Opinion: Using eDNA fingerprinting in high mountain environments to support soil restoration and hazard control

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Abstract

Mitigating erosion, mass movements, and geohazards in high mountains is increasingly conceived within frameworks of ecological restoration, that is, recovering the form and function of ecosystems that have been damaged by degradation (Hubble et al. 2017). From a geomorphological point of view, ecological restoration involves both the prevention and control of slope and riverbank instabilities as well as the confinement of runoff and sediment regimes to the capacity river channels. In this regard, the practice of soil and water bioengineering is rapidly emerging as a short-term hazard control that can enable long-term ecological recovery (Rey et al. 2019). Vegetation, as a chief ecological engineer, is key to soil and water bioengineering applications. However, the application of soil and water bioengineering in high mountains is limited by severe ecological conditions, making plant establishment and ecological recovery times are slow in high mountains (Dupin et al. 2019).

While applications of sediment source fingerprinting using for example geochemical or radionuclide soil signatures yield a rough distinction between sediment sources, they cannot reflect the multiple vegetation covers that are relevant source types and should be discriminated in high mountain environments to prioritize restoration works. Vegetation may be the most distinctive feature of high mountains, where the underlying lithology is heterogeneous and soils are mainly shallow and poorly developed. Because there are strong interrelations between land cover and geomorphological processes in high mountain environments (Geertsema and Pojar 2007; Giaccone et al. 2019; Lizaga et al. 2019), the use of land cover-based sediment tracers would be particularly meaningful. eDNA has the highest source discrimination potential in that regard, providing information up to the species level and reflecting changes in vegetation on over short timescales. Furthermore, eDNA signals in sediments will be strongest from areas experiencing higher erosion rates and which are highly connected with the hydrographic network. The use of eDNA sediment source fingerprinting would thus allow the investigation of complex and often poorly understood

relationships between vegetation cover, restoration activities, and geomorphological response at the catchment scale.

To improve the success rates of restoration activities, collaboration between scientists and stakeholders can accelerate technology transfer rates (Stokes et al. 2014; Giupponi et al. 2019; Rey et al. 2019). However, time and budget constraints often hamper in-situ monitoring of soil and water bioengineering applications, and very few monitoring programs exist (Giupponi et al. 2019). Knowledge of success rates is, however, essential for restoration (Frankl et al. 2021). To this end, sediment source fingerprinting has been shown to provide a valid framework for supporting soil restoration activities (Mukundan et al. 2012). Environmental DNA has already been used to successfully monitor restoration programs, but with a focus on fungal species (Yan et al., 2018). We opinionate that eDNA fingerprinting – as an emerging technique – could be particularly useful to support soil restoration and hazard control in high mountain environments.

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