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Biogeosciences Discussions

Interactive comment on "Microbiotic crusts on soil, rock and plants: neglected major players in the global cycles of carbon and nitrogen?" *by* W. Elbert et al.

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We thank the anonymous referee for reviewing our manuscript. The stimulating comments are very welcome, and the suggestions for improvement will be implemented upon revision as far as possible. Detailed responses to the individual comments are given below.

Referee Comment 1:

In most of the regions of the world the BSC's (biological soil crusts) are presented by mixed compositions of organisms. The composition varies along the rainfall gradient. In low rainfall regimes (less than 70 mm rainfall) the BSC is a thin (1-2 mm), presented

by cyanobacterial crust (mainly filamentous that is the first and main colonizers of the soil surface in undisturbed soils of semiarid and arid lands, and do not fix nitrogen).

Response:

As demonstrated by the numerous studies referenced in Table 9 of our manuscript, nitrogen fixation by BSC has been observed and quantified for lichen- as well as cyanobacteria-dominated crusts. In the revised manuscript further references shall be added. The available data show that cyanobacteria in biological crusts do indeed fix nitrogen. In fact, their capability to fix nitrogen and carbon from the atmosphere in an oxidizing environment enables them to be the pioneering organisms colonizing harsh environments (Fogg, 1947; Shields and Drouet, 1962; Yeager et al., 2004; Housman et al., 2006; Gorbushina, 2007; Schmidt et al., 2008).

Referee Comment 2:

It is very rare that the BSC covers one hundred percent of the soil surface. The BSC is one component composing patchiness in dry landscapes of the world. The percent cover change with the rainfall. The BSC cover can change from about 80% in the dry areas to zero in wet semiarid areas (450 mm rainfall) (see Belnap and Lange, 2001, and the literature in www.soilcrust.org). The authors made general assumptions, which are not obvious and should be discussed in more detail, especially why and how they made them. The growth and the percent cover of the BSC is affected by soil surface moisture quantity and duration related to rainfall and dew regimes, temperature and light intensity. Therefore, it is very hard and complicated to generalize about the duration of the BSC activity. For these reasons I have some doubt on the assumptions and conclusions reached which need additional clarifications. My main concern is with the lack of explanation for the calculations. The authors should reveal some reported values and the recalculation formula used, with assumptions made (e.g. area coverage). The estimations that they provide are not obvious, and the appendices do not help. For example, the scale-up of the 4 kg $ha^{-1}y^{-1}$ to all semi/ and arid environments. I think

that if the authors make a clearer statement of the scale-up methods (suggestion- they may use satellite data for world BSC coverage) and address the above issues, it would improve the paper.

Response:

Following up on the above comment and suggestions, we intend to add the following information in the methods section of the revised manuscript.

Unless mentioned otherwise, the tabulated data were taken directly from the cited references. In these studies the scaling necessary to account for limitations of photosynthetic activity, dark respiration and surface coverage has already been performed by the authors. For studies that had reported only maximal photosynthesis rates under optimal conditions (usually given in units of μmol m-2 s-1), we converted the reported rates into units of g m-2 a-1 (Tab. 1 and 3, column 4), and scaled these values by a factor of 1/72 which takes into account the following effects and characteristic parameters obtained from various studies (Lange, 2000; Zotz and Rottenberger, 2001; Lange, 2003; Lange and Green, 2004; Lange and Green, 2008):

1) The photosynthetic activity is usually limited to about one third of the maximal value (factor $\frac{1}{3}$) and about one quarter of a day (factor $\frac{1}{4}$).

2) Approximately half of the fixed carbon is lost by dark respiration (factor $\frac{1}{2}$).

3) About one third of the surfaces of (semi-)arid soils and rocks (Tab. 10) and of vascular plants (evergreen leaves, evergreen needles, and stems and branches of trees, Tab. 6) are typically covered by BSC, BRC or EPC, respectively (factor $\frac{1}{3}$).

Reported rates from studies that had already accounted for partial surface coverage but not for the limitations of photosynthetic activity and dark respiration were scaled with a factor of 1/24 (Tab. 1). Reported rates from studies that had already accounted for dark respiration and partial surface coverage but not for the limitations of photosynthetic activity were scaled with a factor of 1/12 (Tab. 1). Reported rates from studies that had

already accounted for the limitations of photosynthetic activity and dark respiration but not for partial surface coverage were scaled with a factor of 1/3 (Tab. 1).

