



Phenology of some Woody Plants in Norway as Indicator of Climate Change

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The dates of occurrence of the phenophases for 26 tree species or varieties in southern Norway are analysed. For all of them there has been a change towards earlier phenophases (negative trends) during the period 1971-2005, and for 8 of them the changes turn out to be significant at the 0.05 level according to the nonparametric Mann-Kendall test. On average the phenophases have occurred 7.3 days earlier during this period or 2.1 days/decade. The analyses are based on observations carried out at international phenological gardens (IPG) at Fana (western Norway) and Kvithamar (Trøndelag), also at the Norwegian University of Life Sciences (Ås, south-eastern Norway) and the research station Njøs (western Norway). The longest series are from Njøs (starts 1927), and Ås, (starts 1947), whereas no series at the IPGs goes further back than 1964. Also when the entire length of the series is used, only negative trends are detected, 11 of them are significant.

The phenophases are mostly bud burst, beginning of flowering, petal fall, and also start of growth for the spruce. All of these are spring phenophases, whose mean dates of occurrence vary from the first days in May to the first days in June during an adopted reference period 1971-2000. The dates of occurrence of the phenophases correlate with nearby seasonal temperature series, with the coefficients of correlation varying from species to species within the interval 0.57 – 0.88. For most of the series, the highest correlations were found using mean temperatures for the seasons March – May and April – May.

The species *Larix decidua*, *Betula pubescens*, *Fagus sylvatica* 'Har', and *Populus tremula* have been growing in both IPGs during the period 1971 – 2005. All species show steeper trends towards earlier phenophases at Fana (western Norway) than at Kvithamar (Trøndelag). These regional trends are significantly different for *Betula pubescens* and *Fagus sylvatica*. Similar analyses have also been performed for fruit phenophases at Njøs (western Norway) and Ås (south-eastern Norway), but the trends in those regions do not differ significantly.

The sensitivity of the starting year for the trend studies is also analysed. Series starting in a cold decade tend to have significant trends in the period from the starting year to 2005, whereas series starting in a warm decade tend to have insignificant trends. Thus, the starting year is very sensitive for the results of trend studies.

The occurrences of the phenophases are also examined by a Gaussian filtering technique for several bandwidths using the SiZer-tool. For bandwidths of 3 years (decadal variations) late occurrences in the 1960s are significant for the long series at Ås. Also early occurrences in the 1970s in all temperature regions are significant for many species. Late and early occurrences of the phenophases are nicely reflected by temperature variations.