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Soil creep: the driving factors, evidence and significance for biogeomorphic and pedogenic domains and systems – a critical literature review

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Abstract: Soil and regolith creep have been analyzed for at least the last 140 years, using many methodological configurations and temporal and spatial scales. The general concept of creeping soil and its mechanism, first proposed by W.M. Davis and G.K. Gilbert at the end of the 19th century, evolved since the 1940s towards theoretical models and precise short- and long-term field measurements. This fruitful epoch continued with results enhanced at the turn of the 20th century by the application of new research methods (e.g. radiometry) and a redefinition of the term soil creep to encompass the sum of stochastic shallow subsurface and near-surface processes causing net downslope movement of soil or regolith. Simultaneously, another possibility of creep detection was noticed in dendrochronology, and since the 1970s, in the formally defined discipline of dendrogeomorphology, indirect evaluations of creep activity were performed based on tree-ring analyses of bent trees. This method found many followers, but was also heavily criticized as imprecise and lacking in evidence of which kind of tree trunk curvature (e.g. "pistol-butt"- like deformation, S-shape curvature) could be ascribed to creep movement. From the beginning, soil creep was associated with the activity of living organisms on hillslopes. However, this aspect of creep studies has never been fully developed, in spite of the solid foundations and directions of potential studies pointed out by Charles Darwin at the end of the 19th century.
In this paper we focus on the historical context of soil creep studies, and highlight forest ecosystems as probably the most active environment of biogenic creep, mainly due to tree uprooting and other biomechanical effects of living and dead trees (root channel infilling, tree root mounding etc.) that are a factors in biotransport. In the final sections the position of biogenic creep in the structure of biogeomorphic systems is discussed in relation to such important conceptual frameworks as the biogeomorphic ecosystem, biogeomorphic feedback window and ecosystem engineering. We also describe several hypotheses that should be carefully tested in the future, and propose several research methods that have the ability to further our knowledge about soil creep: radiometry, laser scanning and soil micromorphology.
Key words: creep, bioturbation, trees, ecosystem engineering, soils, dendrogeomorphology, uncertainty

1. Introduction
2. Soil creep – a history of studies performed, terminological issues and driving factors
   2.1. Soil creep research history - from a mechanistic to diffusive-like concept of soil transport