Planting long-lived trees in a warming climate: theory shows the importance of stage-dependent climatic tolerance

Adèle Erlichman*[1], Linnea Sandell[2], Sarah P. Otto[3], Sally Aitken[4], and Ophélie Ronce[5]

[1]Institut des Sciences de l'Evolution de Montpellier – Centre National de la Recherche Scientifique, Université de Montpellier – France

[2]Department of Urban and Rural Development, Swedish University of Agriculture – Suède

[3]Department of Zoology, University of British Columbia, Vancouver, British Columbia – Canada

[4]Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, British Columbia – Canada

[5]Institut des Sciences de l'Evolution de Montpellier – Centre National de la Recherche Scientifique – France

Résumé

Climate change poses a particular threat to long-lived trees, which may not adapt or migrate fast enough to keep up with rising temperatures. Assisted gene flow could facilitate adaptation of populations to future climates by using managed translocation of seeds from a warmer location (provenance) within the current range of a species. Finding the provenance that will perform best in terms of survival or growth is complicated by a trade-off. Because trees face a rapidly changing climate during their long lives, the alleles that confer optimal performance may vary across their lifespan. For instance, trees from warmer provenances could be well-adapted as adults but suffer from colder temperatures while juvenile. We use a stage-structured model, using both analytical predictions and numerical simulations, to determine which provenance would maximize the survival of a cohort of long-lived trees in a changing climate. We parameterize our simulations using empirically estimated demographic transition matrices for twenty long-lived tree species. Unable to find reliable quantitative estimates of how climatic tolerance changes across stages in these same species, we vary this parameter to study its effect. Both our mathematical model and simulations predict that the best provenance depends strongly on how fast the climate changes and also how climatic tolerance varies across the life span of a tree. We thus call for increased empirical efforts to measure how climate tolerance changes over life in long-lived species, as our model suggests that it should strongly influence the best provenance for assisted gene flow.

Mots-Clés: Assisted gene flow, Climate change, Local adaptation, Forestry, Complex life cycles, seed sourcing

*Intervenant