Quantitative assessment of the protective effect of mountain forests against rockfalls

Sylvain Dupire*†[1], Frédéric Berger[1], and Thomas Curt[2]

[1]Université Grenoble Alpes, Irstea, UR EMGR – Irstea – 2 rue de la Papeterie-BP 76, F-38402 Saint-Martin-d'Hères, France, France
[2]Irstea, UR RECOVER – Irstea – 13182 Aix-en-Provence, France

Abstract

Mountain forest ecosystems provide a wide range of ecosystem services (ES) essential for human life and activities. In addition to the renewable wood resources they represent, mountain forests constitute a biodiversity reserve and contribute to the environmental and landscape attractiveness. A significant part of mountain forests also protect people and infrastructure against natural hazards such as rockfalls, flash floods, erosion or avalanches. Thus, in France, approximately 20% of the Alpine forests protect the population against rockfalls.

The assessment of this particular ecosystem service is important for an efficient land-use planning and for the safety of mountainous populations. However, it is a difficult task for both rockfall experts and forest managers. Accurate and simple tools are therefore required to efficiently evaluate the rockfall hazard reduction due to the presence of forest on the slope.

These last years, 3D-rockfall models gradually integrated the presence of forest in their simulation processes. For instance, Rockyfor3D simulates the trajectories of single, individually falling rocks, in three dimensions by calculating successive sequences of free flights through the air, rebounds on the slope surface, and impacts against trees. Using this model, rockfall simulations can be run with and without forest on the same slope surface. The comparison of the results from the forested and non forested scenarios allows an objective and quantitative assessment of the rockfall hazard reduction due to the presence of forest. These models are useful when working at local scale. However, it is not possible to use them on a large scale because of the required accuracy of input data and high computational power needed.

In this study, Rockyfor3D was used to simulate rockfalls propagation on virtual terrains for 3886 different forest stands located in all the French Alps. Three quantitative indicators of the rockfall hazard reduction were defined and calculated from the results of the simulations for each forest stand. Finally, the relations between forest characteristics and compositions and rockfall reduction were investigated.

Our results showed that the three indicators are strongly linked with three forest characteristics : the basal area, the mean diameter at breast height and the length of forest in the maximum slope direction. These three parameters were used to define six levels of

*Speaker
†Corresponding author: sylvain.dupire@irstea.fr

protection only based on forest characteristics. Our results demonstrated that forest ecosystems dominated by shade-tolerant tree species presented a higher protective effect than those dominated by pioneer tree species. Finally, forests with the highest tree species biodiversity showed better protective effect than those dominated by only one specie, especially if the latter were a conifer.

Keywords: Ecosystem service, Mountain, Forest, Natural hazard, Rockfall, Modelling, Indicators