Submitted Abstract

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Abstract

Natural disturbances are a common part of forest dynamics and may cause structural changes over large areas. They alter the functioning of forest ecosystems and affect the provisioning of ecosystem services, such as protection against natural hazards. We studied forests disturbed by bark beetle and windthrow to assess the advancing in wood decay and tree regeneration, as well as their effect on the protection capacity against snow avalanches in the three decades following disturbance.

Field data on tree regeneration and deadwood were analysed in forests disturbed by windthrow and bark beetle outbreaks. We assessed the potential drivers for the establishment of trees on deadwood and we evaluated the development of the protection capacity over the past thirty years. We used surface roughness as a proxy for protection capacity comprising the coverage of deadwood and tree regeneration. After the bark beetle disturbance, we used remote sensing data to evaluate the changing protective effect of the forest and simulated avalanches in frequent and extreme scenarios at different time steps.

Independently of the disturbance agent, over the course of three decades deadwood decomposed and moved closer to the ground, and trees grew taller and at some locations started to form a dense forest stand. Wood in advanced decay stages became a suitable seedbed for tree regeneration, especially after windthrow, as more decomposed deadwood was found compared to bark beetle-disturbed forests. Thirty years after both types of disturbances, forests showed a more diverse structure, due to secondary tree regeneration on deadwood, and a richer species composition, thanks to the higher share of broadleaves. Disturbed forests maintained sufficient protection capacity, especially in the first years after disturbance, when surface roughness was high. The protection capacity reached its minimum 10-15 years after disturbance.

Based on our analyses, unmanaged disturbed forests have the potential to recover well and are even expected to become more diverse, with higher shares of broadleaves and increased vertical structure thanks to secondary tree regeneration growing on deadwood. Such forests are potentially more resistant and resilient to the future disturbances. The protection capacity is preserved for some time, which in the case of bark beetle is mainly due to long-standing dead trees, while windthrows benefit from high surface roughness created by lying deadwood and root plates. Our results help to prioritise management after natural disturbances and to decide under which conditions the natural post-disturbance development offers sufficient protection against natural hazards.