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Development of an operational early warning system to enhance bark beetle risk management – Application of soil water balance models to assess the drought-stress induced disposition of spruce forests to bark beetle infestations

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The warm and dry years of the recent past have once again impressively shown that bark beetle outbreaks are among the most dangerous natural hazards that occur in forests of Central Europe and North America.

The European spruce bark beetle (Ips typographus L.) in particular is one of the most important pests in Central European forests. Induced by the ongoing climate change, it seems to be quite likely that the growing conditions of Norway spruce (Picea abies L.) will deteriorate considerably due to predicted rising temperatures and increasing frequency and intensity of droughts and further extreme weather events. In contrast, the spruce bark beetle is favored by the same trends. As a result, it tends to mass outbreaks and can thereby also infest healthy spruces, causing forests to die off over large areas. Since management resources and warning tools needed for a just-in-time detection of infested trees will remain limited, efficient operational systems are highly desired to enhance and to facilitate bark beetle risk management.

For this reason, we developed the prototype of an operational early warning system to assess the current risk of potentially endangered spruce stands to bark beetle infestations at a high temporal (daily) and spatial (≤ 250-m-grid) resolution.

The system considers the following input layers:

(a) a quasi-static base-risk layer that is calculated from stand and site characteristics;

(b) an annually updated layer determining the bark beetle population density; and

daily-updated layers for increased host tree susceptibility by (c.1) drought stress or (c.2) storm damage and (c.3) the swarming activity of the bark beetle.

From these inputs a daily overall infestation risk plus a 7-day-forcast is calculated and made available online to forest owners and managers in the form of a risk map providing different risk

levels (e.g., low – medium – high).

As one of the main driving factors, the (c.1) drought stress induced disposition of spruce forests to bark beetle infestation is assessed by applying a grid-based soil water balance model at daily resolution. The plausibility of the model is checked via representative soil hydrological measuring areas in the three German project areas Black Forest National Park, Saxon Switzerland National Park, and Hunsrück-Hochwald National Park. At the same time, suitable water scarcity indicators are identified and defined for these threshold values, below or above which an increased susceptibility of spruce trees to bark beetle attack is to be expected. Hence, in connection with daily updated weather forecasts, the water-related disposition of spruce stands to bark beetle infestation can be predicted with reasonable accuracy.

The developed early warning system or implemented sub-systems have the flexibility to be adapted to other bark beetles or further forest pests and can be applied at local, regional and national scales. Furthermore, its functionality can be extended by integrating novel modern approaches, e.g. machine-learning methods or remote sensing technologies.