

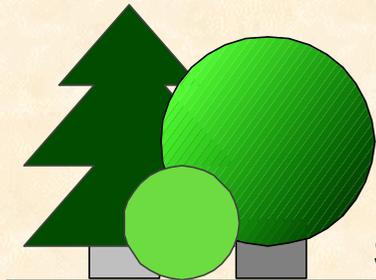


Phenological Observations: A Link Between Different GLOBE Protocols

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Definition

Phenology is the study of the **seasonal timing of life cycle events** and how they respond to seasonal changes in their environment.

Plant Phenology



Animal Phenology

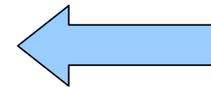
Phenologists observe the timing of developmental stages of plants, such as for the natural vegetation:

- bud burst,
- beginning of leaf unfolding,
- beginning of flowering,
- may sprout,
- first ripe fruits,
- autumn colouring,
- leaf fall.

} Growing season

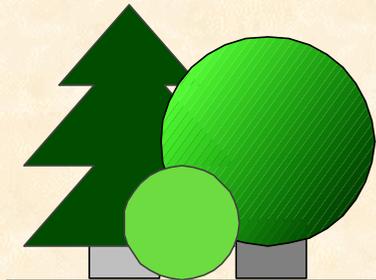
Use

- **Helps decision-making for farmers and foresters (cropping plans, cultivars selection, plant protection, fertilization etc.)**
