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Soil-plant system development 9 to 136 years after marly gully beds rehabilitation (French Southern Alps)

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Marly badlands, showing active eroded gullies and low soil fertility, are found in the French Southern Alps for around 250 years. Negative ecological, social and and economical consequences of such intense erosion historically promoted the ecological restoration of these terrains. In a small catchment of 390 ha (Saignon catchment, France), a first wave of restoration was run in 1876-78, mainly through Austrian black pine plantation on eroded gully sides. A second wave occurred in 2002 and focused on gullies partly vegetated on their sides but still showing active gully beds. Bioengineering works, made of barriers of Salix cuttings, were implanted in gully beds to increase sedimentation and in turn to re-initiate soil formation. This strategy proved to be efficient to retain sediment and to favor plant colonization. The aim of this study was to investigate soil fertility of sediment mounds retained in gully beds 9 to 136 years after their rehabilitation. To answer this question, we compared the topsoil (0-10 cm depth) chemical fertility of 6 gully beds restored in 2002 with bioengineering works to the one of 5 gully beds belonging to gullies stabilized by pine plantation 136 years ago. As a control, sediment mounds found in 15 bare gully beds were also studied. In each gully, basic soil characteristics of composite samples were assessed. Vegetative cover, plant richness and litter accumulation were also measured. We found that soil organic carbon and total nitrogen content significantly increased with time since gully bed rehabilitation (4.3±0.4 / 12±1 / 21±2 g.kg-1 and 0.80±0.02 / 1.4±0.02 / 1.7±0.07 g.kg-1) for bare gully beds and gully beds rehabilitated 9 and 140 years ago, respectively. Carbonate content was lower in restored gullies (average value of 242±5 g.kg-1) compared to control ones (547±13 g.kg-1). These results suggest that pedogenesis was engaged in both sets of restored gullies (decarbonatation process). Available phosphorus was lowest in gully beds restored in 2002 (8.3±4 mg.kg-1; ANOVA test, $p<0.001$), suggesting that phosphorus availability could be limiting factor to set up plant cover recovery dynamics in the early stage of gully rehabilitation. Soil texture is silt loam with sand content varying from 7.1±1.2 to 29±1.3 and 36±1.4 % for bare gully beds and gully beds rehabilitated 9 and 136 years ago, respectively. This observation agrees with previous results showing that plant barriers do not trap fine sediment, thus increasing sand content. In parallel, we observed that plant cover and litter accumulation in gully beds were highest in gully beds rehabilitated 136 years ago (ANOVA test, $p<0.001$), contrary to plant richness which did not show any significant change in gully beds rehabilitated 9 or 136 years ago (around 4 species.m-2). This suggests that plant establishment occurs in the first decade after bed stabilization while the spread of the cover requires more time. We conclude that within the first ten years after gully beds rehabilitation, a real soil-plant system has already developed with early signs of pedogenesis, which could be somehow nutrient limited.