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Soil quality indicators: a critical tool in ecosystem restoration

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Abstract

Soils provide multiple functions that support the delivery of key ecosystem services such as climate and water regulation, carbon sequestration, or nutrient cycling. These functions can be seriously affected in degraded ecosystems, and the global community has accordingly set specific targets for ecosystem restoration. Most soil ecosystem functions are difficult to assess directly and must be inferred from measurable soil properties, i.e. soil quality indicators, which can cover a broad range of soil physical, chemical, and biological characteristics. Developing clear goals for restoration and defining effective tools to assess and monitor progress, are critical to achieve restoration success. Soil quality indicators can be a valuable asset for ecosystem monitoring and assessment in restoration programs, predominantly with respect to understanding the role of soil properties and plant–soil relationships that promote revegetation. Recent advances in the development of methodologies for soil analyses, including soil sensing techniques or molecular methods, provide unprecedented opportunities to further unravel plant-soil feedbacks and interactions during ecosystem recovery. However, despite the substantial potential benefits of using soil quality indicators as tools in ecosystem restoration, the calibration and establishment of global parameters remains a challenge due to the large variability in soil, climate, and ecosystem types. This review provides an overview of the current knowledge of soil quality indicators in the context of ecosystem restoration. Examples of relevant soil physicochemical and microbiological indicators, and current and novel methodologies for their assessment, are presented. Furthermore the benefits and challenges for the global integration of these indicators in ecosystem restoration programs are discussed.

Keywords

Soil health, soil organic carbon, soil microbial communities, Sustainable Development Goals (SDGs), land degradation

Introduction

Land degradation and loss of biodiversity are two of the most pressing global problems affecting terrestrial ecosystems [1]. Approximately 23% of the globe's terrestrial surface is currently affected by some form of degradation, with 5-10 million additional ha being affected annually, and about 1.5 billion people negatively