GUIDELINES FOR PLANT PHENOLOGICAL OBSERVATIONS

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1 Introduction

1.1 Definition of phenology and seasonality

“Phainestai”, the ancient Greek word meaning to show or to appear, is found in many modern language words reflecting the original.

Following the definition of Lieth (1974), which goes back to Schnelle (1955), modern phenology is the study of the timing of recurring biological events in the animal and plant world, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species. Leaf unfolding, flowering of plants in spring, fruit ripening, colour changing and leaf fall in autumn as well as the appearance and departure of migrating birds and the timing of animal breeding are all examples of phenological events. The task of plant-phenology is to observe and record the periodically recurring growth stages and to study the regularities and dependency of the yearly cycles of development on environmental conditions.

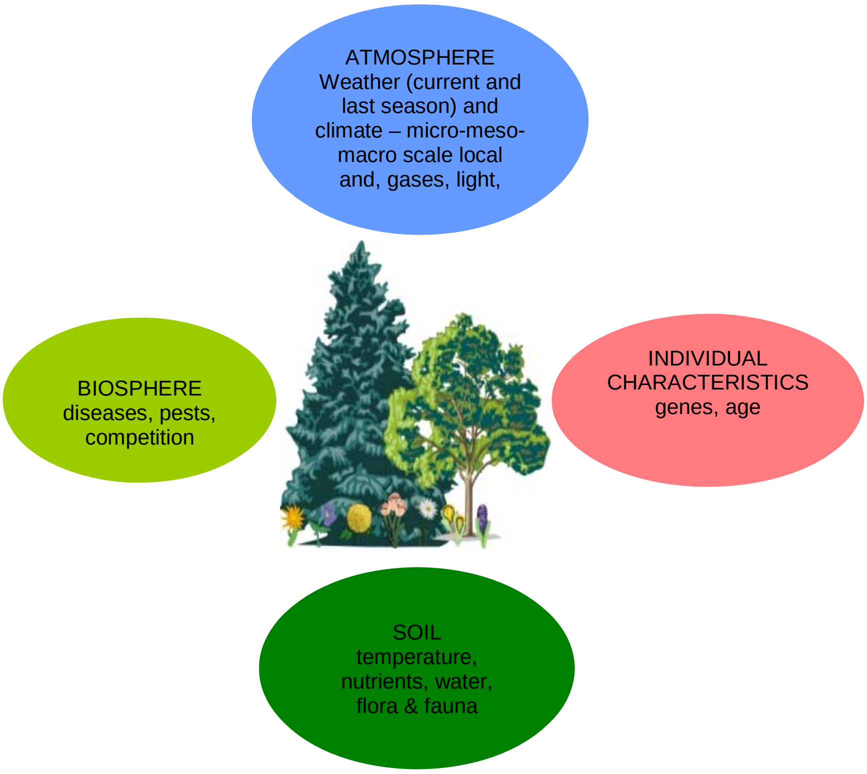


Figure 1: The plant and its environment (Defila, 1992)

Plant development and thus phenological phases show great interannual variability and also large spatial differences. Individual (genes, age) and environmental factors (weather and climate conditions in the micro and macro-scale, soil-conditions, water supply, diseases, competition etc.) influence plants. They can be viewed as integrative measurement devices for the environment. The seasonal cycle of plants however is influenced to the greatest extent by temperature, photoperiod and precipitation (Sarvas 1972, 1974, Morellato and Haddad, 2000, Keatley 2000). In particular spring development in the mid latitudes depends especially on temperature in winter and spring, in the tropics and subtropics rainfall regime is predominant.

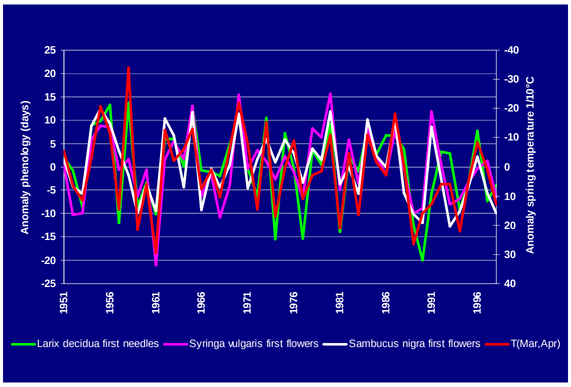


Figure 2a: Anomalies of different phenological phases and spring air temperature in the Alpine region between 1951 and 1998 (Böhm et al., 2001, Scheifinger et al, 2002)

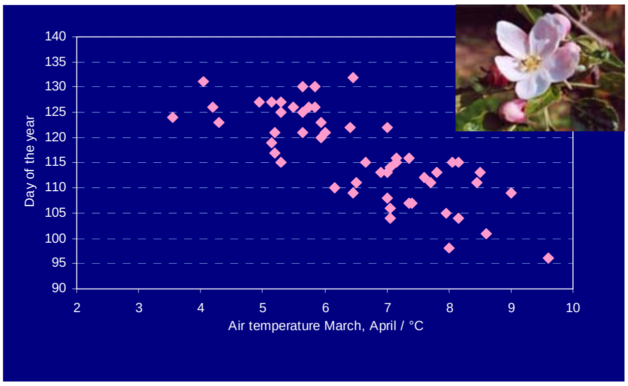


Figure 2b: Correlation of spring air temperature March, April and beginning of flowering of apple tree in Austria (source ZAMG)

Seasonality refers to non-biological recurring events such as lake or sea icing (e.g., the "ice on or off" of rivers or the Baltic Sea, Jevrejeva, 2001, Koslowski and Glaser, 1999, Ranniew, 1982) or, regular inundations of rivers (e.g., the annual flooding of the Nile was an important phenomenon in ancient Egypt enriching the soil and thus bringing good harvest).