- **Definition of natural seasons**
- **Calculation of phenological maps**
- **Frost warning of fruit trees and special crops**
- **Pollen warning, tourism**
- **Development of phenological models**
- **Calibration and evaluation of satellite information (NDVI)**
- **Biomonitoring**
- **Monitoring of environmental changes**
- **Climate impact studies**



Phenological observations are one of the most sensitive indicators of climate impacts on vegetation in high- and mid-latitudes. They can help for a better understanding of interactions between **atmosphere** and **biosphere**.

Regional differences in the timing of phenological events



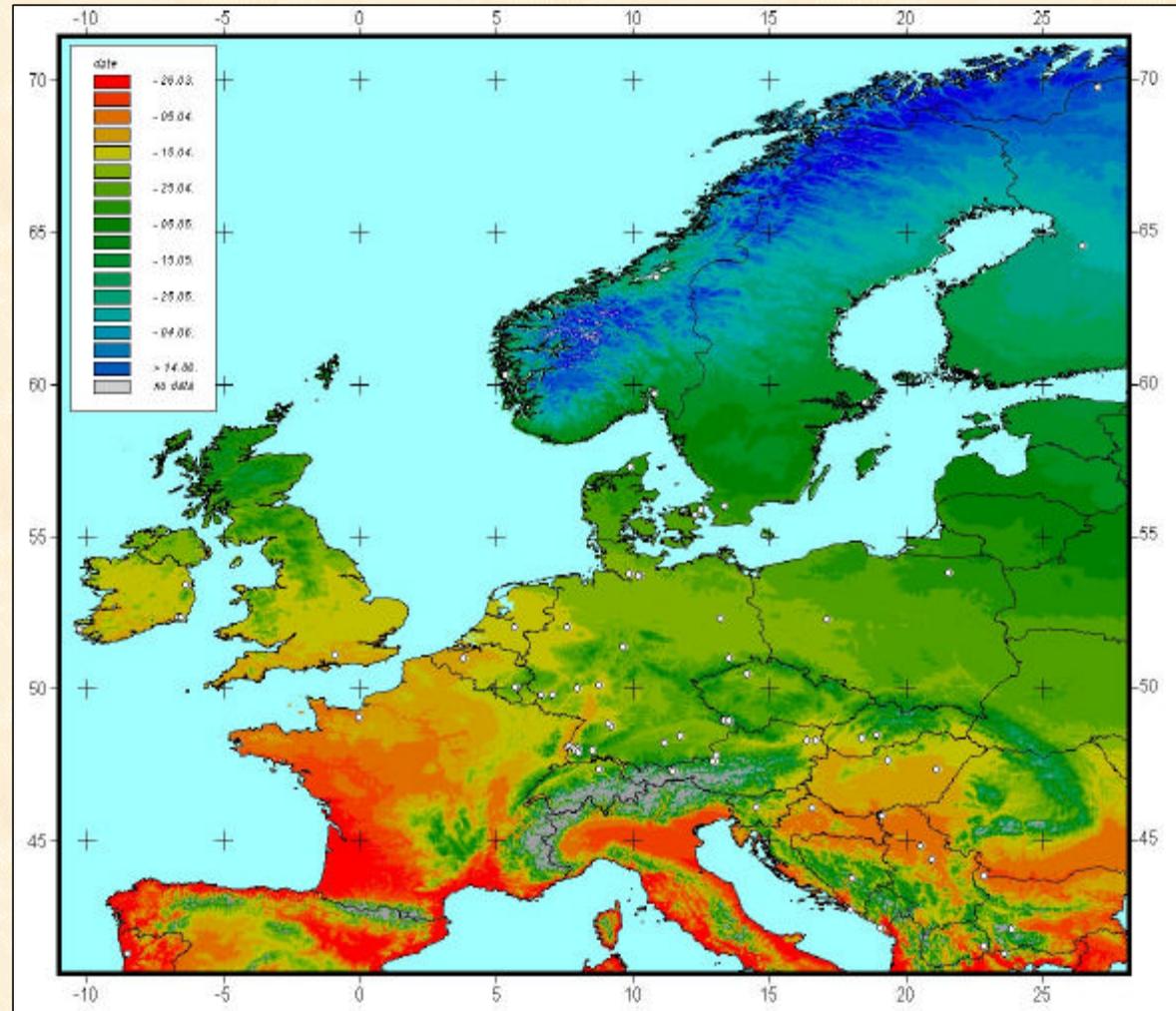
Av. beginning of growing season in Europe, 1961-1998

