Predicting the adaptive dynamics of tree populations under climate change: lessons from a Physio-Demo-Genetic simulation model

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Abstract

Impacts of climate change (CC) on forests are expected to be acute, with irreversible effects on ecosystem functioning if tree populations collapse (tipping point). Adaptive potential could nonetheless be high in trees: besides tracking their ecological niche spatially through migration, they could adapt in the short-term through individual plasticity, or/and in the long term through evolutionary response. However, observed and predicted rates of CC raise the issue of how quickly tree species can adapt. Moreover, predictions and management guidelines are needed at the scale of a few generations, which requires accounting for several adaptive processes and their interactions when environment or demography are unstable. Our study investigated the adaptive dynamics under CC of *Fagus sylvatica* and *Abies alba* along an altitudinal gradient at the southern margin of their distribution. We used a mechanistic, individual-based simulation model, named PDG, which couples: (M1) a physiological module simulating tree functions and structure in response to environmental variations, (M2) a demographic module converting reserves into seed production and mortality and modelling dispersal and (M3) a quantitative genetics module relating genotype to phenotype, and simulating gene pool evolution across generations. The vulnerability of each species (risk of mortality and reproduction failure) along the gradient was first characterised under current and future climates through simulations accounting only for physiological plasticity across tree lifetime. Then, the contribution of genetic adaptation to population dynamics over five generations was investigated using the full model, and considering two evolvable functional traits: the timing of budburst and water use efficiency.

Keywords: forest, adaptation

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