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Explaining plant-soil diversity in Alpine ecosystems: more than just time since ecosystem succession started

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Ecosystem succession in Alpine environments has been a focus of research for many decades. Following from the classic ideas of Jenny (1941, 1961), following perturbation, an ecosystem (flora, fauna and soil) should evolve as a function of time at a rate conditioned by external variables (relief, climate, geology). More recently, biogeomorphologists have focused upon the notion of co-evolution of geomorphic processes with ecosystems over very short through to very long (evolutionary) time-scales. Alpine environments have been a particular focus of models of co-evolution, as a means of understanding the rate of plant colonization of previously glaciated terrain. However, work in this field has tended to adopt an over simplified view of the relationship between perturbation and succession, including: how the landform and ecosystem itself conditions the impact of a perturbation to create a complex spatial impact; and how perturbations are not simply ecosystem destroyers but can be a significant source of ecosystem resources. What this means is that at the within landform scale, there may well be a complex and dynamic topographic and sedimentological template that co-evolves with the development of soil, flora and fauna.

In this paper, we present and test conceptual models for such co-evolution for an Alpine alluvial fan and an Alpine piedmont braided river. We combine detailed floristic inventory with soil inventory, survey of edaphic variables above and below ground (e.g. vertical and lateral sedimentological structure, using electrical resistance tomography) and the analysis of historical aerial imagery. The floristic inventory shows the existence of a suite of distinct plant communities within each landform. Time since last perturbation is not a useful explanatory variable of the spatial distribution of these communities because: (1) perturbation impacts are spatially variable, as conditioned by the extent distribution of topographic, edaphic and ecological characteristics; (2) perturbations supply ecosystem resources, such as organic matter or fine sediment, that can substantially and locally accelerate ecosystem succession; and (3) both of these feed back into the development of the plant-soil community. The result is clear evidence of the co-evolution of floristic communities with geomorphic processes that, at the ensemble of the landform, controls the floristic diversity that is found.