Research at the 1 to 10m Scale in Pedology: The Emergence of Landscape-Scale Patterns of Soil Properties

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Research on soil properties at the 1m scale has long been a focus of activity in soil classification and genesis for it is at this scale that the soil pedon emerges as the major spatial unit of investigation. At scales of 10m, the individual pedons begin to form discernible spatial patterns in the landscape. These patterns result from distinctive pedogenic regimes that occur in response to differences in the type and intensity of pedogenic processes. In regions such as the glaciated Canadian prairies, which lack significant age differences along a topographic continuum, the pedogenic regimes occur due to differences in redistribution of water and microclimate and their effects on soil processes. Both the moisture redistribution and the microclimate controls are primarily governed by the morphology of the landscape. In these regions landform morphology provides an important link between the quantifiable patterns of soil properties and the pedogenic processes responsible for these patterns. The quantitative evaluation of soil properties involves coupling this basic landform-soil relationship with an understanding of the time required for a distinctive spatial pattern to emerge. The models of soil distribution used in soil mapping are based on the occurrence of specific soil taxonomic individuals (i.e., soil pedons in formal taxonomic systems) which result from the action of pedogenic processes over hundreds or thousands of years in these landscapes. The resulting pattern of soil pedons can be quantified into landscape-scale soil distribution models which form the basis for extrapolation of 1- to 10m scale studies into successive, smaller scale studies. Human use of the soil influences the basic landscape-scale soil distribution pattern over a time scale of decades. For example, accelerated rates of soil redistribution due to cultivation in Prairie landscapes has greatly increased the range of soil organic carbon and nitrogen levels, and redistribution leads to accentuation of the pre-cultivation pattern. The rates of processes such as gaseous losses of nitrogen show much less of a memory of past landscape changes but are very strongly influenced by annual differences in landform-mediated hydrological controls. For example, denitrification rates within a 1m cell can show very high spatial variability, typically with coefficients of variation in the range of 100-200%; however despite the great range of values within individuals pedons, a clear landscape-scale pattern of emissions can be discerned and quantitatively evaluated. This evaluation allows the extrapolation of site-specific rates to scales of more relevance for global evaluations of gaseous emissions. The greatest challenge remaining for pedological research at this scale is to integrate observations on the state of individual soil processes with the most important of the responses to these processes, the production of plants at the field scale. With the emergence of precision agriculture as a major research and applied objective in soil science, the need for this greater understanding has become much more acute.