In addition to the more detailed explanation in the methods section, we have reformatted several of the tables and included a detailed record of applied scaling factors together with explanatory footnotes.

With regard to the land surface coverage of BSC and BRC, an additional table with literature data will be included in the revised manuscript (Table 10). These data support the assumption of an effective average BSC coverage of $\sim$1/3 in (semi)arid regions as a conservative estimate. The available information is, however, not sufficient to resolve the global coverage of land surfaces by BSC on the level of ecosystems and regions but represents a best guess.

We agree that the use of satellite data for the determination of BSC coverage is a promising future perspective (Qin et al., 2006; Weber et al., 2008) Unfortunately, however, the available methods are not accurate enough, respectively do not allow an uncontrolled transfer to various geographic regions (Weber et al., 2008) leaving them as a promising future perspective.

References

Fogg, G. E.: Nitrogen fixation by blue-green algae, Endeavour, 6, 172-175, 1947.

Gorbushina, A. A.: Life on the rocks, Environmental Microbiology, 9, 1613-1631, 2007.

Housman, D. C., Powers, H. H., Collins, A. D. and Belnap, J.: Carbon and nitrogen fixation differ between successional stages of biological soil crusts in the Colorado Plateau and Chihuahuan Desert, Journal of Arid Environments, 66, 620-634, 2006.

Lange, O. L.: Photosynthetic performance of a gelatinous lichen under temperate habitat conditions: long-term monitoring of CO2 exchange of Collema cristatum, Bibliotheca Lichenologica, 75, 307-332, 2000.

Lange, O. L.: Photosynthetic productivity of the epilithic lichen Lecanora muralis: long-term field monitoring of CO2 exchange and its physiological interpretation II. Diel and seasonal patterns of net photosynthesis and respiration, Flora, 198, 55-70, 2003.

Lange, O. L. and Green, T. G. A.: Photosynthetic performance of the squamulose soil-crust lichen Squamarina lentigera: laboratory measurements and long-term monitoring of CO2 exchange in the field, Bibliotheca Lichenologica, 88, 363-390, 2004.

Lange, O. L. and Green, T. G. A.: Diel and seasonal courses of ambient carbon dioxide concentration and their effect on productivity of the epilithic lichen Lecanora muralis in a temperate, suburban habitat, Lichenologist, 40, 449-462, 2008.

Qin, Z., Li, W., Burgheimer, J. and Karnieli, A.: Quantitative estimation of land cover structure in an arid region across the Israel-Egypt border using remote sensing data, Journal of Arid Environments, 66, 336-352, 2006.

Schmidt, S. K., Reed, S. C., Nemergut, D. R., Grandy, A. S., Cleveland, C. C., Weintraub, M. N., Hill, A. W., Costello, E. K., Meyer, A. F., Neff, J. C. and Martin, A. M.: The earliest stages of ecosystem succession in high-elevation (5000 metres above sea level), recently deglaciated soils, Proceedings of the Royal Society B-Biological Sciences, 275, 2793-2802, 2008.

Shields, L. M. and Drouet, F.: Distribution of terrestrial algae within the Nevada test site, American Journal of Botany, 49, 547-554, 1962.

Weber, B., Olehowski, C., Knerr, T., Hill, J., Deutschewitz, K., Wessels, D. C. J., Eitel, B. and Büdel, B.: A new approach for mapping of biological soil crusts in semidesert areas with hyperspectral imagery, Remote Sensing of Environment, 112, 2187-2201, 2008.

Yeager, C. M., Kornosky, J. L., Housman, D. C., Grote, E. E., Belnap, J. and Kuske, C. R.: Diazotrophic community structure and function in two successional stages of biological soil crusts from the Colorado plateau and Chihuahuan desert, Applied and

Environmental Microbiology, 70, 973-983, 2004.

Zotz, G. and Rottenberger, S.: Seasonal changes in diel CO2 exchange of three central European moss species: a one-year field study, Plant Biology, 3, 661-669, 2001.

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