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Assessing the landslide susceptibility along roads through a 3-D probabilistic approach: a case study in the northern Italy

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Network of roads, highways and railways play a strategic role for the economy of any country worldwide and particularly in mountainous areas. At the same time, the processes of planning, designing, construction, and maintenance of such infrastructures frequently do not consider adequately the consequent increase of the threat of soil mass failures. Actually, geotechnical structures (e.g. retaining wall, reinforced earth dam, rockfalls protection net) are the most common solutions to contrast and reduce the possible damages caused by shallow landslides, rockfalls, or transport of sediment/woody material; however, they are expensive and often have a huge impact on the environment. Therefore, bioengineering works and, especially, forest management strategies could be the best effective ways to stabilize long and steep slopes and to reduce the consequent problems. Nonetheless, giving a priority of works, selecting the most susceptible portion of road and quantifying the reduction of susceptibility remain open issues, partially unsolved.
On this background, this study intends to improve the effectiveness of forests, both at stand scale than at catchment scale, integrating the assessment of landslide susceptibility and the sediment connectivity through a process-based and a probabilistic model. For this intent, we adopt a physically-based spatially-distributed model, called PRobabilistic MUltidimensional shallow Landslide Analysis, PRIMULA. It combines a multidimensional slope stability model and a stochastic procedure, and incorporates different sub-modules for defining the probability distribution functions of the input parameters, among which the root reinforcement strongly relates to the characteristics of forest stands.
The main purposes of this work are:
1. to identify the areas with a high probability of failure that can directly provoke several damages to portions of roads;
2. to combine the landslide susceptibility map, i.e. the main output of PRIMULA, with the assessment of sediment connectivity provided by an adequately and accurate model, in order to evaluate the indirective susceptibility due to sediment transport and woody debris;
3. to plan suitable and reliable forest strategies to reduce the landslide susceptibility and the soil erosion processes.
The model is tested on a small mountainous headwater catchment in the Central Italian Prealps, covered by deciduous forest and prone to shallow landslides, especially during the late spring and the early autumn. The results show how the proposed procedure is very encouraging.
Due to the low resolution of the necessary data, the proposed procedure is of great interest as a tool to predict the more efficient forest works and the effects of forest alterations (e.g. diseases, fire, clear-cutting or clearing) on the main roads and railways.