A more recent and very charming definition comes from Sparks (Menzel, 2002) "Phenology is pastime with a considerable history. Once considered the harmless activity of a select few country gentlemen and clerics it has now taken on a new importance since its value as (probably) the oldest written biological records has been recognised."

1.2 Benefits for NMHS

Because of the close relationship between plant development, weather and climate, phenological observation networks are run by the national meteorological services in many countries. Phenology is an easy-to-observe and cost-efficient instrument for the early detection of changes in the biosphere, and therefore complements the instrumental measurements of national meteorological services very well. Different types of networks exist: phenological networks observing wild plants, agricultural observation systems and measurements of the pollen concentration by means of pollen traps. Some NMHS as the Austrian, the Slovak and the Estonian as well as the UK Phenology Network also include observations of the timing of migration of some animal species and the timing of animal breeding.

Type of observations	**Applications at national meteorological services**
Agronomic networks	Bulletins, agronomic recommendations
Pollen networks	Forecasts for allergic people Business contacts
Wild plant observation networks	Bulletins Research (climate change) Public relations

Up-to-date observations flow into several products generated at the NMHSs.

The start of the pollen season doesn't only affect sensitive people but also forecasters at many meteorological services. Bulletins reporting the current pollen concentration as well as pollen forecasts are a highly estimated product for people with allergies. Furthermore the pollen products enable important business connections in the medical sector.

From the beginning, phenological observations have been used to support the scheduling of agricultural works. Agricultural phenology networks mainly include intensive observations of fruit trees and vines. Plants vary in their sensitivity to frost or pests depending on their state of development. Information on the actual state of the cultures is indispensable to provide important support in the form of frost warnings and recommendations for pest control measures. Pest forecast models based on meteorological and phenological data have been developed in several countries to enhance cost efficiency in agriculture (e.g. agro-meteorological forecasts of the Deutscher Wetterdienst, http://www.dwd.de).

In recent years phenology changed its image from a traditional data collection to a very important integrative parameter to assess the impact of climate change on ecosystems. In this context long data series originating from the plant-observation networks have become very valuable, and the maintenance of the observation networks has become a higher priority within the national meteorological services.

Long phenological data records are the basis of several climate change research projects at the national meteorological services. Due to the increased scientific value of phenology, these projects are a good possibility for the NMHSs to gain access to third-party funding.

Phenology is a good instrument to communicate climate characteristics in general, and especially the impacts of climate change to the broad public. There is substantial public interest in phenological bulletins indicating the actual state of vegetation development during the growing season. The information on the characteristic of the current year (especially early or late year), may increase the public awareness of nature and its seasonal chronology and may act as a motivation for people to actively observe natural processes.

Furthermore phenology already is (and might become) an even more important topic to enhance the public relation activities of the meteorological services. Several newspaper articles throughout the year indicate the relevance of this topic for the media.

1.3 Importance of phenology for Climate Change studies

Numerous examples – from the duration of the growing season for gingko trees in Japan to the flowering of lilac in the US or the flowering of snowdrops in Germany – show that climate change is significantly changing the seasonality of our eco-systems, especially in the middle and higher northern latitudes. The IPCC (Intergovernmental Panel on Climate Change) concluded in its Third Assessment Report in 2001 that many physical and biological systems, such as hydrology, glaciers and ice, vegetation, insects, birds and mammals, are already reacting to changing temperatures (Jones et al., 2001). By far the majority of these reactions are proceeding in the expected direction, i.e. they reflect the known relationship with temperature.

The importance of phenology lays in it's effectiveness as a tool to monitor impacts of climate change on plants and animals. Some imminent effects on vegetation include: (1) range shifts towards the polar regions and higher altitudes; (2) changes in population density and composition of vegetation; (3) longer growing seasons; and (4) earlier plant flowering, earlier breeding times, earlier egg laying in the year. The last two maybe best delineated by phenology. The intervals at which such events occur are very closely related to climate and weather conditions, especially temperature in spring and summer (Sparks et al., 2001, Menzel, 2003). Unlike the change in range shifts or changing composition of eco-systems, which maybe confounded by other drivers, such as land use change or habitat fragmentation, temperature is the factor of crucial influence here. Thus, phenology is probably the simplest and most cost effective means of observing the effects of changes in temperature, and consequently, phenology has become an important tool in global change research (Sparks and Menzel, 2002, Walther et al., 2002). The use of phenology as a biological indicator of climate change presupposes (1) precise quantitative analysis of changes in phenological time series, (2) a known relationship with temperature and or precipitation (3) an analogous change in corresponding temperature and or precipitation series over time (Root et al., 2003).

In case that phenological study series go well beyond the period of instrumental meteorological measurements, such as for the oldest known series which stems from Kyoto in Japan or the observations of the Marsham family in Norfolk, Great Britain (see Short history of phenology), the findings observed in plants can also be taken as proxy or substitute data for temperatures. The records kept in conjunction with grape picking in France, Switzerland and the German Rhineland since 1480 are a prime example here, allowing an assessment of average temperature during the growing season (Menzel, 2005, Lauscher, 1983).

The picture of the reported observed changes is quite uniform: Numerous studies concur that the onset of growth in the middle and higher latitudes of the northern hemisphere starts earlier in spring and that the growing season has become longer and then breeding season starts earlier (Parmesan and Galbraith,2004, European Environment Agency, 2002, Koch and Scheifinger 2004).

1.4 Short history of phenology

Charles Morren, a Belgian botanist introduced the French word for phenology for the first time in 1853. But of course the history of phenology is much older dating back to the time of hunters and gatherers.

