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Biogeomorphic feedbacks in glacier forelands and their geomorphic and ecologic effects

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Rising temperatures cause glacier retreat worldwide. Consequently, glacier forelands enlarge, which are characterized by high rates of sediment reworking during paraglacial adjustment. At the same time, plants colonize the new terrain during vegetation succession. How quickly plants can colonize and stabilize the new terrain is related to rates of sediment reworking and controls sediment input from the slopes into glacier foreland reservoirs. However, the relationship between vegetation succession and paraglacial adjustment is not yet well understood and several open questions exist: (i) Are some plant species more effective in stabilizing glacial sediments than others? (ii) Under which conditions can plants and geomorphic processes interact in glacier forelands? (iii) How do feedbacks between plants and geomorphic processes affect development of glacier foreland landscapes in time and space?

Biogeomorphic feedbacks were investigated on lateral moraine slopes in Turtmann glacier foreland, Switzerland, using a combination of geomorphic and ecologic methods. Results demonstrate that biogeomorphic feedbacks occur on several spatiotemporal scales. (i) On a small scale, permanent plot data showed that once the dwarf shrub D. octopetala covers more than 35% of a plot, occurring geomorphic processes change from soil erosional to bound solifluction processes. This effect can be explained by D. octopetala's adapted plant traits, which influence mechanical, hydrological and thermal soil and surface properties. Consequently, D. octopetala is an alpine ecosystem engineer species (Eichel et al. 2016, 2017). (ii) The relationship between geomorphic process magnitude and frequency and plant species resistance and resilience determines if ecosystem engineering can occur in a 'biogeomorphic feedback window' (Eichel et al. 2016). In this feedback window, turf-banked solifluction lobes (TBLs) can be created in an ecosystem engineering process. TBLs possess closely related geomorphic and vegetation dynamics and patterns and therefore represent biogeomorphic structures (Draebing & Eichel 2017; Eichel et al. 2017). (iii) On a large scale, plot data showed a strong linkage between geomorphic activity and species composition, which is independent from terrain age. This indicates a pronounced coupling between paraglacial adjustment and vegetation succession, which is interpreted as 'biogeomorphic succession' (Eichel et al. 2013). In space, a patch mosaic of interrelated geomorphic and vegetation patterns was found, indicating spatially highly variable paraglacial adjustment and vegetation succession, which are controlled by biogeomorphic feedbacks.

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