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Controls on small-scale biogeomorphic interactions on lateral moraine slopes and their linkage to large-scale geomorphic and vegetation patterns

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Glacier forelands are characterized by simultaneous and coupled geomorphic and vegetation development following glacier retreat. For lateral moraine slopes, it has been shown that once geomorphic activity decreases sufficiently, ecosystem engineer species (e.g., Dryas octopetala) can establish and a 'biogeomorphic feedback window' is entered, in which the engineer (e.g., through high cover) amplifies the decrease in geomorphic activity and changes the dominant process from erosional (e.g., slope wash) to bound solifluction processes, until it is suppressed by later successional species (Eichel et al., 2015). This temporal sequence is termed 'biogeomorphic succession' and has been found in a glacier foreland (Eichel et al., 2013). However, it remains unclear (1) if and how further factors, e.g., soil properties and thermal and snow conditions, influence small-scale biogeomorphic feedbacks and (2) how biogeomorphic succession dynamics relate to geomorphic and vegetation patterns in space.

Consequently, the objectives of this study are (1) to evaluate controlling factors for small-scale biogeomorphic interactions, (2) to identify geomorphic and vegetation patterns in space and (3) to link small-scale interactions with large-scale vegetation and geomorphic patterns and dynamics.

A biogeomorphic approach was carried out on Little Ice Age lateral moraine slopes in the Turtmann glacier foreland (Switzerland), consisting of (1) a permanent plot survey (2x2 m) to assess geomorphic and vegetation properties, combined with soil sampling and iButton temperature loggers for thermal and snow properties, and (2) a detailed (1:1000) geomorphic and vegetation mapping. Plot data was analysed using multivariate statistics and compared to geomorphic and vegetation maps.
Combined results of multivariate statistics and mapping show a strong relationship between geomorphic properties and species composition. These are independent from terrain age, but controlled by a toposequence gradient and associated material and thermal properties and snow distribution. The moraine crest is often characterized by high percentages of fine material, short snow cover period, high freeze-thaw and geomorphic activity and pioneer species. In contrast, high percentages of larger clasts, long snow cover period, low freeze-thaw and moderate to low geomorphic activity and later successional species occur at the slope foot. However, high-magnitude geomorphic processes (e.g., debris flows) can obscure these patterns by creating passages with differing geomorphic and vegetation properties along the entire slope. Moreover and surprisingly, the occurrence of engineer species associated with low-magnitude solifluction processes is independent from toposequence position.

We interpret the detected geomorphic-vegetation associations as patches situated in different biogeomorphic successional phases, linked and controlled through the toposequence gradient and biogeomorphic interactions between engineer species and geomorphic processes, which both are more important than terrain age.

Eichel, J., Corenblit, D. & R. Dikau (2015): Conditions for feedbacks between geomorphic and vegetation dynamics on lateral moraine slopes: a biogeomorphic feedback window. Earth Surface Processes and Landforms. DOI: 10.1002/esp.3859

Eichel, J., Krautblatter, M., Schmidtlein, S. & R. Dikau (2013): Biogeomorphic interactions in the Turtmann glacier forefield, Switzerland. Geomorphology 201: 98 - 110. DOI: 10.1016/j.geomorph.2013.06.012