



## **One century of forest monitoring data in Switzerland reveals species- and site-specific trends of climate-induced tree mortality**

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Climate-induced tree mortality became a global phenomenon during the last century and it is expected to increase in many regions in the future along with climatic changes. Our current understanding of forest mortality trends is limited by a rather short time span of studies, small number of species and/or narrow geographical ranges. Yet, to quantify trends in mortality, in particular a long-term perspective is needed. Here, we present a unique data set of monitoring records from 127 unmanaged forest stands across Switzerland, which include five common European tree species (Norway spruce, Scots pine, silver fir, European beech, and sessile and common oak) and cover a time span of over one century (1898-2013), with inventory periods of 5 to 10 years.

Species-specific annual mortality rates did not consistently increase in Swiss forests over the entire study period. One exception however was found for pine forests at lower altitudes, which experienced very dry conditions during the recent decades and showed a significant increase of mortality since the 1960s. In addition, temporal trends of mortality varied depending on the size class of the trees, with large trees undergoing an increase in mortality, while mortality of small trees tended to decrease. These trends suggest an ageing effect, but might also potentially point to different size-dependent drought susceptibility.

Mortality rates were strongly affected by stand parameters (stand basal area and stand age), while climatic changes (minimum site water balance, temperature) had species- and site-specific effects. For instance, beech and oak, growing mainly on soils with a good water holding capacity, seemed not yet to be significantly affected by the overall increasing drought conditions. In contrast, pine trees known as rather drought-tolerant and growing on dry sites were severely impacted recent by drought events. Our results further indicate that the impact of drought and/or temperature on tree mortality increased with competition (i.e. higher stand basal area).

In summary, the impact of drought and increasing temperatures on mortality rates in Swiss forests was the likely result of a combination of species and site-specific effects, further modulated by competition and stand age. The long-term data here presented highlight the complexity of forest dynamical processes, including gradual changes of the forest structure, demography and species composition, which in combination with climate may drive mortality rates in temperate forests.