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Linking biogeomorphic feedbacks from ecosystem engineer to landscape scale: a panarchy approach

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Scale is a fundamental concept in both ecology and geomorphology. Therefore, scale-based approaches are a valuable tool to bridge the disciplines and improve the understanding of feedbacks between geomorphic processes, landforms, material and organisms and ecological processes in biogeomorphology. Yet, linkages between biogeomorphic feedbacks on different scales, e.g. between ecosystem engineering and landscape scale patterns and dynamics, are not well understood. A panarchy approach sensu Holling et al. (2002) can help to close this research gap and explain how structure and function are created in biogeomorphic ecosystems.

Based on results from previous biogeomorphic research in Turtmann glacier foreland (Switzerland; Eichel, 2017; Eichel et al. 2013, 2016), a panarchy concept is presented for lateral moraine slope biogeomorphic ecosystems. It depicts biogeomorphic feedbacks on different spatiotemporal scales as a set of nested adaptive cycles and links them by 'remember' and 'revolt' connections.
On a small scale (cm^2 – m^2; seconds to years), the life cycle of the ecosystem engineer Dryas octopetala L. is considered as an adaptive cycle. Biogeomorphic succession within patches created by geomorphic processes represents an intermediate scale adaptive cycle (m^2 – ha, years to decades), while geomorphic and ecologic pattern development at a landscape scale (ha – km^2, decades to centuries) can be illustrated by an adaptive cycle of ‚biogeomorphic patch dynamics' (Eichel, 2017). In the panarchy, revolt connections link the smaller scale adaptive cycles to larger scale cycles: on lateral moraine slopes, the development of ecosystem engineer biomass and cover controls the engineering threshold of the biogeomorphic feedback window (Eichel et al., 2016) and therefore the onset of the biogeomorphic phase during biogeomorphic succession. In this phase, engineer patches and biogeomorphic structures can be created in the patch mosaic of the landscape. Remember connections link larger scale adaptive cycles to smaller scale cycles: configuration and properties of the lateral moraine slope patch mosaic control patch recolonization during biogeomorphic succession, while the patch-internal disturbance regime determines when the engineer can establish (establishment threshold of the biogeomorphic feedback window). Jointly, biogeomorphic feedback adaptive cycles and their connections in the panarchy create structure and function in the lateral moraine slope biogeomorphic ecosystem.

Thus, by linking feedbacks on different spatiotemporal scales in biogeomorphic ecosystems and explaining the creation of ecosystem structure and function, the panarchy concept represents a useful tool for future biogeomorphic research.

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