Context — In mixed forest ecosystems, interactions among tree species influence ecosystem productivity and functioning, but environmental conditions also play an important role in shaping relationships between species diversity and ecosystem functioning. In the context of environmental changes, the carbon and water balance in pure vs. mixed forest stands may thus be differentially influenced by changing soil water availability.

Objectives — In this study, we analyzed the growth and functional response of Abies alba trees growing in the Vosges region to species competition for water and nutrient resources during extreme drought events.

Approach — We analyzed the response of radial growth and the water use efficiency (using carbon isotope composition, δ¹³C, ‰) in tree rings of Abies alba during two drought events (the severe drought of 1976 and the less intense but long-lasting drought episode of 1989-1991). We used wood cores previously collected in the framework of a previous study from 86 stands regularly distributed in the Vosges mountains over three altitude ranges (from 330 to 1100 m), three humus forms (moder to mull), and three species mixture types (pure stands of A. alba (Aa), mixed stands of A. alba with Fagus sylvatica (Aa-Fs), mixed stands of A. alba with Picea abies (Aa- Pa)).
Key results —

- Indices of resistance and resilience to 1976 and 1989 droughts calculated from the tree rings show better resilience for pure stands, as well as less resistance in stands where fir is mixed with spruce (Figure 1).

![Figure 1: Resilience and resistance to 1976 and 1989 drought events for each stand type calculated from tree rings width.](image1)

- As expected, severe droughts generate increased WUEi (Figure 2).

![Figure 2: Interannual variations in WUE (calculated from δ^{13}C) in each stand type. Vertical bars represent standard errors of the mean.](image2)

- Interannual variations in WUEi were similar whatever stand types (Figure 2).
- While WUEi appeared very similar between populations for the period 1975-1978, firs growing in pure stands tend to express higher WUEi than those growing with spruce and lower values than those with beech in the 1988-1993 period (Figure 2; however, differences are significant for the year 1989 only).
- Radial growth was not related with WUEi; however, a positive relationship (and identical for the three stands) was observed between WUEi and resistance to drought in 1989.
- Results were similar regardless of altitude and soil type.
Main conclusions including key points of discussion — During extreme drought episodes, growth of fir seemed penalized by the presence of interspecific competitors, mainly by spruce. The differences are subtle between WUEi of firs growing in pure stands and in mixture. A trend yet still exists towards slightly higher water use efficiency for pine growing with beech and somewhat lower with those growing with spruces. This suggests that the presence of competitors with a different identity (= different functional characteristics) differently influences the availability of water for fir trees.

Future perspectives — Fir stands were distributed across the Vosges Mountains. Although the 1976 and 1989-1991 droughts had wide geographical impact, intensity of water deficit may have varied widely from site to site. In order to take into account this spatial variability in the analysis of drought resistance, a calculation of spatial variation in water deficit is in progress using models developed in LERFoB. The effects discussed here will then be analyzed by taking into account this new variable.

Valorisation —

One journal article is in progress for *Forest Ecology and Management.*