

## Drought as a factor in forest health in Denmark

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Since 1989 forest health monitoring have been carried out in Denmark. The main tree species are Norway spruce (*Picea abies*), beech (*Fagus sylvatica*) and oak (*Quercus robur* / *petraea*). For these three species summer drought can be seen to influence the health of forest stands (fig. 1). However, the effect is often more pronounced when biotic factors occur at the same time, mainly insect attacks, as exemplified by oak (fig. 2-5). The importance of drought in forest health only becomes apparent when a long time series of monitoring is available.

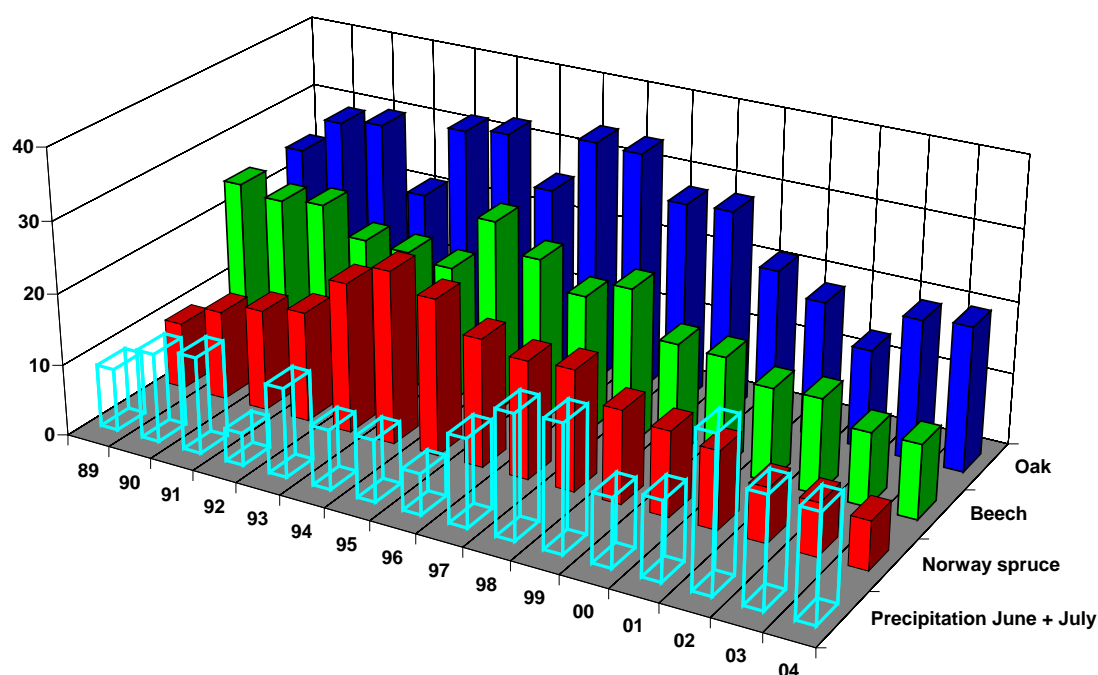


Figure 1 Development in percent average defoliation for the three main tree species on Level 1 and national plots in Denmark. Years with low summer precipitation were common in the 1990's (92, 94-96), and the highest defoliation scores were seen in the middle of that decade. The summer drought and heat wave of 2003 was not so severe in Denmark, so impact on forest health was low.

