Submitted Abstract

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Abstract

Long-term monitoring of the development of mountain spruces after large-scale and intensive bark beetle disturbance helps us to clarify the degree of adaptation of these ecosystems to disturbances. Due to the gradual breaking of dead trees, the change in the amount of light in the undergrowth is gradual with the steepest increase was in the third and fourth year after the disturbance. The peak occurred about 10 years after the disturbance. Then the understory light started locally to decline due to recruitment of new trees. Contrary to our expectations, bark beetle disturbances did not change relative proportion of the dominant herbaceous species cover. Rather, there was an increase in the total biomass of herbs. Both spruces and rowans regenerated from individuals that occurred in the undergrowth before disturbance. Only a small proportion of spruce seedling germinated in the year of the disturbance. Both spruce and rowan regeneration have a special adaptation for long-term survival in the shade of undergrowth: adventitious roots formation and root sprouts formation. The mortality of regeneration has remained very low throughout the 15 years of monitoring since disturbance, despite the fact that the numbers of individuals in the clusters are very high (exceeding 50 individuals per 1 m2). High mortality occurred only in one-year and two-year-old seedlings within two years after disturbance. The seed bed plays a minor role in the mortality rate (the most regeneration dies in vegetation and the least on dead wood). Dry years partially increase the probability of mortality in the following year. After 15 years of disturbance, the regeneration structure is heterogeneous both in height and space on several levels (from meters to kilometres). The strongly heterogeneous regeneration pattern mirrors the spatial pattern of the most preferable microhabitats (stumps, dead trees, lying dead wood). The structure of the forest tends to be passed on from generation to generation. Higher regeneration density and smaller diversity in seedling heights occur where there had been a closed canopy forest before. Measurement of the carbon balance in aboveground biomass shows the greatest carbon losses shortly after disturbance, when the fine parts (twigs, bark and foliage) decompose and the activity of wood-decomposing fungi is the fastest. At about 20 years after the disturbance, carbon release slowed and the overall carbon balance turned to higher intake due to rapid growth of regeneration. At the same time carbon stocks have reached about half of pre-disturbance levels.