Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2017-430-AC1, 2017


Biogeosciences Discussions
Open Access
EGU



# *Interactive comment on* "Aerobiology and passive restoration of biological soil crusts" *by* Steven D. Warren et al.

**Steven D. Warren et al.**

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Received and published: 27 December 2017

We respond to Bowker's comments in the order that they were presented:

1. Novelty - Dr. Bowker implies that this work "is not new." He states that it is old material, and has been presented in chapters by Weber and Zhao in a book edited by Weber et al. To some degree, that may be minimally correct. However, the chapters in the book do not treat the subject with even similar detail. From my own experience, books are much less available than journal manuscripts, and often overlooked. For example, Warren published several chapters relative to crusts and hydrology in the 2001 volume on crusts, only to discover 2 subsequent journal articles on the same topic, one of which was published by one of the editors of the book itself. Books



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Discussion paper

apparently do not carry the same weight as journal manuscripts.

2. As noted in the current article, with few exceptions, almost all crust organisms have been reported as being aerially dispersed. This includes spores, gametophyte fragments, and specialized asexual diaspores of mosses (lines 217-219) and asexual reproductive lichen fragments and soredia, and lichen-forming fungi (lines 215-217). Numerous citations are listed. They do travel long distances, as noted in the abundant literature citations provided.

3. We agree that manuscripts highlighting large-scale trials may have been submitted, but, as of yet, few, if any, have appeared in the published literature. We praise such efforts and look forward to successful results with economical strategies. However, given many years of experience with the same class of efforts, much of which was not published because journal editors are largely averse to publishing negative results, we are skeptical of favorable results.

4. As noted above, our pessimism is not unfounded. And we do not recommend giving up. Nor do we recommend costly field trials before small-scale success has been shown. We have expended large sums of money on this topic. In addition, Warren was previously employed as a civilian research scientist for the Department of Defense, who has been known to expend large sums of money on promising new ideas. In that capacity, he expended hundreds of thousands of dollars experimenting with novel approaches to crust restoration at military bases around the nation. All artificial approaches failed. He worked with various approaches to distribute crusts. He worked with various vendors and organizations to encapsulate crust organisms so that they might be distributed with seeding equipment. All failed. He worked with a private company to grow cyanobacteria in a liquid culture that could be applied in the field. Although the technique showed promise, the company failed when it was unable to find a private entity to fund further efforts. He has worked on military bases around the U.S., but they were unwilling to fund further investigation when attempted delivery techniques failed to establish viable crusts. The DoD has millions of acres that could

benefit from successful crust restoration.

5. Although crust organisms are perpetually available. It is true that nobody knows the natural delivery rate of airborne crust organisms. When going to the office in the morning in Provo, UT and College Station, TX Warren often discovered a layer of dust on his car. In Fort Collins, CO he witnessed several days with a dark haze the news media attributed to dust from a dust storm in China. These facts support the contention that the presence of crust organisms accompanying the dust is frequently present. The rate of delivery is not known, but merits further research. And not all airborne organisms will be adapted to climatic and edaphic conditions at all sites. But, in the final analysis, one must ask how biological soil crusts became so common on arid and semi-arid areas around the globe. Any why do they frequently occur on disturbed soils in mesic areas?

6. The nexus section is strong evidence that aerobiology is working. Without it, it is extremely unlikely that Dr. Liu's straw barriers could have worked. The straw barriers and aerobiology work in concert, hence the word 'nexus' in the section title.

7. This seems a frail argument. We must work within the socio-political environment where we live. We cannot control everything. We must do what we can where we can. By demonstrating success at a smaller scale, we improve the odds of being able to apply the technique at larger scales. If we cannot afford to scale-up, what have we gained?

Note: We encourage the reviewer to consider the title of the manuscript. The primary emphasis is Aerobiology and Passive Restoration of BSCs. This is not a complete review of all aspects of active restoration of BSCs. While we briefly discuss artificial restoration, such a review was not the primary focus of the manuscript.

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