EGU26-17632, updated on 18 Nov 2026
https://doi.org/10.5194/egusphere-egu26-17632
EGU General Assembly 2026
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Carbon sequestration potential of high-altitude afforestations in the Eastern Alps

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Changes in alpine land management have led to the abandonment of high-altitude pastures in the European Alps. At the same time, climate warming facilitates upward forest expansion, creating opportunities for carbon (C) sequestration by afforestation. However, the magnitude of this potential remains uncertain, as soil C responses and forest growth at high elevations are still poorly understood.

We quantified biomass and soil C stocks in forest stands planted on subalpine pastures (1,600–2,100 m a.s.l.) in the Austrian Alps and compared them with adjacent pastures. In addition, we assessed vascular plant diversity and analysed timberline dynamics surrounding the afforestation sites.

Afforested plots stored 121 ± 49 Mg C ha□¹ more organic C than pastures, corresponding to a sequestration potential of 441 ± 179 Mg CO□ ha□¹ within ~55 years after planting. Carbon sequestration occurred predominantly in tree biomass, which grew remarkably well despite the high-elevation conditions, while soil C stocks remained largely unchanged. Vascular plant diversity declined significantly under closed forest canopies, although higher diversity in nearby mature forests indicates partial recovery at later stand stages. Despite regional warming, the upper forest boundary remained largely stable over the past two decades.

Our results suggest that afforestation can accelerate forest establishment around the current upper forest edges and create local carbon sinks, while biodiversity impacts are mixed and strongly context-dependent.