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Bark beetle in mountain forests in the canton of Grisons: challenges and opportunities

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In the canton of Grisons, approximately 30 % of the total area is forested, providing a wide array of ecosystem functions and services to both the local inhabitants and tourists. However, these mountain forests face growing threats form natural disturbances, notably the European spruce bark beetle (*Ips typographus*). This insect has already caused substantial damage to many spruce forests across Europe. In mountainous regions, rising temperatures accelerate the bark beetle’s development, while increased drought frequency reduces tree defences, making mountain spruce forests more susceptible to infestation. Consequently, this poses risks to their protective role against natural hazards, and other ecosystem functions and services.

Given these circumstances, timely planning and effective implementation of control and adaptation measures are therefore crucial tasks for maintaining the protective role and the ecosystem functions and services. To assist various stakeholders in fulfilling their responsibilities, the development of methods for the early detection of both vulnerable and infested trees is essential to limit the extent of bark beetle outbreaks. However, prompt intervention and removal of infested trees are not always feasible. Therefore, at the same time, it is also important to define intervention strategies for the post-disturbance phase to ensure continuity of functions and services.

By focusing on these challenges, we examined six study sites in the canton of Grisons, Switzerland. We are exploring different methods for early detection of bark beetle damage in mountain spruce forests using a combination of multispectral data, field observations, pheromone traps, and real-time data on new infestations. Additionally, we are examining the impact of bark beetle disturbance and subsequent management strategies on the protective effect of these forests against natural hazards like rockfall and avalanches, as well as the occurrence and diversity of tree-related microhabitats as a proxy for biodiversity.

Our results show that different vegetation indices (e.g., NDVI, EVI, VARI) present characteristic patterns for different tree health categories. Most indices show significant differences between healthy trees and trees in a late stage of infestation. In some cases, also the vegetation index values of trees in an early phase of the attack are different from other health categories. The presence of bark beetle-killed trees reduces the protective effect against rockfall by 2 % on average (range 0 - 24 % depending on disturbance severity), mainly due to the lower energy dissipation ability of dead trees. Salvage logging further impairs this protective effect (-12 % on average, range 0 to - 92 %). A similar pattern is observed for the protective effect against avalanches, with salvage logging reducing the protective effect by 8 % (range 0 - 83 %). In terms of potential biodiversity, retaining bark beetle killed trees leads to a greater abundance of tree-related microhabitats. Disturbed areas exhibit on average almost twice as many microhabitats per study site compared to undisturbed sites, with counts of 82 and 42 microhabitats, respectively. Insect galleries, bark losses and bark pockets are mainly observed within areas affected by bark beetle disturbance.

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Given the likelihood of increased bark beetle disturbances in mountain forests due to global change, we will face new challenges but also opportunities to maintain the protective function of forests. At the same time, these disturbances will also contribute to increased tree-related microhabitat diversity and abundance, thus enhancing the availability of suitable habitats for forest biodiversity. Our results help to understand the impacts of disturbance in these forests, and support the implementation of proactive measures crucial for sustainable forest management and for preserving their essential ecosystem functions and services.