Chapter 4.7

PLANT PHENOLOGICAL "FINGERPRINTS"
Detection of Climate Change Impacts

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1. INTRODUCTION

Observation of phenological phases is probably the simplest way to track changes in the ecology of species in response to climate change. Other possible responses, such as altered species distribution, population sizes, and community composition, will be much harder and more expensive to detect (Walther et al. 2002). Thus, during recent years, phenology has received increasing attention as a bio-indicator for Global Change. "Snowdrops as bearer of bad tidings" was, for example, the title of an article about climate change in a German newspaper in January 2002. Phenology seems to be an ideal climate indicator at regional, national, and international levels, because it is easily understood by the general public, allows the study of changes at a smaller scale, raises awareness of climate change issues, engages the public in the climate change debate, and reconnects people with their natural world (Sparks and Smithers 2002). However, the scientific community also welcomes phenology as a tool for global change research. Among others, the length of the growing season and phenological phases are proposed by the European Environment Agency as global change indicators.

Recent reviews about observed phenological changes, e.g. Menzel and Estrella (2001), Walther et al. (2002), Menzel (2002), Sparks and Menzel (2002), and Root et al. (2003) summarize various indications of shifts in
plant and animal phenology that have been reported for the boreal and temperate zones of the northern hemisphere. This review, however, will be confined to plant phenological changes, as responses of animal life are described in the chapters of Part 6.

2. OBSERVED PLANT - FINGERPRINTS

The picture of observed changes is consistent: in the last three to five decades, spring phases, such as leaf unfolding and flowering, have advanced by 0.12 to 0.31 days per year in Europe, and 0.08 to 0.38 days per year in North America. Fewer data on autumn phases exist (mainly in Europe), and autumn is delayed by 0.03 to 0.26 days per year in Europe.

In order to compare recent reported results correctly we should distinguish between studies analyzing one phenophase at one site (not included here), several phenophases per season at one site (small signs in Plate 1), one phenophase in an observational network (medium signs) and several phenophases per season in a network (large signs). All data in Plate 1 are given as phenophase / site / network average trend in days / year.


Multi-site network data allow assessment of the spatial representativeness of changes. These data show evidence of spatial variability with differences among sites either on maps (Walkovszky 1998; Schwartz and Reiter 2000; Menzel and Estrella 2001; Menzel et al. 2001) or by statistical descriptions. In general, positive trends indicating a delayed onset of spring also occur, however with clearly smaller numbers. Only around one third of stations have statistically significant trends. Thus, analyses of network data clearly reveal phenological responses, although these are sometimes inhomogeneous due to local microclimate conditions, natural variation, genetic differences (not for the IPG, see Chapter 2.3) or other non-climatic factors.

On the continental scale geographical differences are evident with delayed rather than earlier onset of spring phases prevailing in southeastern Europe (Menzel and Fabian 1999), advances in spring in Western and