Geophysical Research Abstracts
Vol. 18, EGU2016-7216, 2016
EGU General Assembly 2016

Does the start and end of the biological growing season respond independently to a changing climate?

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Adaptation of the biological growing season to a changing climatic requires that plants can adapt their phenology plastically or genetically to new conditions. Physiological and evolutionary constraints may, however, hamper such adaptations. Here, we study correlations between leafing out and autumn coloration phenology, that is, the start and end of the green growing season.
In temperate, deciduous tree species the period with green leaves is more or less the same as the individual leaf's life span. General plant ecological strategy schemes suggest that the individual leaf's life span is one of the major dimensions evolutionary associated with other leaf and plant characteristics, including expensive investments in leaf nutrient content and leaf morphology. Leaf life span is thus considered highly conserved within evolutionary lineages. At the same time, local adaptation of leaf phenology to the length of the climatic growing season is common, both when it comes to leafing out cues and autumn senescence cues, suggesting that there are strong selection pressures and adaptability (plastic and/or genetic) to make use of the climatically defined growing season.

We used a data set from a Swedish, national phenology network where volunteer observers recorded the start of leafing out defined as 'when the tree looks green from a distance' and the start of autumn leaf coloration as 'when 1/3 of the tree canopy had attained autumn colors'. In the subset used observations were made at 489 sites/farms between 1873-1922. We only included data when the observer at a site and year had recorded both spring leafing and autumn leaf coloration phenology on the same species. In total, the data set comprised 25'099 observations of 17 species.

As the participants in the phenology monitoring network were volunteers, the data matrix has lots of missing data and unbalanced representation from different sites. We used linear mixed model analyses, including year as random factor, to analyse correlations between spring phenology, autumn phenology, the length of the green leaf period and geographic factors.

Earlier spring leafing out is correlated with a 0.6-0.8*days longer green leaf period. Later leaf autumn coloration is correlated with a 0.8-0.9*days longer green leaf period. Earlier spring is correlated with a 0.1-0.2*days earlier onset of autumn leaf coloration.

These results suggest that the autumn phase phenology is affected by spring phenology and thus will not respond independently to changes in summer and autumn conditions only. Before using these results in forecasting/predicitive models, the mechanistic background for the correlations need further study.