Australia

Aboriginals have occupied the Australian continent for at least 50,000 years. Their culture developed a deep understanding of the interrelationships between the environment and its influence on fauna and flora, partly because their survival depended heavily on their understanding of phenology or seasonality of food resources. Aboriginal calendars recognize between 5 and 10 seasons, varying in length between 2 weeks up to 4 months. Each season is defined by the changes in flora and fauna as well as the strength of wind, amount of rain and temperature. The Yolngu people in the Northern Territory have 6 major seasons. The beginning of Midawarr, the fruiting season is signalled by a wind change from the northwest to the east and lasts 8 weeks from March to April. Some of these calendars are still in use mainly associated with communities in Northern Australia whereas those in southern states have been lost (Keatley and Fletcher, 2003).

Nowadays the two most notable community-based networks are “Timelines Australia Project” and Faunawatch. Each network voluntarily coordinated aims to engage the general public in monitoring of flora and fauna. The Timelines national program was launched 1997 with the goal to develop an Australian seasonal calendar similar to the aboriginal calendars, as the European seasons are inappropriate for Australia.

Asia

Japan has the oldest existing (and still on-going) phenological monitoring record. The flowering of cherry tree has been observed and recorded for about 1300 years. Since 1953 the Japanese Meteorological Agency has run a phenological network observing 12 species of plants including cherry and 11 species of fauna.

China started modern phenological observation and research in the 1920s, but Zhu (1931) shows that phenology in China is at least 3000 years old. In 1980s, the Chinese Meteorological Administration started a countrywide network.

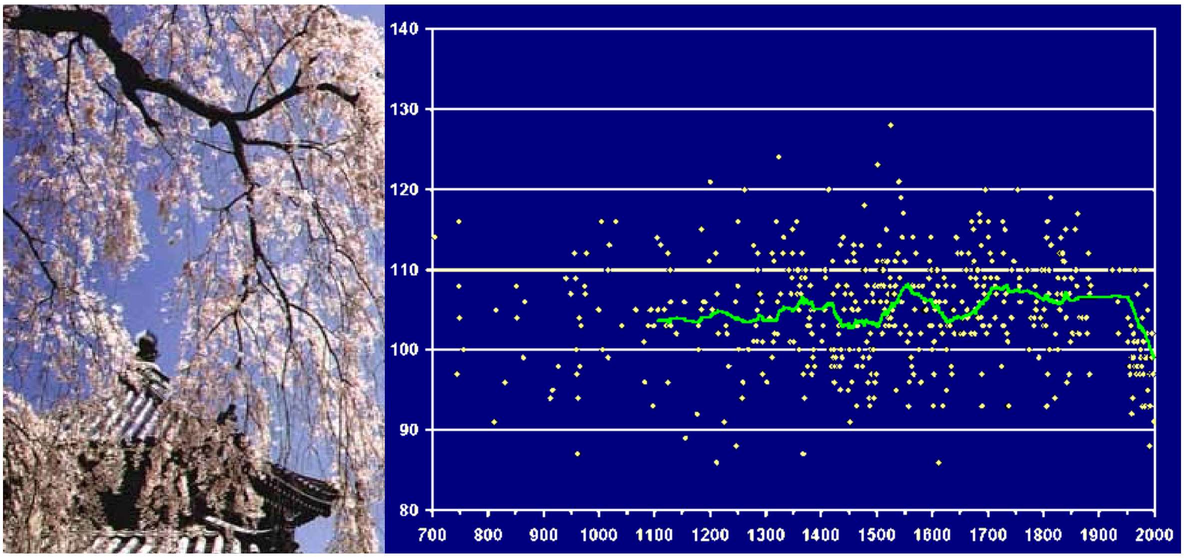


Figure 3: Beginning of flowering cherry (day of year) in Kyoto dating back till 705 AD, Menzel and Fabian, 2002

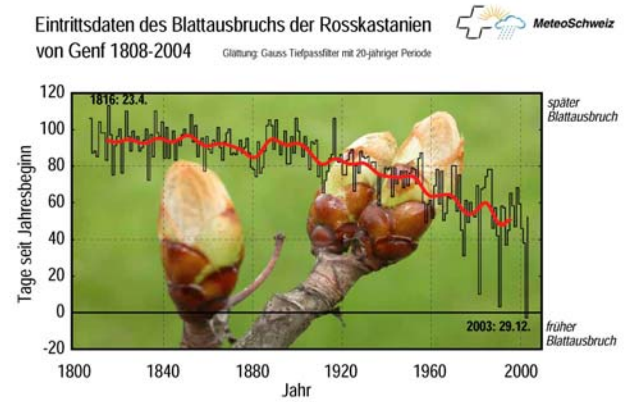
Europe

Carolus Linnaeus is looked upon as the father of modern phenological networks. The first known phenological network was installed by him in Sweden in the middle of the 18th century. In his work Philosophia Botanica he outlined methods for compiling annual plant calendars of leaf opening, flowering, fruiting and leaf fall, together with climatological observations “so as to show how areas differ”… (Linnaus, 1751).

Some networks started in the middle of the 19th century (e.g. Karl Fritsch in the Austrian Hungarian monarchy). Fritsch (1851) also published guidelines for phenological animal and plant observations in the 2nd yearbook of the newly founded K.K. Centralanstalt für Meteorologie und Erdmagnetismus, now the NMS of Austria.

A very old time series of phenological observations is the bud burst of horse-chestnut in Geneva, dating back to 1808. A clear trend towards earlier appearance (0.24 days per year) was detected becoming more pronounced since the beginning of the 20th century. This coincides with the growth and industrial development of Geneva (Defila and Clot, 2001).

