

# Regeneration pathway shapes nutrient stocks and litter accumulation under newly established silver fir stands in secondary Norway spruce monocultures: a stand-level comparison

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Silver fir (*Abies alba* Mill.) has experienced a substantial decline across Europe over the past century, largely driven by anthropogenic influence. At the same time, Norway spruce (*Picea abies* (L.) H.Karst.) has become the dominant tree species in many Central European forests, often occurring outside its natural ecological range where it is increasingly vulnerable to disturbance under ongoing climate change. Reintroducing silver fir into these secondary spruce monocultures could serve as a promising strategy to enhance their stability. However, the success of fir establishment may strongly depend on the regeneration pathway. As a highly shade-tolerant species, silver fir often benefits from sheltered establishment conditions, such as underplanting beneath an existing canopy. In addition to providing favorable light conditions for regeneration, canopy cover may also maintain more stable soil conditions and thereby reduce rapid decomposition of organic matter and associated nutrient losses from the forest floor. Therefore, the aim of the present study was to compare litter accumulation and nutrient stocks in the mineral soil under young silver fir stands established under similar climatic conditions using two contrasting regeneration pathways: underplanting beneath a spruce canopy and artificial regeneration in a small-scale clear-cut.

The results revealed clear differences between regeneration pathways in both litter accumulation and nutrient stocks. The underplanted stand exhibited substantially greater accumulation in the organic horizons compared to the stand regenerated in a clear-cut, indicating enhanced organic matter retention under continuous soil cover. In addition, significantly higher stocks of base cations were observed in the mineral soil under the underplanted stand. Calcium stocks in the 0–10 cm mineral soil layer reached 332 kg ha<sup>-1</sup> under underplanting compared to 147 kg ha<sup>-1</sup> in the clear-cut stand. Similar patterns were observed for magnesium and potassium, with consistently higher values under the underplanted stand. Differences between regeneration pathways were most pronounced in the upper mineral soil layer, suggesting that canopy-protected regeneration enhances organic matter accumulation and nutrient retention during the early stages of stand development.

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