Quantification of burrowing animals’ impact on landscapes: a review of numerical methods.

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The presence of burrowing animals is a recognizable characteristic in almost all types of landscapes and climates. Independent of their size, their activity of mounding and digging plays a significant role in landscape evolution, to the point of being addressed as ecosystem engineers. For example, while tunnels facilitate water infiltration, mounds slow down surface runoff and make soil available for erosion. Several models have included animal activity as a bioturbation process, and many studies have quantified the impact of animals’ presence on soil properties. However, how to best include burrowing animals’ role in other soil hydro-physical processes in hydrological, landscape evolution, or soil erosion models is still unclear. Indeed, the significant heterogeneity of animals’ distribution and their impact at different spatio-temporal scales complicates their inclusion into models. Therefore, this study aims to explore numerical methods (equations, coefficients, ratios) used to quantify the impact of burrowing animals on soil hydro-physical processes. Furthermore, it explores how these methods can be integrated with the most common equations implemented in hydrological, landscape evolution, or soil erosion models to calculate those processes. We focused on surface runoff, soil lateral transport, soil excavation, soil mixing, water infiltration and subsurface preferential flow. Peer-reviewed studies about burrowing animals’ impact on soil hydro-physical processes were collected. Of those articles, we reviewed studies where numerical methods were used to quantify or discriminate the role of the animals. The articles were classified according to the processes measured, the spatio-temporal scale, whether the animal was vertebrate or invertebrate and smaller or bigger than 2.5 cm.

As a first result, the main processes quantified are soil lateral transport, water infiltration and soil mixing. Most of the studies were conducted with field or laboratory experiments on a yearly scale. Because of this, most equations collected were empirical and used to quantify single processes for a specific environment. Rates were the primary means of quantification for runoff or soil lateral transport, and coefficients for soil mixing. Infiltration was quantified as change in soil moisture or as rate. Overall, hydraulic properties were mainly calculated in relation to the presence/absence of earthworms or insects, while mammals and vertebrates were primarily linked to soil physical properties and soil transport. We can argue that, to better incorporate animals’ influence on soil hydro-physical processes, a more comprehensive investigation of their role in soil hydraulic
properties is fundamental. However, this might not be sufficient when considering large spatio-
temporal scales (centuries, catchments). For this, the development of an ad hoc faunal-hydro-
physical module can be used to explore the impact of animal bioturbation on processes at
different scales.