The climatological and phenological records of the Marsham family in Norwich, England are another example for very old European data series as well as the newly published series of cherry flowering in Alpenvorland Switzerland, dating back to 1721 and last but not least the grape harvest dates from France go back to the Middle Ages (Menzel, 2005, Lauscher, 1983, Chuine et al., 2004, Msargary, 1926, Rutishauser, 2004).



Time series of leaf bud burst of horse chestnut in Geneva, 1808 - 2004, http://www.meteoschweiz.ch/web/de/klima/klimaentwicklung/phaenologie.html

South America

Contemporary studies on phenology in South America were initiated by Araújo, 1970. The INPA (Instituto Nacional de Pesquisas da Amazonia) phenological work started in 1965 in the Amazonas State in Brazil and is still ongoing thus likely providing a unique time series of tropical forest trees (Morellato, 2003).

North America

Canada's First Nations (as for instance the Blackfoot) used the flowering of Golden Bean (Thermopsis rhombifolia) to indicate the best time in spring to hunt Bison bulls. The Nuu-Cha-Nulth people from the west coast took the time when salmonberries (Rubus spectabilis) ripened as indicator for adult sockeye salmons starting to run in freshwater streams. The first modern countrywide phenological survey started in 1867, the Royal Society of Canada passed a resolution in 1890 to "obtain accurate records in their individual localities of meteorological phenomena, dates of the first appearance of birds, of the leafing and flowering of certain plants, … (Schwartz and Beaubien, 2003). Plantwatch began in 1995 based at the University of Alberta. Initially the focus was on students from 8 to 11 years old, but by 1997 the survey had expanded to a Canada-wide program for both adults and youth with seven indicator plants. In 2000 to 2002 Plantwatch expanded with assistance from Environment Canada's Ecological Monitoring and Assessment Network Coordinating Office. The protocols from the German NHMS were taken as base to standardize the phenophase description (http://www.plantwatch.ca).

In the United States the Smithsonian Institution established a network in 1851 including observations of 86 plant species, birds and insects in thirty–three states (Hough, 1864). Bailey published guidelines for phenological observations in 1896, the Weather Bureau also set up instructions in 1899. In the first half of the 20th century, A.D. Hopkins (1938) formulated the famous "bioclimatic law" the most well known part of it being that the south to north movement of spring phenological events in the temperate climatic zones of the US is delayed by four days for each degree of latitude northward, for each five degrees longitude eastward, and for each 400 feet increase in altitude.

In the 1950s a series of regional agricultural experimental stations projects were initiated to employ phenology to characterize seasonal weather patterns and improve predictions of crop yield. The first of these projects were initialised in Montana, but observations ended in the western USA in 1994 (Caprio, 1957). Lilac data from the eastern and western USA networks have recently been published on the web (http://www.ncdc.noaa.gov/paleo/phenology.html). In 1961, the Wisconsin Phenological Society was established to promote phenological observation in that state (http://www.naturenet.com/alnc/wps/). The policy of the recently-created National Phenology Network (http://www.uwm.edu/Dept/Geography/npn) is to facilitate collection and dissemination of plant phenological data to support climate change studies.

International networks

In the early 1960s, the International Phenological Gardens were founded by Volkert and Schnelle. The idea was to plant clones of different trees and bushes throughout Europe to study their phenological development and to remove any influence of different genetic material (Chmielewski, 1996, http://www.agrar.hu-berlin.de/pflanzenbau/agrarmet/ipg.html).

In 1993 the Phenological Study Group of the International Society of Biometeorology (ISB) started a new initiative called GPM (Global Phenological Monitoring) whose main objectives (among others) are to form a global phenological backbone with a “standard observation programme”, to link 'local' phenological networks and to encourage establishment and expansion of phenological networks throughout the world (Bruns et al., 2003).

The European Phenology Network gives an overview of phenological observations in Europe, North, Central and South America and also of multinational networks (http://www.agrar.hu-berlin.de/pflanzenbau/agrarmet/gpm.html).

The GLOBE Programme (Global Learning and Observations to Benefit the Environment, www.globe.gov) founded in 1998 recognized the value of phenological observations in education and encourages students to take scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover/phenology, combining scientific research with education. In Australia the Macquarie University developed a website which hopefully may serve as nucleus for a network to gather and collate flowering and fruiting observations from observers around Australia (Rice et al., 2001, http://www.bio.meg.edu.au/ecology/BioWatch). Nevertheless one needs to acknowledge that little in the way of phenological networks are available in some countries, particularly in the Southern Hemisphere.

1.5 Applications of phenological observations

Phenological phases reflect (among other environmental conditions and genetic factors) the characteristics of the climate. Consequently, long series of phenological observations may be used to detect climate variability and/or climate change. The significant response of live cycle events to global changes have caused a strong increase in interest in phenological processes as an indicator for climate change impacts. (see chapter on the importance of phenology for climate change studies).

However, the actual timing of phenological events is also of importance for other issues in education, agriculture, human health, tourism and recreation, bio-diversity and ecology, reflecting the significant response of life cycle events to global changes.

