

Submitted Abstract

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First Author First Name Last Name	Alessandra (1,2) Bottero
Submitting Author First Name Last Name	Alessandra Bottero
Correspondence	alessandra.bottero@wsl.ch
Co-Authors >> E-Mails will be not listed	Frei, Esther R. (1,2,3); Krumm, Frank (1,2,3); Bebi, Peter (1,2)
Organisations	1: WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland 2: Climate Change, Extremes and Natural Hazards in Alpine Regions Research Centre CERC, Davos, Switzerland 3: Swiss Federal Institute for Forest Snow and Landscape Research WSL, Birmensdorf, Switzerland
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Abstract

Snow avalanches are a common disturbance in mountain forests in the Alps. The catastrophic avalanche winter of 1950/51, the so called “Winter of Terror”, damaged 2100 hectares of protective forests in Switzerland. This dramatic series of events raised questions and discussions about causes and possible measures to prevent such damages in the future.

The high elevation afforestation experiment “Stillberg” was initiated near Davos in the Swiss Alps to investigate methods to replace avalanche-damaged forests at the treeline, supporting the development of ecologically and technically sustainable measures to reduce avalanche risk. In 1975, 92'000 seedlings of *Larix decidua*, *Pinus mugo* ssp. *uncinata*, and *Pinus cembra* were planted following a gridded planting scheme along an altitudinal gradient at and above the current treeline (2075 to 2230 m a.s.l.). Trees were planted in >4000 square plots, with 25 trees in each plot placed into the original dwarf shrub community at 70 cm planting spacing. The research area also features a climate station and 400 snow stakes for the optical measurement of snow depths.

Here, we focus on the main factors driving tree regeneration, mortality and growth based on measurements and studies conducted over more than forty years of monitoring. All regeneration individuals were visited regularly from 1975 to 1995 to assess growth, health status and mortality, with further assessments in 2005 and 2015. The height of the surviving trees was recorded every 10 years. Additionally, microsite features (e.g. elevation, solar radiation, snowmelt date) were recorded for each plot.

Snowmelt date was the most important environmental factor influencing mortality of all tree species, while growth was strongly correlated with elevation during the first 30 years of the afforestation. Mortality rates were highest during the first 15 years post-establishment. Primary agents of mortality among *P. cembra* saplings were the pathogenic snow fungi *Gremmeniella abietina* and *Phacidium infestans*, which occurred mainly on plots with late spring snowmelt. The relative importance of different environmental variables for tree seedlings and saplings changed during the regeneration phase, and led to a forest dominated by *L. decidua* with participation of *P. mugo* and *P. cembra*.

Today, almost 50 years after the establishment of the Stillberg long-term research area, new questions arise about competition and facilitation processes occurring between trees at and above the treeline, and suitable management strategies to adapt high elevation forests to future climatic and environmental conditions without compromising the multiple ecosystem services they provide.