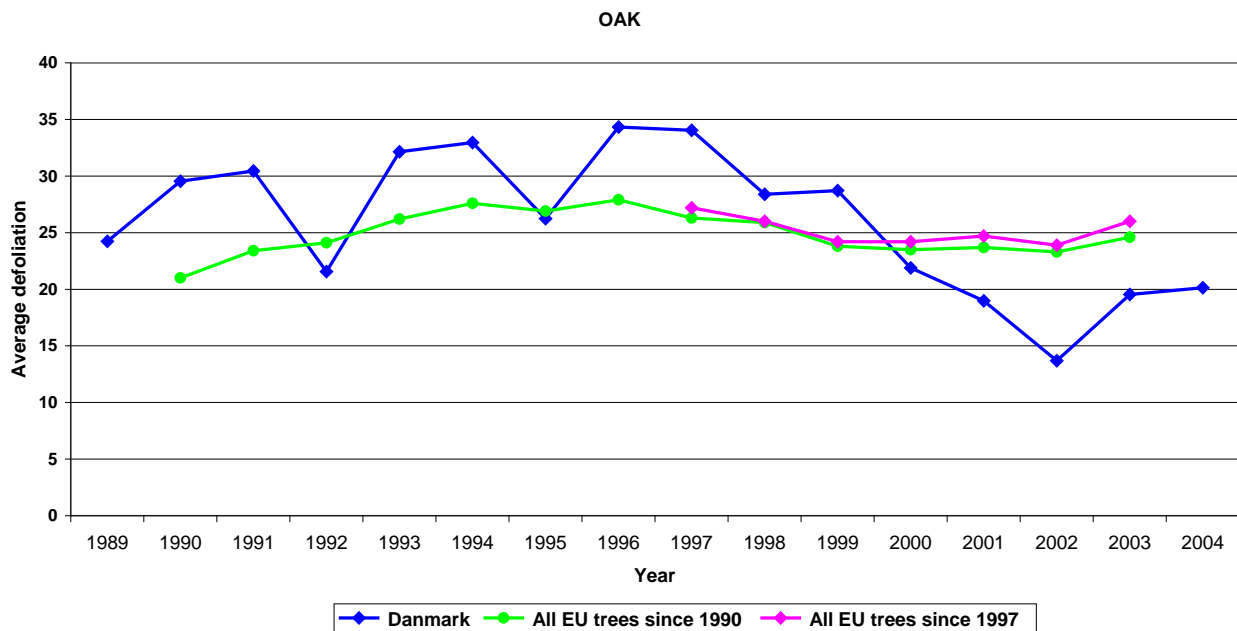


Figure 2 Development in average defoliation in oak for Level 1 and national plots in Denmark compared to European time series. In the 1990's defoliation was higher in Denmark but fluctuated strongly. Since 1999 oak health has improved considerably. In 1992 there was a severe summer drought, and many oak trees shed twigs in late summer. As this happened after the monitoring period, the impact of the drought became visible in 1993.