B = 23 April, [113]
s = 5.8 d (1961-1998)

MIN = 09.04. [99], 1990
MAX = 03.05. [123], 1970
DIFF = 24 days

$a_x = 0.5 \text{ d}/100 \text{ km (W-E)}$
 $a_y = 2.3 \text{ d}/100 \text{ km (S-N)}$
 $a_z = 3.1 \text{ d}/100 \text{ m}$

$R^2 = 83 \%$ $s = 5.2$
 $p < 0.001$ $n = 37$

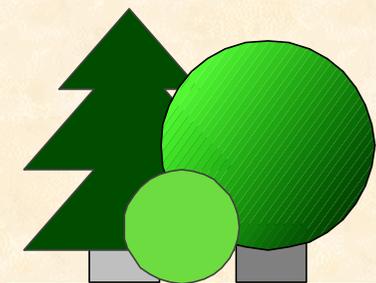


B: av. leaf unfolding of *Betula pubescens*, *Prunus avium*, *Sorbus aucuparia* and *Ribes alpinum*

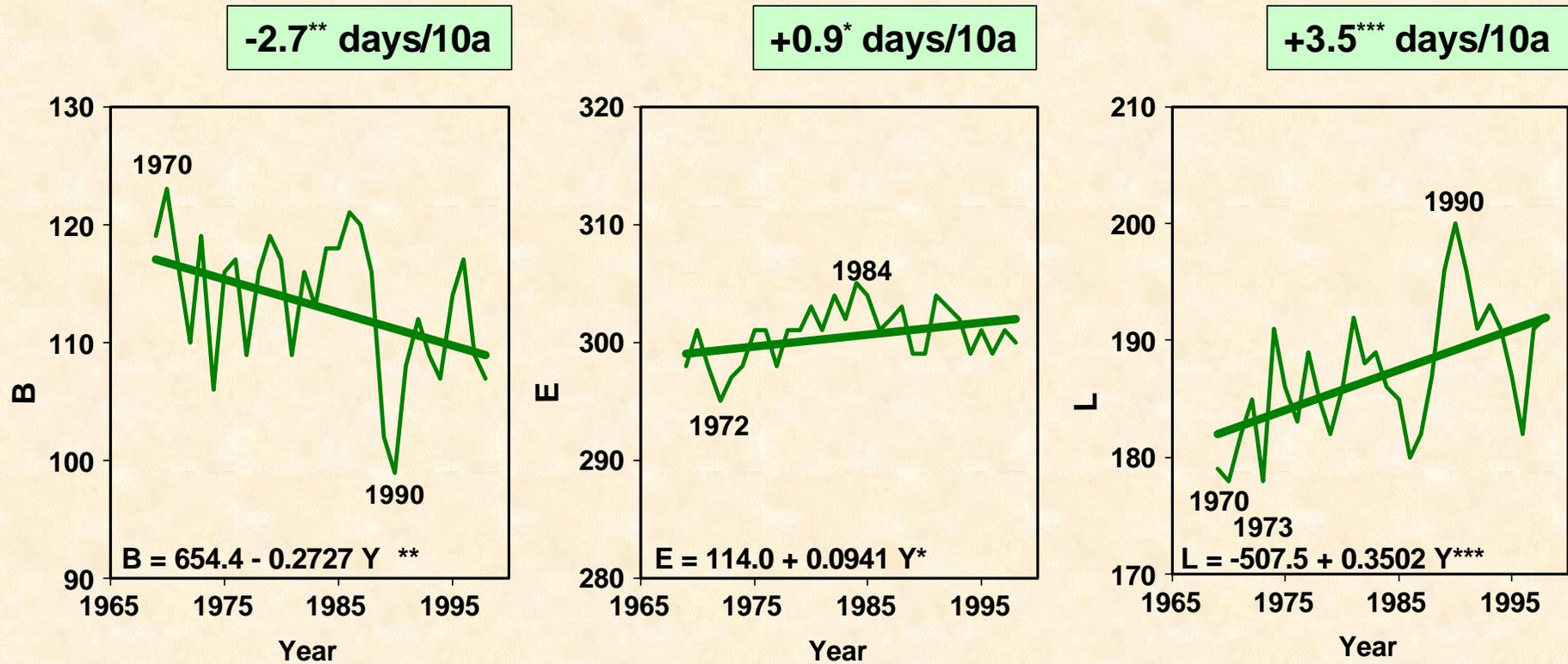
Data: IPG

Rötzer and Chmielewski, 2001

Trends in the annual timing of phenophases



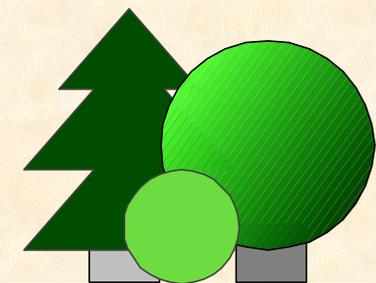
Trends in beginning (B), end (E) and the length (L) of growing season in Europe, 1969-1998



