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Mapping of areal erosion rate in marly badlands based on anatomical changes in exposed roots

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Extensive areas of the French Alps are underlain by Jurassic black marls. Wherever these "terres noires" crop out they become subject to intense erosion, causing major sedimentation in regional reservoirs and river system. In the badlands near Draix (Alpes de Haute-Provence, France), measured sediment rates were obtained at the plot scale by surface elevation change-based methods and at the catchment scale by monitoring sedimentation in dams. In this study, we use a dendrogeomorphic approach based on anatomical changes in exposed roots of Pinus sylvestris L. to quantify continuous denudation rates with high resolution. A total of 123 cross-sections (75 from buried and 48 from exposed roots) were sampled in the Moulin basin. In cross-sections of buried roots, a sharp reduction of earlywood tracheid lumen area, a growth signature which has traditionally been used to determine the moment of root denudation, was observed as soon as erosion reduced soil cover to $\leq$3 cm. As a consequence, estimates of eroded soil thickness had to be adjusted to take account of this bias.

At the plot scale, after bias correction, average medium-term soil erosion rates derived from exposed roots vary between 1.8 and 13.8 mm yr–1 (average: 5.9 mm yr–1) and values are significantly correlated with slope angle. The dendrogeomorphic record of point-scale soil erosion rates matches very well with soil erosion rates measured in the Draix basins. Based on the point-scale measurements and dendrogeomorphic results obtained at the point scale, a linear regression model involving slope angle was derived and coupled to high-resolution slope maps obtained from a LiDAR-generated Digital Elevation Model so as to generate high-resolution soil erosion maps. The resulting regression model is statistically significant and average soil erosion rates obtained from the areal erosion map (5.8, 5.2 and 6.2 mm yr–1 for the Roubine, Moulin and Laval catchments) prove to be well in concert with average annual erosion rates measured in traps at the outlet of these catchments since 1985 (6.3, 4.1 and 6.4 mm yr–1).

This contribution demonstrates that dendrogeomorphic analyses of roots clearly have significant potential and that they are a powerful tool for the quantification and mapping of soil erosion rates in areas where measurements of past erosion is lacking.