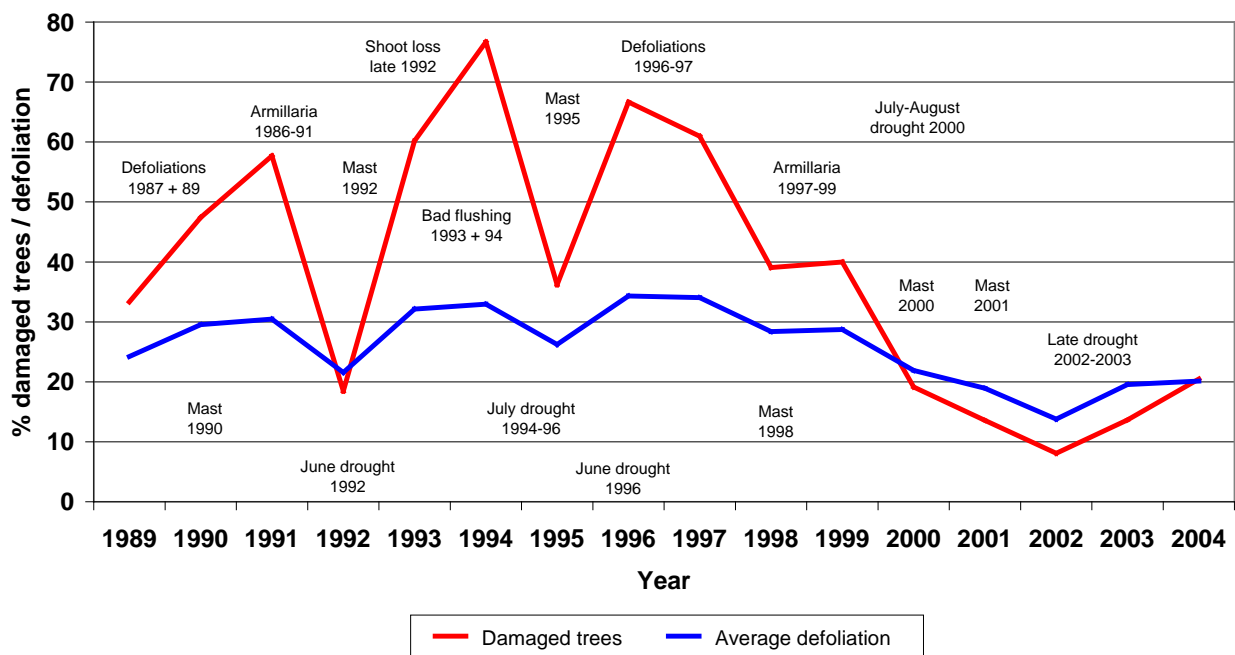


Figure 3 Development in average defoliation and percent damage trees (defoliation class 2-4) in oak for Level 1 plots in Denmark. The fluctuations in health become even more pronounced, and in the worst year (1994) more than 75 % of the monitored oak trees were damaged. Various events are thought to have influenced oak health over the years; mainly defoliation by caterpillars, drought, attacks by honey fungus (*Armillaria* sp.) and perhaps mast production.

