# Rock-fall and debris flow hazard assessment in protection forests: a case study in Slovenia

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## Introduction

Only 10% of all forests in Slovenia have an indirect protection function, out of which 30% perform direct protection role. More than 40% of them are European beech (*Fagus sylvatica* L.) dominated forests. Since beech dominated protection forests have not received enough attention in the Alpine region, our goal was to make a contribution to the overall understanding of their protection functioning. Furthermore, various methods have been used in Europe to objectively delineate influential areas of natural hazards. Our goal was to quantify rock-fall and debris-flow processess with modern empirical methods.


Figure 1: Location of study area Soteska in NW Slovenia

## Materials and methods

We studied protection efficiency of beech dominated forests in NW Slovenia, where a main state road and railway are endangered. We assessed the influential area of the debris-flow natural hazard based on a small-scale geological survey of the terrain characteristics and local debris flow susceptibillity map which was prepared by **Geolological Survey of Slovenia**. For determination of the run-out zones we used the TopRunDF model. For rock-fall hazard assessment, source zones were delineated and roughness of terrain was estimated. We used the RockyFor3D model for precise delineation of the rock-fall run-out zones. Forest structure data was obtained from 47 sample plots (500 m² each) where all trees with DBH ≥ 10 cm were measured. We assessed the performance of the protection function of the forest stands based on the Swiss methodology (NaiS, Frehner et al. 2005).

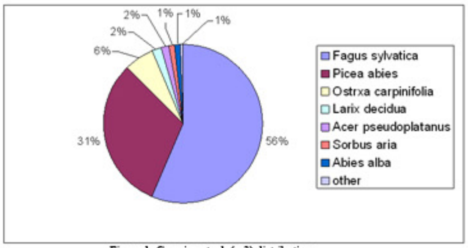


Figure 1: Growing stock (m3) distribution

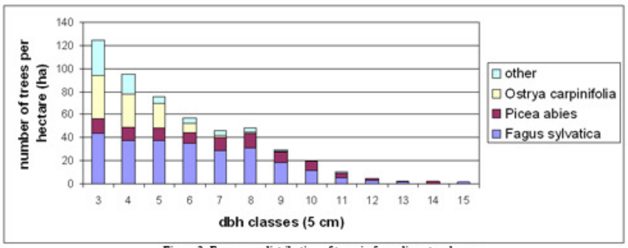


Figure 3: Frequency distribution of trees in 5 cm diameter classes

## Results and discussion

We found that 1,9 km of the railway and 4,5 km of the road is endangered of debris flow and rock-fall processess. For long-term protection efficiency, spatially-explicit regeneration cuttings were planned in uniform forest stands. All silvicultural measures should be coordinated with the necessity for interventions in particular stands. In places where logging is not possible, trees should be cut and left for future erosion processess mitigation. In areas where silvicultural measures could not provide sufficient protection, technical measures are needed (sills, array of dams, flexible net barriers, deflection dams). Natural disturbances (e.g. wind throw) are frequent thus causing a high amount of coarse woody debris. In places where torrent channels are present, coarse woody debris removal is essential. If the wood demand will increase in the future, management of theese forests will become more important.

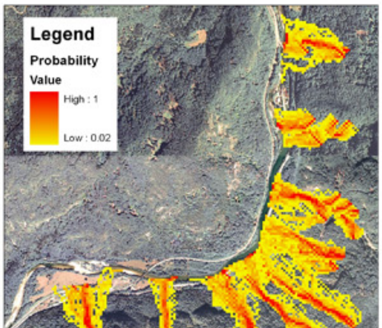


Figure 4: Debris flow warning map. Map is result of modeling with TopRunDF. The colour range shows overflow probability of each related cell (colour range: 1 = 100%, 0,02 = 2%).

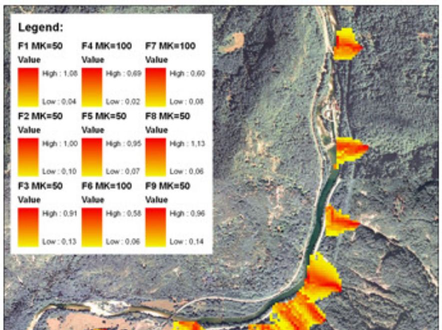


Figure 5: Inundation areas of debris flows on torrential fans. F1, 2, 3,…is fan sequence number, fans follow from top to bottom. MK = mobility coeficient used for simulation. Colour range shows the depth of deposited debris flow material in metres (m). (MK=50 or 100, MCI=50, Magnitude = 5000 m3).

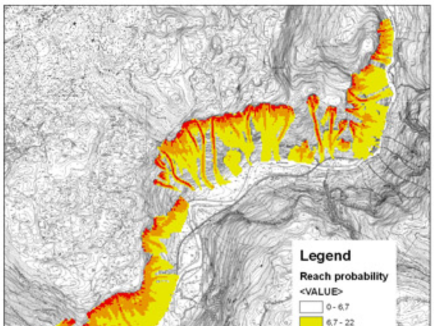


Figure 6: Reach probability of the rock-fall process modelling by RockyFor3D (without forest).

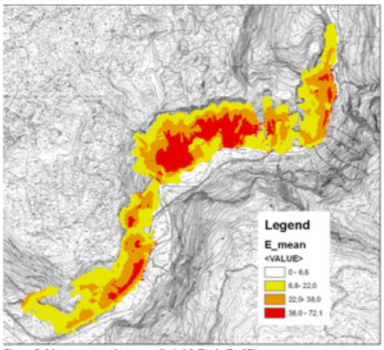


Figure 7: Mean energy values per cells in kJ (RockyFor3D).

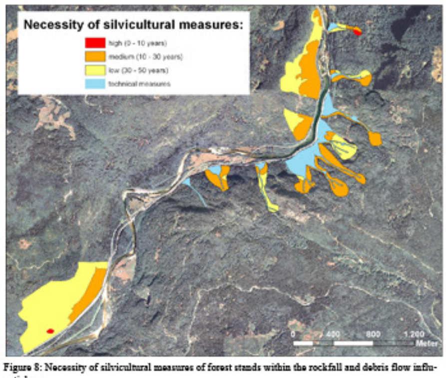


Figure 8: Necessity of silvicultural measures of forest stands within the rockfall and debris flow influential area

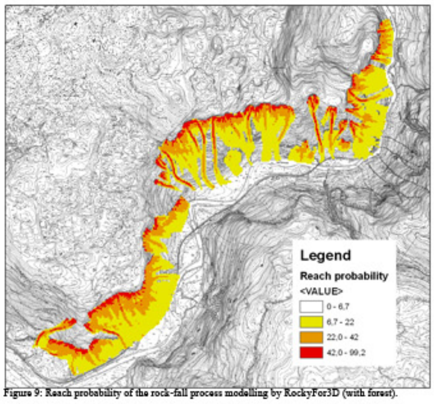


Figure 9: Reach probability of the rock-fall process modelling by RockyFor3D (with forest).

**References:**
Frehner, M. et. al. 2005. Nachhaltigkeit und Erfolgskontrolle im Schutzwald. Bundesamt für Umwelt, Wald und Landschaft, Bern.
Dorren, L. K. A. (www.ecorisq.org, RockyFor3D model)
Scheidl, C. 2009. Prediction of debris-flow mobility and deposition on torrential fans: PhD thesis. Vienna, University of Natural resources and Applied Life Sciences.
http://www.debris-flow.at/ (18. 9. 2011)