Submitted Abstract

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Abstract

Disturbances are key drivers of forest ecosystem dynamics. Under natural conditions, abiotic disturbance agents like wind, fire and avalanches, as well as biotic agents like insects, are the main causes for stand-replacing disturbances in temperate mountain forests. However, for large parts of temperate forests worldwide, the patterns of natural disturbance regimes are unknown, due to direct and indirect human influence over centuries to millennia and/or a lack of (spatially explicit) data in areas less impacted by humans – such as mountain regions. We aim to close this gap for the European Alps by quantifying the natural forest disturbance regimes of Alpine mountain forests, focusing on the distribution of patch sizes (i.e., the size of canopy gaps created by stand-replacing disturbances).

We make use of the Alparc network to identify 12 strictly protected forest landscapes (IUCN-category I or II and forest cover > 4 km^2) distributed across the entire European Alps (Austria, France, Germany, Italy, Lichtenstein, Slovenia and Switzerland), with good representation of the prevailing ecological and climatic gradients. For each landscape, we derive the size of disturbance patches using satellite-based disturbance maps covering the timespan 1986 to 2020 at annual resolution. The maps depict all stand replacing disturbance patches at a spatial grain of 30 x 30 m. Focusing on the no-intervention zones of the protected areas allows us to exclude direct human impact on disturbance regimes, and thus to study the disturbance patch size distributions under natural conditions. We apply a Bayesian approach to derive the underlying distribution functions for the patch sizes of a) all observed patches and b) annual extreme events.

We show that, comparing a set of distribution functions, patch sizes in the Alps (median 0.36 ha, 10.6% > 1 ha) follow a Fréchet distribution, capable to characterize positive skewed data with heavy tails. For all observed patches, explicitly modelling mean and dispersion parameters improved model performance, whereas the inclusion of environment parameters did not. Contrastingly, environmental parameters did influence extreme events significantly. This indicates high stochasticity in realized overall patch sizes, and the importance of environmental drivers for the occurrence of extreme events.

Disturbance regimes and resulting patch sizes shape the physical template for future regeneration dynamics. Our results allow the mapping of return intervals of extreme events across the European Alps. Comparing natural and observed patch size distributions further allows for informing about naturalness of disturbance regimes outside protected areas and reveals chances and challenges for nature conservation.