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Theoretical models dealing with local adaptation generally use individual fitness as a parameter driving the process of adaptation. This parameter is either directly determined by the genotype, or indirectly derived from life history traits linked to the genotype. Despite benefits of such assumptions and valuable theoretical concepts that emerged, evolutionary drivers must be partitioned into genotype-phenotype-demography maps to account for complex interactions among genes or traits regarding selection when environment or demography is unstable. In such demo-genetic models, individual fitness is determined dynamically from demographic processes and environment quality, which can vary in space or in time. Trees can be considered model organisms for testing such a theoretical framework, because tree populations usually experience high spatial and temporal heterogeneity due to high longevity, size and dispersal abilities. In order to study short-term evolution in a non-equilibrium population, we used a demo-genetic model on the CAPSIS platform to model Atlas cedar (*Cedrus atlantica* (Endl.) G. Manetti ex Carrière) colonization in south-east France over three generations. We studied interactions between gene flow and environmental spatial heterogeneity during the colonization process by simulating evolutionary trajectories over three generations in two different landscapes (random or gradient variation of a site index) and under high and low levels of seed and pollen dispersal. Three generations were enough for natural selection to lead to genetic and phenotypic differentiation among micro-environments. The positive effect of low gene flow on the maintenance of diversity was more pronounced under the random environment than under gradient variation due to greater differences among sites. Gene flow interacted with spatial pattern of environmental heterogeneity. The divergence between differentiation patterns observed on neutral markers, QTL or adaptive traits increased when environmental conditions were spatially aggregated, more so when seed and pollen flow were low. Thus, selection is more intense along a gradient than in a random environment. Heritability and evolvability decreased differently across generations. Heritability decreases continuously whatever the gene flow or the type of environment, while evolvability decreased continuously when gene flow was low but declined strongly at first and stabilized after the first generation when gene flow was high.

Keywords: *Cedrus atlantica*, demography, genotype, model, phenotype