Five pine defoliating insect species in Central Europe: evidence of climate driven changes in severity and frequency of outbreaks

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Predictions of changes in the severity and frequency of outbreaks of forest insect pests due to climate change emphasize a need to examine the responses of multiple pest species to the climate changes observed to date. Here, we examine a 212-year record (1800-2011) of outbreaks of five pine defoliating insect species (*Bupalus piniarius*, *Panolis flammea*, *Lymantria monacha*, *Dendrolimus pini*, and *Diprion pini*) in Northern Bavaria for evidence of climate driven changes in the severity, cyclicity, and frequency of outbreaks. Statistical analysis of relationships between climatic conditions (15-yr running means of temperature and precipitation) and mean outbreak severity suggested that three of the defoliator species (*B. piniarius*, *P. flammea*, and *Dendrolimus pini*) exhibited reduced outbreak severity in response to unusually warm summer temperatures. Warming may have contributed to the cessation of *Dendrolimus pini* outbreaks in Northern Bavaria since the 1930s. We found only one positive relationship between temperature and outbreak severity, which involved increased severity of *P. flammea* outbreaks associated with periods of unusually warm fall temperatures. The effects of precipitation on outbreak severity were less consistent, varying according to the season the precipitation occurred and defoliator species. There were no consistent long-term trends in the cyclicity of outbreaks, but outbreak frequency generally increased over time in two of the species (*B. piniarius* and *P. flammea*). Our findings suggest that continued warming, particularly in spring and summer months, may cause an overall reduction in defoliation by historically damaging pine defoliators while paradoxically increasing the frequency of outbreaks in some of these species.

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