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Risk of fruit production failure caused by the interaction of phenology changes and extremes events occurrence detected with a process-based model

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Many perennial species, such as trees, show large variations of fruit production between years (the so-called masting) which can have major consequences on forest dynamic and species interactions. Among other drivers of fruit production failure, years of reduced fruit production can be due to the increase of temperature and the resulting advance in vegetative and reproductive phenology and timing of extreme events, such as drought or late frost. Indeed, flowers may fail to complete their maturation due to a 'veto' effect, i.e. variation of climatic conditions, promoting pollen limitation, fruit abscission, or more generally inducing reproductive failure. This veto effect may alter reproductive cycle which in turn impacts forest ecosystem functioning. Our hypothesis is that interactions between shifts in phenology and "veto" effects have major consequences on reproductive tree cycle at species range scale, considering the increasing number of extreme climatic events associated to ongoing and predicted climate change. To investigate this hypothesis, we used a process-based model (CASTANEA) previously calibrated and validated on European beech, a major European temperate tree. The model simulates stocks and fluxes between forest and atmosphere, from physiological characteristics of tree species. We simulated fruit production across Europe with a scenario accounting for veto (frost or drought) and a scenario without veto in order to detect the species margins associated to reproduction failure for that species. The detailed comparison of the two scenarios allowed us to assess when and where the different "vetos" explain the reproductive failure and how they interact with phenology changes. This study highlight how extreme climatic events can disrupt phenology of reproduction and thus change species distribution.