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Forest thinning effects on tree growth, survival and water use efficiency

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Water deficit is the main factor limiting survival, growth, and productivity of trees worldwide. In Mediterranean areas with limited water availability, an accurate knowledge of tree growth and intrinsic water-use efficiency (iWUE) in response to drought under different managements could contribute to improving the stability and sustainability of forest resources. We selected two stands of Aleppo pine (*Pinus halepensis* Mill.) and used dendrochronology and stable isotope (δ^{13}C, δ^{18}O) analyses to understand the growth and physiological responses of high-density pine forests to two different management treatments (Control and 60% removal of basal area) intensity in two climatically different sites. The main objectives were: (1) assess the radial growth and iWUE responses to different thinning intensities; and (2) analyze the mid-term and long-term effectiveness of thinning on three resilience indices (resistance, capacity to maintain growth level during drought; recovery, growth increase after drought; resilience, ability to recover pre-drought growth levels). These resilience indices were calculated on basal-area increment (BAI) data for selected drought episodes during the period 1961-2017. Thinning increased growth resistance, resilience and recovery for drought events after thinning in both sites. Differences between control and thinning treatments were found in growth and intrinsic water-use efficiency (iWUE). Thinning increased BAI and reduced iWUE, suggesting a more conservative water use strategy in unthinned than in thinned stands. Our findings show that the influence of tree density on tree growth should be considered when implanting management strategies for drought-prone environments to promote the long-term sustainability of semi-arid conifers under likely effects of climate change.