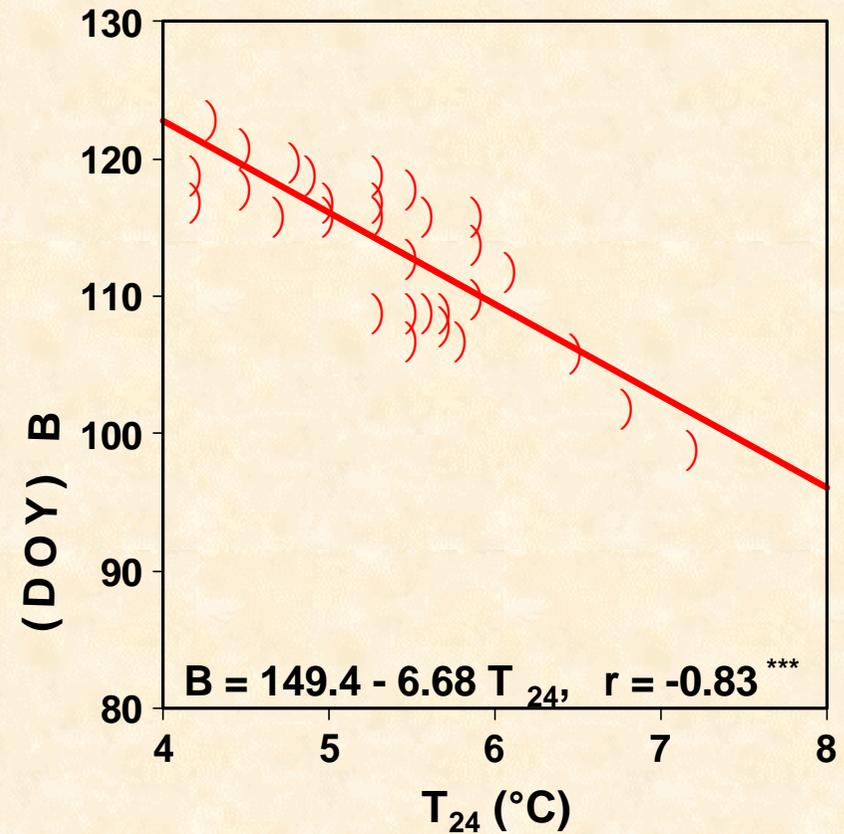
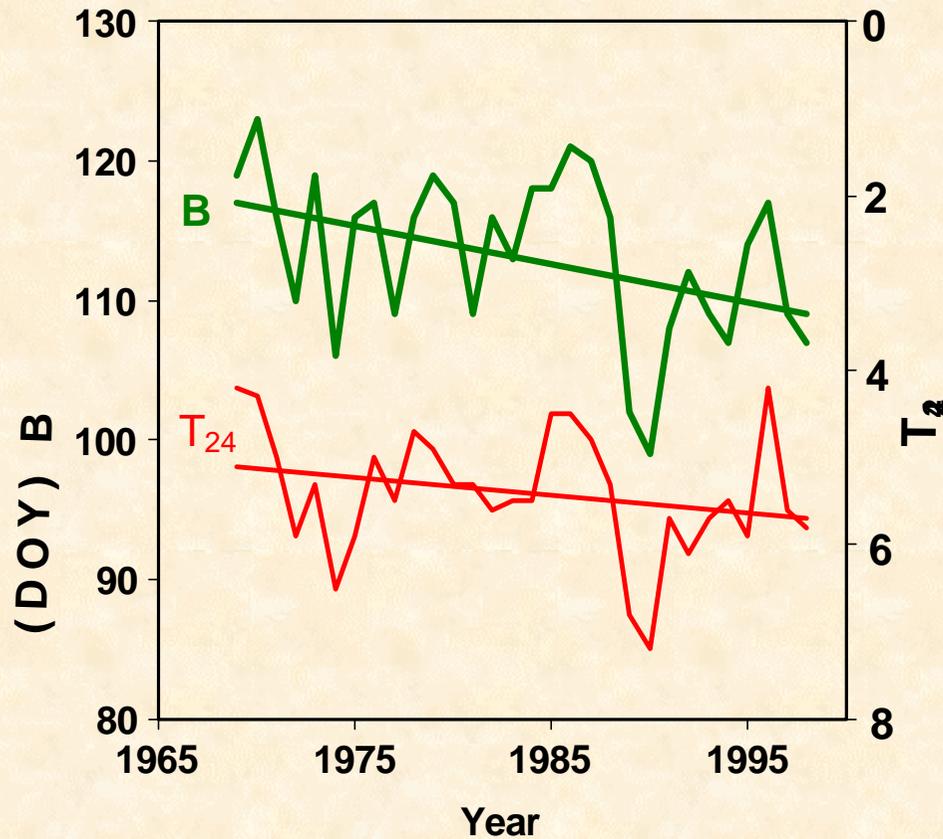
B: av. leaf unfolding of *Betula pubescens*, *Prunus avium*, *Sorbus aucuparia* and *Ribes alpinum*
E: av. leaf fall of *Betula pubescens*, *Prunus avium*, *Salix smithiana* and *Ribes alpinum*
L: E - B

(DOY)

Relationships between climate changes and phenology

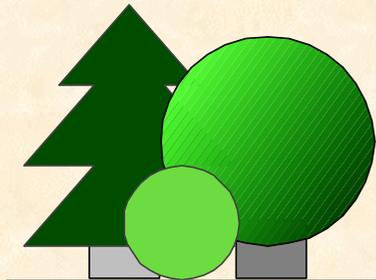


Relationships between changes in air temperature (T_{24}) and in the av. beginning of growing season (B) in Europe, 1969-1998



B = 23 April

Correlation between phenological phases



Indicator plants

Most **phenological phases are very well correlated**, so that the phenological event of one species is a good predictor for another event.