The following table gives more details and selected examples for phenological applications:

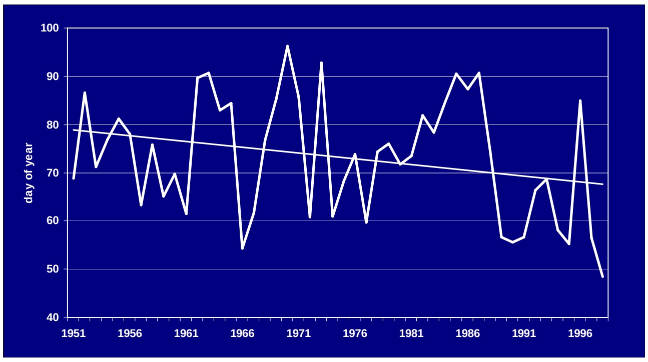
Agriculture	Providing phenological data as input for crop models, and for the timing of management activities
Biodiversity / Ecology	Assessing the impacts of extreme events, species interaction, migration of plant-communities to new zones (e.g. to higher altitude or latitude), mismatch of timing e.g. in food chains or mismatch of climate and species
Natural Resource Management	Timing of management activities, resource management under climate change (e.g. locating new reserves, linking of reserves)
Education	Involving school children and the public in scientific research by a very cheap and easy accessible means (plants and animals can be observed almost everywhere without any tool apart from keen interest, some knowledge on plant-identification and some basic rules), thus bringing people closer to nature.
Gardening	Giving information to the public on planning activities like pest control
Human Health	Providing pollen information for sensitive groups, assessing the impact of climate change on vector borne diseases (e.g. ticks, mosquitoes)
Increasing environmental interest	Informing the public on environmental issues like climate change and its effects on vegetation
Tourism, Recreation & Sports	Giving information on phenomena or events that potentially can interest people (e.g., in Austria, bike-tours on cherry-flowering or apricot-flowering are organized, bird watch tours)

adapted from European Phenology Network (Vliet et al., 2003)

Agriculture and forestry science has applied phenological data for the timing of agricultural work, and the selection of suitable crops and cultivars. Phenology has also been a complimentary measurement method for the assessment of local climate conditions e.g. investigating the urban heat islands. Nowadays phenological data are widely used in delivering valuable input data for crop yield modelling, they provide important support to frost warnings and are indispensable for pest control measures.

Pollen forecast is an example of an application of phenological data in the medical sector. The observed earlier onset of spring in the moderate temperate climate zones have prolonged the pollen season, bringing with it the negative effects on well-being and health of allergic people, and causing additional costs in health care (Beggs, 2004).

In recent years phenology has changed its image from a traditional data collection method to a very important integrative parameter to assess the impact of climate change on ecosystems. In this context long data series originating from the wild-plant-observation networks have become very valuable and the maintenance of the observation networks has increase in priority within the national meteorological services.



Time series of pollination of hazelnut 1951 – 1998 in Austria.
Data source: ZAMG

2 Guide to plant observations

In the following only plant phenology is dealt with. Plants have a stationary nature, can be planted in the location of interest as it is in the case of the international phenological gardens or the global monitoring program.

2.1 Introduction

It is necessary to follow defined guidelines to get comparable homogenous data. IMO (the predecessor organisation of WMO) formed a taskforce for phenology within the commission for agricultural meteorology which met in 1935 in Germany and made a proposal for an international observation programme. In 1953 regular phenological observations were included in the official agro-meteorological work-programme (WMO, 1953) which was recommended for all member states. But so far no agreement on common guidelines have been accomplished.

In 2000 A. Bussay published an evaluation of a questionnaire related to phenological observations and networks run by NMHSs within regional association VI of the WMO (WMO, 2000). Twenty-eight countries or 57% of the members of RA VI replied, and among them 22 were running a phenological network. Bussay further states that the observed plant (or rarely animal species) and the observed phases vary from country to country. “Besides the skill of the observer one of the main factors affecting data quality are guidelines for observations…” also conferences expert meetings or handbooks could increase the accuracy, reliability and comparability of the measurements.

The questionnaire also dealt with the main usage of phenological data which was for agro meteorological reports and bulletins, research, agro climatic evaluation and crop modelling. The user community consists mainly of scientists (37%), farming advisors (30%). Media represents 5%, university and education 25%.

In recent years phenology has gained new importance besides uses in agro meteorology, as it has become a bio-indicator for climate change (e.g. IPPC, 2002, Parmesan, Galbraith, 2004, EEA Report No 2/2004).

This is one of the main reasons why the CCl decided to publish specific guidelines for plant phenological observations organized by NMHSs.

2.2 Principles for observations

If you want to make phenological observations you do not need costly equipment, as the “instrument” for monitoring the environmental conditions is the plant itself. Indispensable for the observer are the observation form, observation guidelines and binoculars for large trees.

Remarkable stages of plant-development whose start dates can be determined to a specific day are observed. Recording imprecise time spans like “the beginning of March”, etc. are to be avoided as they cannot be evaluated. One of these striking stages of growth (which are called phenological phases) is for example, the beginning of flowering: on the start day several flower buds are open while on the preceding day the buds were still closed. For other phenological phases it is sometimes more difficult to fix a certain day (e.g. 50% leaf colouring) but nevertheless one day should be indicated.

The most important precondition to get homogenous comparable data is the exact definition of the phases. Further, the observations of the different phases of perennial plants (e.g. native or forest trees, shrubs or fruit trees) are carried out on one object. It should not stand out as being very early or very late in development. Extreme development is often associated with the site. Attention should therefore be paid to making sure that the site (see Where) of the plant to be observed is representative of the observation area. As a rule the observer will have several plants of a species to choose from. Once she or he has selected an object, she/he should carry out the observations on this plant for as many years as possible.

Herbaceous plants are observed year after year at a site, e.g. in the same meadow as meadow foxtail or along a farm track as mug-wort. The phase in question should have occurred in three plants of this site.

The observations of crops are usually carried out at the first cultivated field and all phenological phases during the course of a year are reported from this field. It may be important to record additional information for plants that are managed. As for example, the timing of some phenological events may be influenced by changes of the varieties of crop species of by watering regimes particularly in regions where rainfall variability is an issue (see metadata).

