



Linking sediment connectivity with direct protection forest management: the case study of Lombardy Region

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Direct protection forests (DPFs) play a key role in mitigating natural hazards by reducing their impacts on exposed elements such as buildings, infrastructure, and transportation networks. By definition, a DPF requires the simultaneous presence of three components: (i) a potentially damaging natural hazard, (ii) people or assets exposed to this hazard, and (iii) a forest capable of preventing or mitigating the resulting damage, thereby providing a protective function. Despite the conceptual clarity of this definition and the importance of DPFs for land-use planning, their delineation at the regional scale remains challenging. This is because the protective role of forests varies with the type of natural hazard and is often constrained by limited or heterogeneous data availability.

This study proposes an integrated, spatially explicit methodology for delineating DPFs based on the overlay of multiple geospatial information layers: (i) natural hazard maps describing the spatial distribution of susceptibility (or probability of occurrence) to shallow landslides, rockfalls, debris flows, and avalanches; (ii) a forest cover map providing both forest extent and canopy cover classes; (iii) elements at risk derived from regional authority databases; and (iv) a connectivity map used to identify sediment linkage areas between potential hazard source zones and exposed elements. A key component of this last layer is the Sediment Connectivity Index, which provides spatially explicit estimates of sediment connectivity and allows the identification of forest patches that perform a direct protective function for the selected elements at risk.

The methodology was applied to the Lombardy Region in northern Italy, whose territory extends over 23,860 km², including large portions of Italian Alps and Pre-Alps, and is characterized by a forests cover of approximately 6,259 km² (26% of the entire regional area). The results indicate that DPFs extend over 992 km², accounting for the 16% of the forested area. Based on this delineation, spatially distributed indices were developed to assess forest protection predisposition and the priority of silvicultural interventions. Overall, the proposed approach provides an effective decision-support tool for forest management, improving mapping consistency and supporting targeted strategies aimed at enhancing the long-term protective function and resilience of forests under increasing natural hazard pressure.

