooth moss crust	Moss crust with small phyllids on short thalli, e.g. *Bryum*; present but too rare for study in our site, commonly found on granitic soils elsewhere in the Mojave Desert
RMC	Rough moss crust	Moss crust with minor hair-like extensions on phyllids, brownish when dry, green to brown-green when moist, e.g. *Syntrichia*; broadly distributed in intershrub spaces
HMC	Hairy moss crust	Moss crust with extensive hair-like extensions on phyllids that appear like whitish-gray carpets, e.g. *Crossidium*, *Pterygoneurum*; requiring shady environments
DMC	Dark moss crust	Clearly blackened, moss-dominated crust (mostly *Syntrichia*), associated with heterocytous cyanobacteria (*Nostoc* spp.); broadly distributed in intershrub spaces

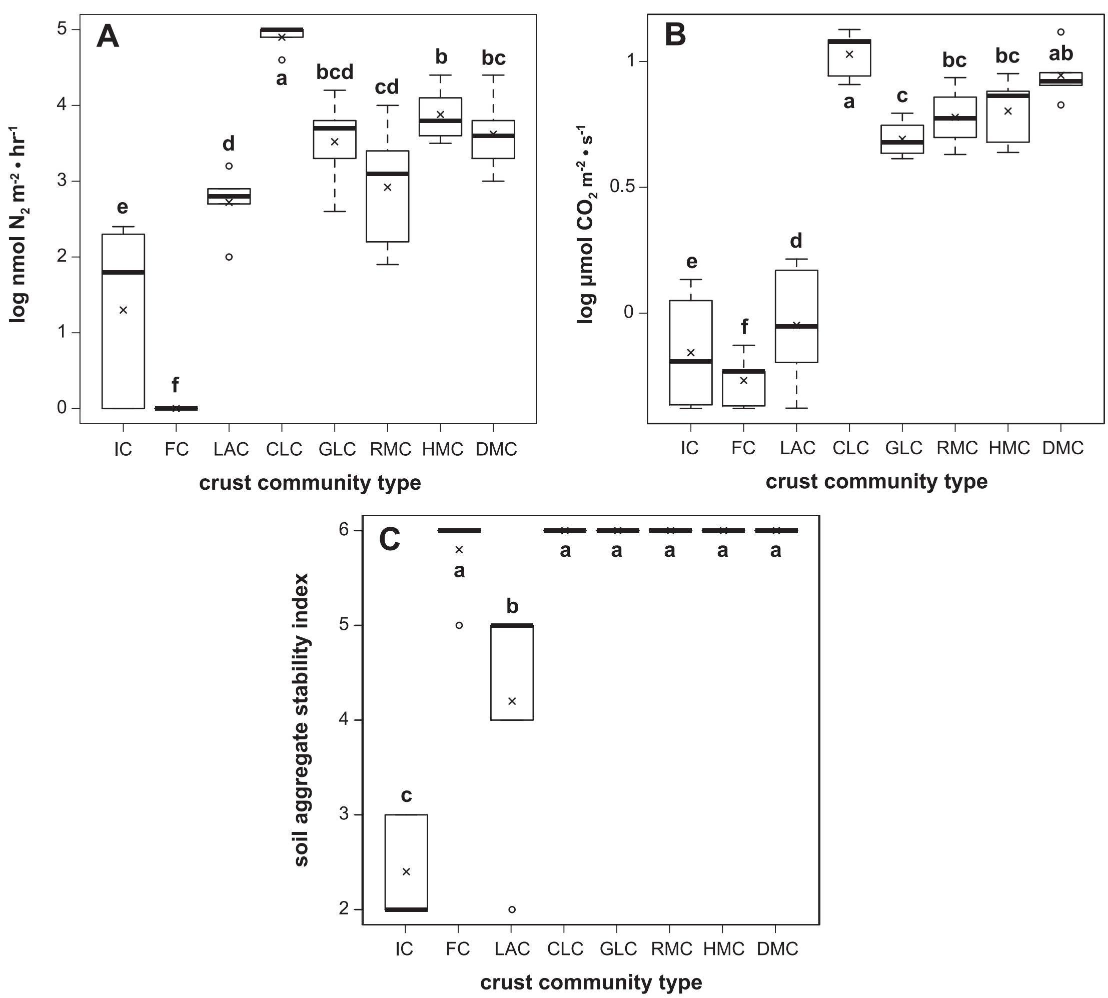

Fig. 1. Boxplots calculated in R (R Core Team, 2012) showing the three ecosystem functions investigated among eight biological soil crust community types. Dark bars represent median values, with boxes enclosing the upper and lower inner quartiles, with extremes indicated by whiskers or circles when the extreme is an outlier (Crawley, 2007), black "*x*" represent means of log-transformed data. Lowercase letters represent significant differences in means (stability) or means of log-transformed data (N-fixation, C-fixation) detected with ANOVA and the LSD test. For key to crust community types see Table 1. Field collection of dry soil crusts from randomly selected sites occurred over one weekend in April 2011; samples were refrigerated until analysis, which occurred within 30 days. (A) Nitrogen fixation as determined using fixation of ^{15}N enriched gas following methods of Pietrasiak (2012). Briefly, rates were determined following a 24-h rehydration period at field capacity, and a 48-h incubation period, with rates calculated according to Warembourg (1992); (B) carbon fixation as determined following hydration at field capacity from a 2-h incubation period at a photosynthetic photon flux density of 1600 μmol m^{-2} s^{-1} at ambient relative humidity and temperature; (C) Herrick's stability index values.