The frequency of observation depends on growth-stage and on the weather. Thus for example in spring in the mid- and high-latitudes it can be even necessary to make daily observations while during summer and fall bi-weekly tours are usually sufficient (details in When, how often).

And last but not least, it is of more value to have less but more exact data from a limited number of plants than for a very extensive program which implies much work and therefore is stopped after only a few years of observation.

2.3 Which plants

The selection of plants to be observed depends on the aim of the phenological network (for agricultural use, human health – pollen warning, climate change monitoring, education, information of the public, biodiversity…) and on the vegetation zone (mainly related to climate). It is therefore impossible to find plants which can be observed in all climatic regions of the globe and are suitable for all purposes.

In Europe the International Phenological Gardens network (founded by Volkert and Schnelle, now organized by F.-M. Chmielewski, Humboldt-University, Berlin, http://www.agrar.hu-berlin.de/pflanzenbau/agrarmet) covers a big part of the continent with sites stretching from Portugal to Russia and from Finland to Greece. Since the 1960´s genetically identical (cloned) trees and bushes have been observed according to common guidelines. Among others, the following plants are in the programme: Quercus robur, Tilia cordata, Prunus avium, Picea abies, Ribes alpinum, Robinia pseudoacacia, Sambucus nigra, which do grow in wide parts of Europe. Many NMHS of RA VI are involved in this program (plant list in annex).

In 1993 the Phenological Study Group of the International Society of Biometeorology (ISB) started a new initiative called GPM (Global Phenological Monitoring) whose main objectives among others are to form a global phenological backbone with a “standard observation programme”, to link 'local' phenological networks and to encourage establishment and expansion of phenological networks throughout the world (Bruns et al., 2003, plant list in annex).

For the GPM observation programme plants where chosen which meet certain criteria as easily recognizable phases, sensitivity to air temperature, and broad geographic distribution. The phases should ideally cover the whole growing season. Therefore mainly fruit trees, some park bushes and spring flowers were selected for the program. As temperature has the greatest influence on the phenological spring phases in mid-latitudes, GPM is restricted to latitudes from 35° north to the Arctic Circle and Tropic of Capricorn to 50° south. But even so, one has to accept that it is not possible to have the same plant collection everywhere in mid-latitudes due to different environmental condition requirements of the plants.

Nevertheless, when establishing a new phenological network it is strongly advised to have at least some plants of the GPM program (for the plant list see annex) under observation in order to facilitate international network linkage.

In Europe many NMHS run a phenological network. Seven of these monitoring programs and five other networks operated by different organisations were compared (Bruns and Vliet, 2003). As a result, a European backbone program was introduced containing species with phenological phases which are at least similar in 60% of these networks. The list comprises forest and ornamental trees and bushes, herbs, fruit trees and bushes and grapevine and crops (see annex).

As mentioned above, the selection of plants depends on the purpose of the network and of the vegetation zone. But it is strongly advised to include at least some plants of the GPM and/or European backbone program in order to facilitate international network linkages (the plant lists are in the annex).

Obeying the following basic rules when establishing a generic nationwide network with volunteer observers (and limited botanic knowledge) is recommended:

1. The plants should be important and well known, and thus easily identified/recognized.
2. They should have a broad distribution in the region and the phases should span the whole vegetation cycle of one year, e.g., leaf unfolding, flowering, fruit ripening, autumn coloration and leaf fall.
3. For monitoring climate change impacts observation of native plant species is recommended.

2.4 Which phases

The basic principles of the BBCH scale

In order to gain comparable phenological data it is necessary to define exactly the phases which are to be observed. The use of the so called extended BBCH scale (Growth stages of Plants, BBCH Monograph, Meier, 1997) based on ZADOKS et al (1974) cereal code is a system for a uniform coding of phenological similar growth stages of all mono- and dicotyledonous plant species is recommended. This is a general scale so one can also apply it to those plants for which no special scale is available. For the description of the main (longer-lasting) phenological development stages called principal growth stages clear and easily recognised external morphological characteristics are used. The secondary growth stages define a short step of development.

Principal growth stages

The entire developmental cycle of the plants is subdivided into ten clearly recognizable and distinguishable longer lasting phenological developmental phases.

Table 1 Principal growth stages

Stage	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (main shoot)
4	Development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / Heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence beginning of dormancy

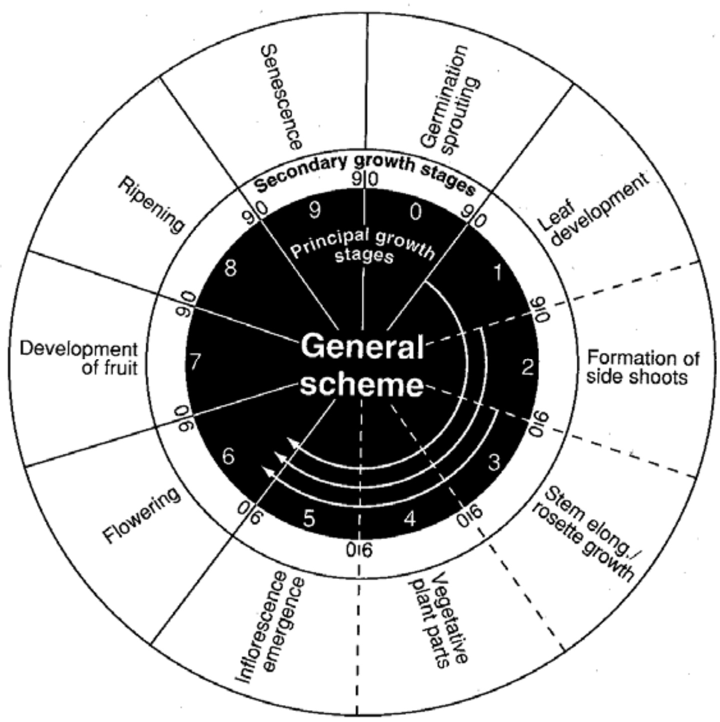


Figure 1 Principal and secondary growth stages of the BBCH code (from Meier, 1997)

This principal growth stages are described using numbers from 0 to 9 in ascending order (see table 1). They do not need to proceed in the ascending order of the table but can proceed in parallel for example the flowering stage BBCH6 can occur before leaf development BBCH1 as it is in some fruit trees, or owing to the very different plant species certain stages may even be omitted.

