

## **A historical review of the methods of determination of soil properties for soil quality and land degradation assessment**

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Properly assessing soil quality and land degradation is one of the main concerns of soil scientists in recent decades. Nowadays there are several available assessment systems based mainly on indicators, i.e. on soil-related parameters, that allow one to determine the current state of natural soils at different scales. These systems vary depending on ecosystem type and soil function studied as well as the accuracy of the methods (techniques and tools) historically used in the determination of several soil parameters.

In this study, we show a historical review of many methods of determining soil properties used regularly as soil quality and land degradation indicators. We have considered 5 worldwide historical periods: [1] The pioneers: before 1889, [2] USDA impulse: 1889 – 1945, [3] Productivity paradigm: 1946 – 1972, [4] Conservationist paradigm: 1973 – 2001, and [5] Current methodologies: 2002 – present.

The limits of each period have been determined according to some key milestones, for humanity in general and soil science in particular, such as the creation of the United States Department of Agriculture (USDA) in 1889, the end of World War II in 1945 or the publication of relevant works such as *The limits to growth* in 1972. The development of the Soil Management Assessment Framework (SMAF) indexing tool by American soil scientists in 2001 marks a turning point from which new methodologies and paradigms began to be dominant among methods of determination.

Finally, the methods historically used to determine more than 100 soil properties have been reviewed by consulting around 1,500 references published between 1305 and 2017. Approximately 10% of the references were key works to contextualize the first two historical periods, i.e. before 1945, and almost half of all references were published in the second half of the twentieth century (1946 – 2001). A logical tendency in gaining progressively accuracy in methods has been observed as well as a major boom in the study of biochemical properties such as enzyme activity in the last period.