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Capability of existing spectral indices to map biocrusts in a spatially heterogeneous semiarid areas

Marta Alonso (1), Emilio Rodriguez-Caballero (1), Paula Escribano (2), Sonia Chamizo (1), Lourdes Luna (2), and Yolanda Cantón (1)

(1) Departamento de Agronomía, Universidad de Almería, Spain., (2) Departamento de desertificación y Geoecología, EEZA), CSIC, Spain.

Dryland ecosystems cover about 40 % of the land surface and play a major role in global biophysical processes. These systems usually show sparse vegetation cover interspersed over a bare open matrix, often covered by complex communities of cyanobacteria, algae, fungi, lichens and bryophytes, so called biological soil crusts (BSCs). These microorganisms control gas, water and nutrient exchange into and through soils and affect essential ecosystem processes, including soil respiration, carbon and nitrogen fixation, establishment and performance of vascular plants, soil erodibility, evaporation, water retention and water infiltration. Given the importance of BSCs in ecosystem functioning, accurate and spatially explicit information on the distribution of BSCs is mandatory. With this objective, considerable effort has been devoted in the last decades to identify and map BSCs using remote sensing data, and some spectral indices have been developed for BSC mapping: the crust index (CI), the biological soil crust index (BSCI), the continuum removal crust identification algorithm (CRCIA) and the methodology proposed by Chamizo et al. (2012), hereafter Crust Development Index (CDI). Despite many of these indices have demonstrated their usefulness to map BSCs in the areas where they have been developed, their applicability for mapping BSCs in other areas, with different BSC composition, has not been tested.

In this study, we test the feasibility of the 4 previous indices published in the literature (CI, BSCI, CRCIA and CDI) for mapping different types of BSC in a topography complex area (a badlands system in SE Spain) covered by sparse vegetation embedded in a heterogeneous bare matrix dominated by two main types of BSC, lichen and cyanobacteria. We calibrated all indices for both, lichen and cyanobacteria separately, previous to their application to a hyperespectral image of the area. Moreover, we applied a support vector machine classification (SVM) to test its accuracy as compared with that obtained by the 4 spectral indices. The SVM classification provided the best results (Kappa coefficient 0.92). The CDI, which was developed in this study area, correctly discriminated between types of BSC and also BSCs against bare soil or vegetation (Kappa coefficient 0.75). However, the application of the indices developed in other different areas, such as CI, BSCI and CRCIA, did not correctly identify BSCs in our study area (Kappa coefficients of 0.49, 0.48 and 0.55, respectively), despite the local calibration of each index. These results suggest that spectral indices need to be calibrated to each study area. Moreover, their calibration does not guarantee to obtain accurate results when they are applied in areas different to those in which they have been developed, and more effort is needed to apply these indices in other areas which may have additional types of BSC, different soils, or more complex spatial distribution with heterogeneous pixels covered by a mixture of surface covers. In these situations, supervised classifications may be a suitable alternative to achieve this objective.