The 10 principal growth stages can be seen in table 1 and figure 1.

Secondary growth stages

It is clear that the principal growth stages are not sufficient to define exactly application or evaluation dates since they always describe time spans in the course of the development of a plant. Therefore secondary growth stages are introduced to define exact points of time or steps in the plant development. In contrary to the principal growth stages they describe short developmental steps characteristic of the respective plant species that are passed successively during the respective principal growth stage.

They are also coded with the digits 0 to 9. The numbers 0 to 9 correspond to the respective ordinal numbers or percentage values, 0 defines the beginning, 9 depicts the end of the principal growth stage (e.g. BBCH60 beginning of flowering, BBCH69 end of flowering). For example secondary growth stage 3 could represent 3rd true leaf or 3rd tiller or 3rd node or 30% of the final length or size typical for the species or 30% of flowers open. The combination of the numbers of the principal growth stage and the secondary stage results in a two digit code.

In general it is easier to observe the beginning of one phase (i.e., the secondary growth stages 0 or 1). Therefore many NMHS have chosen this growth stages for many of their observations, especially for phases at the beginning of the growing season. 50% or BBCHx5 is also used, e.g. in Switzerland. The phenological phase leaf fall is mostly defined with BBCH95, i.e. 9 is the principal growth stage for senescence, beginning of dormancy, secondary growth stage 5 in this case stands for 50% of the leaves have fallen.

2.5 Where

The site of the plant to be observed should be typical for the observation area. Avoid sites which are known to have climatic extremes, or where deviations from characteristic conditions can be expected due to their topography (e.g., southern slopes speed up the plant development in early spring on the other hand frost hollows hamper the growth).

The area to be observed is generally determined by the observer. It is rare for all plants/agricultural crops of the programme to exist in a small space. The following recommendation is given for the extent of an observation area:

An area of observation within a 1.5 – 2.0km radius of the observer’s base (home or workplace) is usually completely sufficient. Longer distances can be covered, whereby the limit should be around 5km from base point.

The “mean” geographical observation site and a “reference height” to which the data refer must be defined for each observation area. This can be done with the help of the observer using an exact map or other means (GPS) to determine the geographical coordinates and height above sea level. The observations should not deviate by more than 50 m above or below this reference height.

2.6 When, how often

The frequency of observations depends on season. In temperate zones during the main vegetation period when temperatures are favourable the plants may develop at a tremendous speed making it necessary to carry out daily observations in order to obtain the exact date of a defined phase; time spans like mid-May are not sufficiently specific. For determining slower processes (such as fruit ripening) two to three visits per week are usually adequate.

Light and visibility (especially fog, deep sun and the general brightness) exert an influence on the sensitiveness for colours of the human eye. Therefore uniform conditions are desirable. For example, the colours of leaves can be determined when the sun is high and behind the observer, (best time for this is early afternoon). This time of the day also helps to eliminate the possibility that phases might have been “missed“ during previous observations (blossoms of different species often do not open until late morning). And to emphasize again, the exact day when reaching a certain phase is to be recorded.

2.7 Observation sheet, observation manual

The network operator has to provide the observer with the observation sheet and observation guidelines.

The observation sheet contains all plants and species that are part of the phenological program. In principal there are at least two possibilities to arrange the spreadsheets: The plants/phases are arranged chronologically according to their appearance in the course of the year, or all phases from one plant are grouped in one line following their natural development. For examples see in the annex.

In case online data delivery via internet exists, it is also of use for the observers to have a list with all plants and species.

The purpose of the network determines when the phases are reported to the center. For agro-meteorological purposes or for pollen monitoring it is necessary to transmit the data as soon as a phase has occurred, while for a generic network it is sufficient that the observations sheets are transferred to the organisation once or twice a year.

The observation manual should give clear rules for the observers. Pictures and graphs help to illustrate the phenological program. As it is unavoidable that some changes will occur over time, so a folder or something similar with exchangeable pages is recommend (as used by the German and Austrian NMHS).

3 Data Documentation – Metadata

3.1 Introduction

Metadata should reflect how, where, when and by whom information was collected. As it is with all other climate data data-documentation in phenology is of paramount importance. The metadata includes the administrative data, data inventories, station description, histories and data set documentation.

The metadata inform the user which phenological data are available, which observing rules are applied, where the stations are located; they help to detect breaks in time series and thus make the observations comparable with each other.

One of the GCOS Climate monitoring principles emphasizes the importance and necessity of metadata: "The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.

Following chapters are based on the WCDMP-53: Guidance on metadata and homogenization, WMO-TD No. 1186 (Aguilar et al., 2004).

3.2 Station identifiers

Station name, aliases, station number/code, opening/closing days, type of station, name, and address of the observer are the basic information which is needed.

Personal data of the observer (name, address, telephone number, email etc.) are also necessary (for instance to keep in contact with volunteers). Some NMHS as the DWD publish a periodical journal for phenological observers not only to keep them informed on new rules but also to give an overview of the scientific utilization of the data they provide and to note anniversaries, etc. All this helps to maintain communication with the observers and motivate them.

