Functional trajectories and current impairments of trees in the case of a long term decline: the study of beech in Fontainebleau forest.

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Abstract

In a context of long-term decline caused by droughts, we investigated the past and current functional differences between healthy (H) and declining (D) mature beech (Fagus sylvatica) trees. Using a retrospective approach based on tree rings, we studied several functional traits including ring width and microdensity profiles for the period 1942-2010, as well as stable carbon isotopes (δ13C) and related iWUE (intrinsic water use efficiency). Moreover, some carbon, nitrogen, and hydraulic functions were seasonally studied over two recent years. We found a cascade of responses to drought events leading to final decline, all of them occurring before visual symptom apparition (end of 90's) except the δ13C which started to differ between H and D trees at the same time as the crown defoliation was observed. The earliest warnings were found at the end of 50's regarding the change of intra-population variability between H and D trees. On the contrary, increased autocorrelation indicating the closeness of a tipping point only occurred in the last two decades for all variables. Currently, declining trees were characterized by growth clearly lower than that of healthy trees but there is no indication of carbon starvation, nitrogen deficiency, or hydraulic failure. However, stronger reserve seasonal dynamics for declining trees seems to indicate a compensatory mechanism

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to cope with the inter-annual climate variation. Declining trees exhibited surprisingly a higher proportion of the xylem parenchyma with larger rays. This study highlights the complex dynamics of functional shifts occurring during a long-term decline and reveals some unexpected structural differences.

Keywords: tree, decline, ring, microdensity, d13C, growth, reserve, parenchyma rays