SOIL GENESIS, CLASSIFICATION AND MAPPING

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Contents

1. Introduction

Soils serve as the natural foundation of civilizations. They directly affect agricultural production, waste disposal and community development. Yet, history is replete with examples of soil misuse accelerating the collapse of civilizations. In many cases this happens as soil productivity and water quality are impaired via human-caused erosion, desertification, and/or salinization. These problems develop because of a poor understanding of what soils really are and why different soils behave differently. And while those differences are measured in terms of soil physics, soil chemistry and soil biology, a complete understanding of soils and their proper use also require an understanding of their genesis.

Three global principles underlie the genesis of all soils. These are:

(1) The atmosphere is constantly and systematically redistributing energy and matter, especially water, across the earth.
(2) Minerals and landforms at the earth's surface are unstable under conditions of fluxing energy and matter.
(3) Autotrophic organisms are extremely adept at and in fact highly evolved to capitalize on energy and matter fluxes.

The tangible product of these principles is formation of soil profiles. The formation begins as precipitation and sunlight hydrolyze and hydrate minerals in the geologic parent material. This occurs at different rates and with different effect across a given landscape and across different climates. Regardless of the geographic setting though,

diurnal and seasonal wetting and drying and heating and cooling cause the parent minerals to decompose. During wet phases, the pores between the mineral grains become enriched in nutrient-bearing solutions. Plant roots and microorganisms grow into these pores in order to consume these soluble nutrients as well as to keep their cells turgid via uptake and transpiration of the pore water. Different plants and microorganisms grow well at different places on the landscape and under different climates because of the differences in weathering and water storage that occurs with differences in elevation, aspect, mineral types, rain patterns, etc. The unique set of processes that occurred at a given location, results in a unique soil for that spot on the earth. Across the whole earth, the wide range in climate, biota, minerals, and landscapes has resulted in the myriad of soils that exist across the earth.

Each of these soils is a unique product of the interplay over time between their original minerals and type of geologic parent material, location on the landscape, the type of climate of the area and the type of biota present. Or written more succinctly, soil is the product of parent material, relief, climate, biota, and time. The Russian scientist V.V. Dokuchaev and the US scientist E.O. Hilgard independently reported this concept in the 1870's and 1880's. It was refined into a state factor equation by H. Jenny in 1941. This conceptual approach remains the global foundation of soil genesis thinking today.

The preceding discussion illustrates the four core components included in the science of pedology (pedology = Greek root: "ology," the science of "pedo," soils;). First, soils exist because of physical, chemical, and biological processes simultaneously acting upon the solids, solutions, and biota present at or near the earth's surface. Second, soil formation occurs differentially in space because processes act unequally as one moves vertically into the earth as well moving across landscapes. This results in soil profiles vertically and catenas laterally. Soil profiles and catenas are discussed in more detail separately in the following sections.

The third component of pedology is that over the very long term (millennia to 10s or 100s of millennia) there is a feedback loop between soils, ecology, and climate wherein soil formation is both a product of and contributor to ecological and climatic evolution. An illustration of this feedback loop is to consider soil formation on a well-drained, nutrient rich sand dune under a high rainfall environment with a deciduous forest ecosystem. Over time, the rainfall and organic acids from the deciduous trees result in a gradual depletion of nutrients from the soil with the result being it can no longer support deciduous trees. This causes ecological succession as conifers migrate in and replace the deciduous trees. The conifers have lower evapotranspiration rates. The reduced evapotranspiration results in both decreased water vapor available for future precipitation as well as a decrease (getting closer to the surface) of water table depth. The progressively more shallow water table eventually forces the conifers out. Those are replaced by hydrophilic vegetation, which again affects precipitation amounts and patterns as well as the other properties found in the soil. Thus this third component is simply that no part of the system is static, nor is any part completely controlling or the result of another part. This component has special meaning when humans seek to modify the soil or ecosystems and is at least part of the cause in climate and hydrological changes being experienced in numerous parts of the world (e.g., Western Australia where 10% of the sols in the wheat belt has been affected by a rising saline

water table, which is becoming more shallow due to removal of trees and conversion to cropland)

The fourth component of pedology is that understanding of and discussion about the soils across a region necessitates having a soil classification system that takes into account the properties of the current soil as well as the processes and properties involved in its genesis. Likewise, similar soils must be grouped and mapped in a manner that is logical in the context of their current properties as well as their genesis.

Thus, the definition of pedology given earlier is somewhat narrow. Pedology, more properly, is the science of soil genesis, classification, and mapping. As such, it provides much fundamental information to societies and nations seeking to best manage their resources. The term "pedology" was first coined by the German soil scientist F.A. Fallou in 1862. Fallou recognized pedology as "natural scientific knowledge of soil" although it is not generally thought that Fallou thought of pedology in the same manner as it is today.

Given that I have now refined one of the basic terms used in soil genesis, I feel compelled to forewarn readers that a drawback with pedology is that it is a term-rich science. Much jargon has necessarily been developed to properly explain soil genesis, classification, and mapping. However, for the purposes of this encyclopedia I have chosen to minimize the terminology used and instead focus on concepts. Readers interested in more complete terminology are directed to the Soil Science Society of America's Glossary of Soil Science Terms and the various text and scholarly books pertaining to the subject. Likewise I have chosen to not directly cite other work to facilitate the flow of ideas. I have included a list of useful and highly readable references at the end.

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Biographical Sketch

C. Lee Burras is an assistant professor of agronomy at the Department of Agronomy, Iowa State University, USA.

He researches carbon in soil; soil variability, particularly as related to crop yields; and the long-term impact of humans on soil. He serves a soil science examiner, which involves certifying and licensing soil scientist in the US. His extensive teaching activities, including working with a learning community for freshmen in agronomy.