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The impact of climate change on Scots pine and oak forests in dry inner-alpine valleys of Switzerland

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Temperature in Switzerland has risen by 1.6°C over the last 100 years. While 20th century temperature rise had been mainly during winter months, summer temperature has risen at a fast rate over the last three decades. The current warming has its strongest effects in the dry inner-alpine valley of the Rhone river, were mean annual precipitation is around 600 mm and summer drought and heat occurs frequently. Here, Scots pine (Pinus sylvestris L.) forests are declining, while pubescent oak (Quercus pubescens Willd.), is increasing in numbers. Can this observed change in forest condition be related to the climate change? Since 1999 intensive research began to study the phenomenon

We analyze data from large-scale inventory data, long-term monitoring plots, present results various experiments und use models to predict changes in forest composition under climate change scenarios. We compared proportion of alive trees, mortality and removal rates of Scots pines and pubescent oaks on a systematically spaced 1x1 km grid assessed in 1983/85 and in 2002/2003 of 201 plots. We also assessed regeneration on these plots in 2002/2003. For a long-term monitoring plots we compared recorded annual mortality rates with climatic data and computed drought indices. We use data from felling experiments to study the effect of climate and insect infestation. We compared growth, mortality and foliage development in irrigated and control plots. We compared and analyzed long-term tree thinning trails for effects of stand density and competition on mortality and tree growth. We used a process based forest model to predict how projected increases in temperature and decreases in precipitation will further influence the composition and structure of forest in the region over the next 100 years. Using our model we focus on the relative effect that drought dependent decreases in growth, increases in mortality, and changes in fire regimes will have on pine and oak populations.

We found that pine mortality was highest on driest sites. Pine mortality was more than twice as high than oak mortality. Regeneration on the other hand was higher for oak than for pines and occurred on dry sites than pine regeneration. At the long-term monitoring site we found a high correlation between summer drought and pine mortality over the following year. Oaks did not die. Foliage amount was reduced following dry years in pines and deciduous trees. Beetle infested mainly trees of poor health and infestation was highest following dry and warm summers. Irrigation, on the other hand, reduced pine mortality to less than half, tripled pine growth and increased needle mass. Pine mortality and growth in the thinning study highly depended on stand density. Soil moisture was inversely related to stand density. In heavily thinned stands mortality was reduced to levels similar to wet sites in Switzerland, while the control stands had four time higher mortality rates. Maximum pine stand density declined over the last 20 years.

Our modeling work suggests that pine abundance will continue to decrease over the next 100 years. In contrast, Oak abundance is predicted to be less negatively affected by climate change initially, but that it too will diminish during the latter part of the century. The detrimental effects of drought on both pine and oak is predicted to be most pronounced at lower elevations, while at higher elevations climatic changes will increase the competitive ability of these species.

In conclusion observation and experimental data show that the currently observed decline in Scots pine forests in the Swiss Rhone valley is linked to drought and reduced water supply. Increasing temperatures in the last three decades have increased evaporative demands of trees. Oak supported dry years better. Modeling data suggest a further decline of pine forests at dry sites under the predicted climate change, which will eventually also diminish oak forests at low altitudes.

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