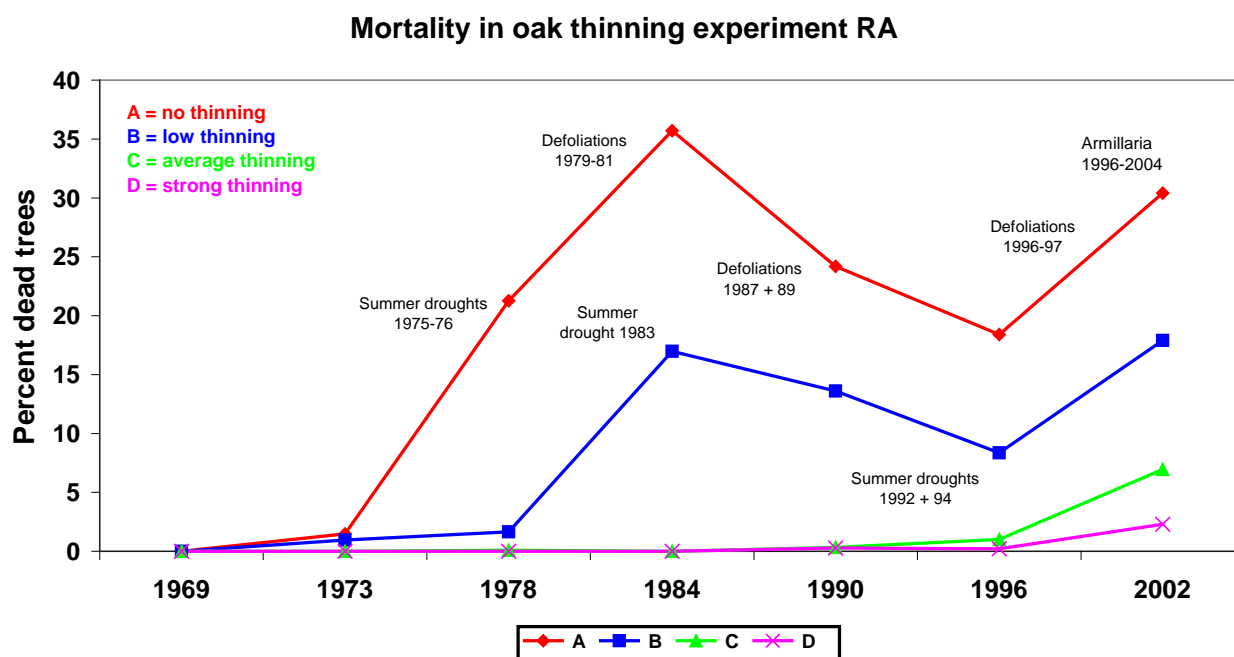


Figure 4 Mortality in thinning experiment in oak. The number of dead trees since last thinning is counted before thinning and expressed as percent of total tree number. In the unthinned A plot only new dead trees are counted, and some of the mortality is due to natural competition. Possible explanations for mortality are given in the graph. In 2002 more than half the thinning trees in plot B-D had visible attack of *Armillaria* sp. at the base of the tree.

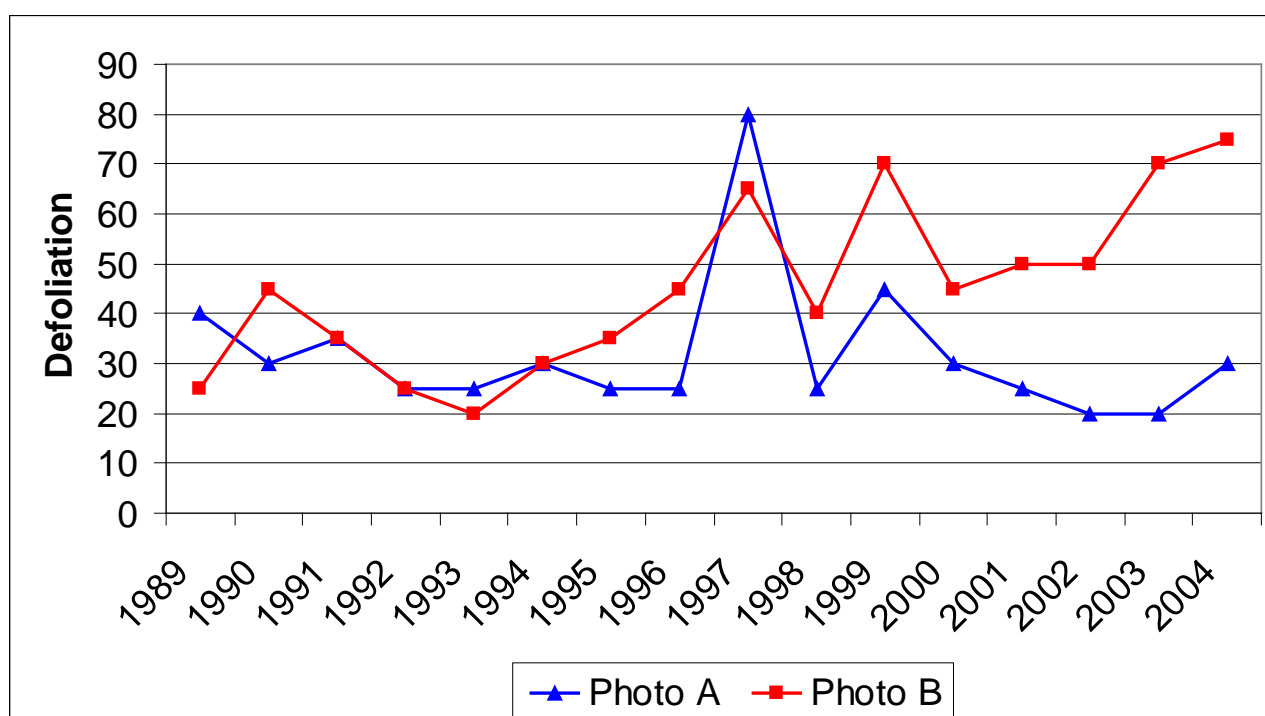


Figure 5 Development in defoliation for the two oak trees shown in Photo A and B. They are almost the same age, and until 1995 there was not much difference in defoliation score. In 1997 both trees were heavily defoliated by caterpillars (mainly *Operophtera brumata*), but only one of them recovered in the subsequent years. The oak with continuous decline was also defoliated by caterpillars in 1996, which may explain the difference.