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Biogeomorphic interactions and patterns on Little Ice Age lateral moraines

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Glaciers and their forefields are strongly affected by climate change. This leads to increasing geomorphological and ecological dynamics in these environments. Glacier recession exposes high volumes of unconsolidated sediments, with lateral moraines being among the most important sediment storages. Their sediment is reworked by a variety of slope processes, e.g. sheet wash, debris flows or gullying. At the same time, these landforms are colonized by plants and other organisms, proceeding into vegetation succession. It is believed that this process ultimately leads to sediment stabilization which is an important factor for reservoir management in glacier forefields. Recent biogeomorphic research revealed a strong coupling of geomorphic and ecologic processes and complex feedbacks. Geomorphic processes disturb vegetation while at the same time, certain plant species, 'geomorphic-engineer species', can influence geomorphic properties and processes. The strength of these interactions changes during biogeomorphic succession. Corresponding patterns of vegetation and geomorphic forms and processes arise at the mesoscale. The resulting spatial heterogeneity can be mapped as patches.

In our study, we investigate patterns of vegetation and geomorphic forms and processes on Little Ice Age lateral moraines in the Turtmann glacier forefield, Switzerland. Despite higher terrain age, these landforms show strongly heterogeneous vegetation as well as geomorphic activity patterns, indicating that sediment stabilization has not yet been accomplished. This could result from varying strengths of biogeomorphic interactions. To assess this influence, vegetation and geomorphic properties of 50 vegetation plots were sampled and statistically analyzed. Results showed that vegetation composition does not relate to terrain age, rather, geomorphic disturbances seem to be a dominant influencing factors, producing patch dynamics. Certain species compositions can be related to specific geomorphic forms and processes. Pioneer vegetation was found proximal to moraine crests with frequent sheet wash, linear erosion and occasional debris flows. Shrub vegetation (Salix spp.) occurs on polygenic cones at the moraine toe. Alpine grass communities with dwarf shrubs (Dryas octopetala) grow at various slope positions and are associated with solifluction forms and processes. With its adapted plant functional traits (strong roots, mat growth form) Dryas octopetala acts as scree-dammer. Thereby, this geomorphic-engineer species generates biogeomorphic interactions and could induce a transition from dominant sheet wash and linear erosion to solifluction.
The specific combinations of vegetation and geomorphic properties and processes and related patterns can be seen as the emergent result of small-scale biogeomorphic interactions and as the spatial representation of different biogeomorphic succession phases. They can thus be categorized as 'biogeomorphic patches' that probably determine mesoscale sediment dynamics on lateral moraines.