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Impact of forest cover on increases in temperature under the canopy

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Many physical and biological natural systems are changing their seasonal timing due to increases in temperature. Our observations of open-site and below-canopy climatic conditions from 14 sites in Switzerland based on LWF data (Long-term Forest Ecosystem Research) show that there is an important impact of forest cover on temperature under the canopy. This impact strongly differs between daily minimum and maximum temperature, and also depends on season, altitude or forest types.

Our results show that the general moderating effect of canopy on below-canopy microclimate was strongest during the growing season, particularly in summer, and depended in a complex way on the general weather situation. It was often strongest during extraordinary warm and dry periods, thus creating relatively stable conditions for plants and regenerating trees under the canopy.

The Swiss LWF sites represent different regions, orientations and elevations, from the Jura Mountains to the southern side of the Alps, composed of deciduous, coniferous and mixed forests. Meteorological measurements were carried out under the canopy at the observation plots, and in open areas outside the forest plots. We compared air temperature differences between open-site and below-canopy, relating them to air humidity and other meteorological parameters as well as to site specific conditions.

Our results illustrate the moderating effects of different forest ecosystems on temperatures. They show that the cooling impact of the forest on daily maximum temperatures is predominantly determined by the forest composition and by the dominant tree species, i.e. factors strongly linked to the degree of canopy closure, causing greater differences during warmer periods. For daily minimum temperatures (warmer temperatures under the canopy), the differences were greater in conifer forests, the determining factor appearing to be linked more to slope orientation.

The most efficient ecosystems for providing a cool shelter during heat waves appear to be beech, beech–silver fir and silver fir-spruce forests. The opposite effect was seen in pine forests, with warmer temperatures under the canopy compared to open-site. The differences can partially be explained by the horizontally oriented needles and leaves of shade-tolerant beech and fir allowing little light to reach the ground versus the needles of light-demanding pine species growing in all directions and allowing more light to penetrate.

The moderating effect of canopy on below-canopy microclimate also depends in an often complex way on the contemporary and antecedent water balance. While the moderating effect was usually strongest when conditions were most challenging for plant growth with respect to water availability, high-altitude and pine forests showed no or a much smaller moderating effect, which may render the understorey vegetation most sensitive to climate change.