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Structural and functional control of patch- to hillslope-scale runoff and sediment connectivity in Mediterranean-dry reclaimed slopes

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Runoff and soil erosion in Mediterranean-dry landscapes are affected by multiple factors (e.g. rainfall characteristics, vegetation patterns, soil and landform variability) that interact at a variety of spatial scales (from the surface patch to the hillslope and the larger catchment and landscape scales) with variable degrees of connection. In these complex systems, the concept of connectivity has emerged from the hydrological and Earth science disciplines as a useful concept to analyze the movement of runoff and sediments between locations or scales of the landscape. In this study, we examine the structural and functional controls of patch- to hillslope-scale runoff and sediment connectivity in three Mediterranean-dry mining slope systems that were reclaimed about three decades ago obtaining different long-term development levels of vegetation cover (from 30% to 55%) and rill network density (from 0.6 to 0.0 m m-2). Structural connectivity, i.e. the extent to which surface patches that facilitate the production of runoff/sediments are physically linked to one another, was assessed in the studied slope systems using terrain-based flowpath analysis. Functional connectivity, determined as flow continuity across scales, was analyzed using the ratio of patch- to hillslope-scale observations of runoff and sediment yield for 21 active events monitored in 27 Gerlach (3-16 m2) and 3 hillslope (500-1500 m2) plots distributed along the studied slope systems. The presence of rills largely controlled the structural connectivity of the slopes, providing preferential pathways that maximized the connection between barely covered soil patches that act as runoff/sediment sources and the hillslope toes. Event-based functional connectivity of runoff was dynamically controlled by antecedent precipitation conditions, rainfall intensity and storm depth and, at the same time, was modulated by the structural connectivity of the slopes. In the absence of rill networks, both runoff and sediment yield per unit area decreased from the surface patch to the hillslope-scale due to internal redistribution of both water and sediment fluxes. Functional connectivity of sediments increased with rainfall intensity, particularly for the least successfully restored hillslope where active rilling under high intensity storm conditions led to large non-linear increases in sediment yield from the surface patch- to the hillslope-scale. Overall, these results reveal the usefulness of the structural and functional components of the connectivity concept for assessing the complex links and controlling factors that rule the transference and movement of both runoff and sediment yield across different scales of the landscape.