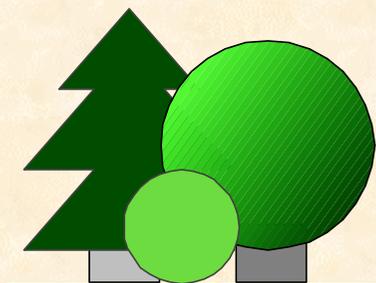
For this reason it is possible to define some **indicator-plants** or **indicator-phases** which allow to predict the phenophases of other plants.

Correlation coefficients between different phenophases in Germany, 1961-2000

	x	s	B_G	B₃₀	B_C	B_A
B_G	109.8	7.3	1.00	0.88	0.92	0.95
B₃₀	116.6	6.1		1.00	0.91	0.88
B_C	116.9	7.5			1.00	0.96
B_A	125.3	7.4				1.00

B_G: Beginning of growing season, **B₃₀**: stem elongation of winter rye **B_C**: blossom of cherry trees, **B_A**: blossom of apple trees,

Suggestion for a GLOBE Phenology Garden



Purpose

To **observe the flowering and leaf stages of selected cloned plants** throughout the year. The plants are genetically identical, that means they respond the same way to changes in temperature and moisture.

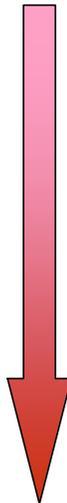
Outcomes

Students will learn **how to identify the different flowering stages** during plant growth. They will study relationships between climate, particularly temperature, and plant blooming.

Students will learn **how the growing season is changing** from year to year as well as they will see if there is an overall change in the growing season over a longer period of time.

Suggestion for a **GLOBE Phenology Garden:**

Species	Variety	Flowering time
1. Witch-hazel	<i>Hamamelis x Intermedia</i> 'Jelena'	12/01
2. Snowdrops	<i>Galanthus nivalis</i> 'genuine'	01/02
3. Forsythia ¹⁾	<i>Forsythia suspensa</i> 'Fortunei,	03/04
4. Lilac ¹⁾	<i>Syringa x chinensis</i> 'Red Rothomagensis'	04/05
5. Mock-orange	<i>Philadelphus coronarius</i> 'genuine'	05/06
6. Heather	<i>Calluna vulgaris</i> 'Allegro'	08
7. Heather	<i>Calluna vulgaris</i> 'Long White'	09
8. Witch-hazel	<i>Hamamelis virginiana</i> 'genuine'	09



Observed phenological phases:

BF: Beginning of flowering, GF: General flowering, EF: End of flowering

¹⁾Additionally: Beginning of leaf unfolding, Full leaves



Witch-hazel



Snowdrops



Forsythia



Lilac



Heather

Flowering time
JAN - SEP

GLOBE *Plant Phenology Observations*

Phenological observations can **link** different investigations in GLOBE.

Atmospheric Investigations

- air temperature
- precipitation

Land Cover Investigations

- natural vegetation species
- timing of phenological events

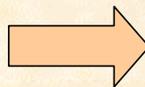
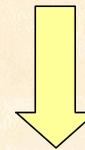
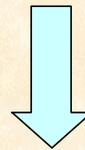
Soil Investigations

- soil temperature
- soil type
- water capacity

Phenological Investigations (GLOBE Phenology Garden)

Seasons Investigations

- definition of natural seasons



How the data will be used by scientists?

The plants in the **GPG** are part of a new worldwide scientific phenological network, called Global Phenological Monitoring (GPM) Programme.

In this programme mainly **phenophases of fruit trees** are observed. The suggested plants for the GPG are a supplemental programme within GPM.

This means the **phenological data in the GLOBE Phenology Garden** are also **indicators of the flowering dates of fruit trees**. This is very important for managing agriculture and horticulture.

Organization:

The plants need to come from **selected tree nurseries** to make sure that the plants are clones. For Europe the parent garden is in Erkelenz (Ger).

Further parent gardens will be established in **Beijing for Asia** and one in the **United States for North America**.

The costs for a complete garden are about **100 US\$ / Euro**.

In autumn 2002 the first phenological gardens will be established in Europe.

A **new GLOBE protocol** will be added on Internet.

THE END

