Provenience and species specific differences in sapling resilience to frost and ungulate browsing enhance regeneration problems in mountain forests

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Résumé

Local climate and ungulate browsing are two major factors that affect tree regeneration and genetic adaptation in Central European forests. Owing to climate change and increasing ungulate numbers, the abiotic and biotic environments of trees are changing, making it necessary to investigate the separate and joint effects of provenance origin (and climate) and ungulate herbivory. The aim of this study was to analyse the influence of intraspecific genetic variation on the sensitivity and resilience of tree species to stress due to frost and simulated winter browsing.
In an genecological experiment, we investigated quantitative genetic variation within and among provenances of *Abies alba, Picea abies*, and *Fagus sylvatica*. Each species was represented by 72 - 90 autochthonous provenances, covering the species' ecological range in Switzerland. In spring 2015, the ca. 4000 saplings per species were clipped with three intensities (heavy, light and no clipping) to simulate winter browsing by roe and red deer. Growth reactions were assessed one and two growing seasons after treatment, and provenance differences were related to environmental variables of seed sources.

For *Abies*, frost damage and clipping resulted in reduced height growth in the first year after the stress and reduced height for at least two (clipping) to four (frost) vegetation seasons. Sapling biomass and diameter increment decreased after heavy clipping. For *Picea* and *Fagus,* the effect of this single simulated browsing event disappeared over time for the growth traits. Reduced growth only persisted for *Picea* saplings after frost damage. However, sapling quality decreased after clipping for all three species.
The 'reaction type' after browsing seems to be species specific but independent of seed origin. In contrast, the time lag between simulated browsing and formation of a clear new leader shoot increased for *Abies* with lower temperatures at the seed source. Differences in sapling resilience to stress enhanced the existing differences among provenances. Lowland provenances with warmer climates grew faster, and in *Picea* also qualitatively better, and recovered faster (*Abies*) or more efficiently (*Picea*) to leader shoot loss. Thus, there is no clear evidence of a tradeoff between adaptation to climate change and resilience to stress.

Mots-Clés: climate change, common garden, evolutionary adaptation, herbivory, provenance test, tree regeneration, ungulate browsing

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