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Disturbing mountain forests reduces their protective effect against natural hazards

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Sebald, J., Senf, C., Heiser, M., Scheidl, C., Pflugmacher, D. and Seidl, R. (2019). The effects of forest cover and disturbance on torrential hazards: large-scale evidence from the Eastern Alps. Environmental Research Letters. 14(11): 114032.

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Human settlements exist in many mountainous areas of the world, and related infrastructure is highly exposed to natural hazards such as debris flow and flooding. Mountain forests play a central role in balancing the environment and minimising the risk of such hazards, but this protection is being threatened as canopies are increasingly disturbed (by events both natural, such as beetle outbreaks and trees being uprooted by wind, and anthropogenic, such as forest management). This study sought to quantify the effects of forest cover and disturbance on torrential hazards in the Eastern Alps.

Global economic and human losses from natural hazards have increased by almost 70% in the last 30 years. In the Eastern Alps, torrential hazards such as flooding and landslides caused €877 million of damages between 1972 to 2004 and 49 lives were lost.

During such rainfall-triggered events, material from the mountainside gets relocated to valley bottoms, often damaging roads and houses. Forests stabilise the ground on mountain slopes and buffer surface run-off by absorbing water through soil. However, forests are disturbed by both anthropogenic management practices and natural causes. Due to the growing need to protect mountainous settlements from torrential hazards[1], a new study explored how disturbances impact forests' protective effects.

The researchers combined remote-sensing data on forest cover and canopy disturbance with official records on torrential hazard events in the Eastern Alps in Austria over the last 31 years. These data covered 3 768 torrential hazard events in almost 11 000 watersheds. Four indicators were used to evaluate the role of forests and canopy disturbance on torrential hazards: forest cover, forest patch density, disturbance extent and disturbance type. Geographical and geomorphological features of the watersheds — such as elevation (height), ecoregion (a unit of land or water containing a geographically distinct group of species and environmental conditions) and area covered by urban infrastructure — were included in the

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analysis to control for general predisposition to torrential hazards. Statistical analysis was conducted at the watershed scale, with separate models for the occurrence and frequency of debris flow and flooding.

The analysis found that forest cover was the most important predictor for lowering occurrence probability and frequency of floods and debris flow events — for example, increasing forest cover from the average of 63% to 88% decreased torrential hazard probability by 8.7%. In addition, when the forest was more distributed over an area (i.e. a higher patch density), this reduced the occurrence probability and frequency of torrential hazards. For example, raising the number of patches of forest per square kilometre (km^2) from 6.5 (the average) to 12.5 decreased debris flow probability by 8.2%, and flood probability by 5.7%.

Disturbances that occurred regularly during the study period, such as tree cutting, increased the probability of both flood and debris flow events. Large areas of disturbance increased the probability of debris flow events, with the highest probability found in watersheds that had large forest disturbances on a regular basis. When moving from 10% of the forest regularly disturbed to 50% disturbed during the 31-year period, the annual probability of a debris-flow event occurring increased from 0.18% to 0.6% (+248 %)[2].

The increase in climate change-related extreme weather events raises concern around the risk that torrential hazards pose to human infrastructure in these regions. This case study shows that forests are an important green infrastructure in mountain regions, efficiently protecting humans from natural hazards. However, large-scale ongoing forest disturbance in mountain areas might increase the probability of torrential hazards occurring, and the frequency at which they will do so, bringing potential loss of life and damage to infrastructure.

While the guidelines for protective forest management in the Alps propose frequent, small-scale logging interventions to increase structural diversity, management should avoid interventions as much as possible, to reduce the probability of torrential hazards. The researchers posit that this supports the view that non-interventionist forest management is most able to regulate ecosystem services and protect against natural hazards in mountainous regions. The methodology in this study contributes to our understanding of the protective effect of forests to torrential hazards and could be replicated in further studies to aid policymakers and forest managers.

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1. The European Commission has established a cross-sectoral overview of disaster risks to the EU using the results of national risk assessments — and this incorporates flooding and landslides.

2. This is the relative increase from 0.18% to 0.6% (2.5 fold increase = +248%). In other words, with 10% of the watershed disturbed the annual probability of a watershed experiencing a debris flow event is 0.18 % (or once every 556 years). With 50% of the watershed disturbed, the annual probability is 0.6% (or every 167 years), which corresponds to an increase of 248% (a 100% increase would be 0.36% per year, 200% increase would be 0.54% per year, and a 248% increase would be 0.60% per year).