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The ecology of deglaciated terrain revisited

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A traditional understanding of vegetation succession within glacial forefields considers the primary driving factor of vegetation patterning to be the age of the landscape, with environmental heterogeneity acting as a secondary factor. However accelerated rates of glacier recession in Alpine and Polar regions since the 1980s may be rendering such chronosequences less clear, as rates of glacier recession are so high that large areas of proglacial forefield may be created with relatively similar "time zeros." Thus, the signal of environmental heterogeneity becomes more important. Data from five glaciers in the Swiss Alps show that rates of production of deglaciated terrain since the 1980s are two to three times higher than from the 1850s to the 1980s. A case study at the Glacier d'Otemma, Valais, Switzerland shows how environmental heterogeneity in the form of geomorphic perturbation and water availability appear to act as the primary controls on vegetation patterning within areas deglaciated since the 1980s. The Triangular Green Index was used to map vegetation distribution within the glacial forefield, and a 25cm DEM was used to calculate stream power (proxy for geomorphic perturbation) and a wetness index (proxy for water availability) in Matlab. Probability density functions show that the highest vegetation concentrations were found in areas with intermediate values of both wetness and perturbation, with vegetation establishment declining rapidly for higher values of perturbation and lower values of wetness. This suggests that there exists a window of opportunity for vegetation establishment where there is sufficient moisture and not too much perturbation. Based on these observations, a conceptual model was developed describing the factors and feedbacks driving vegetation patterning within glacial forefields under a scenario of rapid glacial retreat. In this model, climate amelioration and more rapid glacial retreat cause greater production of deglaciated terrain, which then results in geomorphic perturbation and gradients in hydraulic flow driving the patterning of vegetation establishment. Vegetation establishment can then influence geomorphic perturbation and hydrology via biogeomorphic feedbacks.