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Soil indicators to assess the effectiveness of restoration strategies in dryland ecosystems

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Soil indicators may be used for assessing both land suitability for restoration and the effectiveness of restoration strategies in restoring ecosystem functioning and services. In this review paper, several soil indicators, which can be used to assess the effectiveness of restoration strategies in dryland ecosystems at different spatial and temporal scales, are discussed. The selected indicators represent the different viewpoints of pedology, ecology, hydrology, and land management.
The recovery of soil capacity to provide ecosystem services is primarily obtained by increasing soil rooting depth and volume, and augmenting water accessibility for vegetation. Soil characteristics can be used either as indicators of suitability, that is, inherently slow-changing soil qualities, or as indicators for modifications, namely dynamic, thus "manageable" soil qualities. Soil organic matter forms, as well as biochemistry, micro- and meso-biology, are among the most utilized dynamic indicators. On broader territorial scales, the Landscape Function Analysis uses a functional approach, where the effectiveness of restoration strategies is assessed by combining the analysis of spatial pattern of vegetation with qualitative soil indicators. For more holistic and comprehensive projects, effective strategies to combat desertification should integrate soil indicators with biophysical and socio-economic evaluation and include participatory approaches. The integrated assessment protocol of Sustainable Land Management developed by the World Overview of Conservation Approaches and Technologies network is thoroughly discussed.
Two overall outcomes stem from the review: i) the success of restoration projects relies on a proper understanding of their ecology, namely the relationships between soil, plants, hydrology, climate, and land management at different scales, which is particularly complex due to the heterogeneous pattern of ecosystems functioning in drylands, and ii) the selection of the most suitable soil indicators follows a clear identification of the different and sometimes competing ecosystem services that the project is aimed at restoring.

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