3.3 Geographical description and local environment

Basic information for locating the station should be provided in an unambiguous way: geographical longitude, latitude (used system of coordinates), elevation of the reference point, site description (local scale as exposure including orientation of the slope, steepness). Additional information on soil properties and irrigation is helpful when observing agricultural crops (e.g., when the data are used for crop/yield modelling).

Sometimes when observing for a special program (as for example Swiss forest monitoring) it is necessary to mark the trees under observation and to draw maps of their positions, as it is not easy to find the same tree within a forest stand.

3.4 Data set documentation

This gives an overview of which data, i.e., plants including specification of the observed crop varieties and phases, are available from where (site-location) for which time. They are not only useful for the data keeping institution but are very highly needed by data-users. A reference climate station for each phenological observations site is highly recommended. Quality control procedures must be documented if were applied to the data.

Over the years the observation programme might change including modifications of the observed plants and/or the definition of phases e.g. in Switzerland, Primault, 1971, Brügger and Vossalla, 2003. In order to detect such breaks all observation guidelines should be archived.

3.5 The station history

All information on changes that might influence the homogeneity of the data set should be included: changes of observers, location sites, changes of the observation rules. The date of the changes must be recorded.

As phenological observations remain to some respect subjective despite observing guidelines (as is the case with estimation of cloud cover or visibility) it is necessary to keep records on the time (year, month of change) of change of observers even when the location site remains the same.

Even minor changes in the location of the observing sites can cause major differences in the observed data especially when the general rules (see chapter 2.5) are not obeyed.

The instrument for recording the environment and changes in the plant itself (therefore also changes in the observed (perennial) plants) might become very helpful for climate change studies.

4 Data management

4.1 Introduction

Observations are the fundament and grounding of all scientific research and analysis. But before you are able to make some calculations and evaluations, they must be

- collected
- digitised and checked
- archived
- and the most important thing for the research community **accessible**

In former time, data were collected and written only on papers and journals. Every evaluation of the data was very painful, each calculation and graph/plot must be made by operators. But with the use of computers, the only main issue of the basic non scientific work is to get the observations from the station network, digitize and check them and put them in a database system. Essential is, that the scientific community has access to this database. But many of the ultimate use for data cannot be foreseen when the data acquisition programs are planned and frequently new emerge after the information is acquired in the formal models, algorithms and new operational applications. The global climate change issue is an example that is forcing the requirements for climate as well as for phenological data and data management systems to the extreme. To meet this needs, it is critically important that phenological data and information are managed properly in a systematic and comprehensive manner. In phenological data management systems are needed to control and handle data from the traditional observations but also NDVI-data (Normalized Difference Vegetation Index) from satellites. The data management task for a phenological network is very similar to the task for running a climate network. So if you want to have a deeper and more comprehensive insight, please have a look on the **"Guidelines on Climate data Management, WMO, 2005"**.

4.2 Database model

Before building up or redesigning your phenological database, an analysis of the data set is necessary. In the most cases, an inventory of the station network exists which has information about coordinates, altitude of the station and a list of observed species. Additional information like a short area description, the range of altitude in which the observation will take place are very useful. For the quality control process a definition of groups of related stations that depict similar phenological characteristics is desirable. And if you have constraints and thresholds for each group of related stations and for each species, then you have nearly perfect prerequisites for your quality control process. Each quality control step and its result should be stored like a trace for each data value in an own description value, called flag. The flagging values must describe, if a value

- is checked or not
- is original or not
- is suspect or not
- is correct or not
- is calculated or not

and optional, if a value

- is checked automatically or by operator
- is calculated with non suspect values
- is calculated with non missing values

The images and drafts of the station sites could also be stored in the relational database system. But it is recommended, that all these data should be put on a disk-system and only the information how to find that files should be stored in the relational database system. The advantage is, that

- disk space of a file system is much more cheaper than disk space of a relational database system
- to make security copies in a file system is much easier than in a relational database system
- the only disadvantage can be, that users who have write access to the file system can move or rename the files beside the organisation of the inventory in the relational database system. To avoid this, you have to revoke write access to other users.

The design of the data, flagging data and metadata tables depend on your database management system, if you have the possibility to participate on the database equipment of a NMHS, then add your tables to it and you need no own software and hardware for the database. If you have to build up your own database equipment, a standard PC with enlarged memory and additional disks is adequate. The PC operating system can be Linux or something else and the database management system should be a relational one, for instance MySQL.

4.3 Data acquisition

Today, the carrier of a national phenological network is either the NMHS or an University Institute (UK). But in both cases, the approach will be the same. The observer, who are trained to observe a pre-selected list of plants, phases, fruits, etc. put their observations on

- single paper or an email and send this message on the very same day to the collection center
- a seasonal observation or annual paper and after the end of the term it will be sent to the collection center
- an entry mask on a PC which is linked via internet to the collection center (e.g. the International Phenological Gardens, De Natuurkalender in the Netherlands, Nature's Calendar in UK..)

To accelerate the data capture, a digital message system is desirable and more and more carrier will plan such a system. The only prerequisite is, that each observer has his own PC or his own mobile -phone. Important to mention is, that the date of the observation must always be written in the same format, either month and day or day and month. If the format changes, you will run into risk to mix for instant the 3rd of May with the 5th of March. For an easier data evaluation of the observation dates, they will be converted automatically by the data capture software in day of year DOY (that means 1st January = (DOY) 1, 31st January = (DOY) 31, 1st February = (DOY) 32, and so on).

4.4 Data entry

After receiving the paper - data from the observers and entering station identification and type of data message in a book of arrivals, first checks should be made:

- have all papers a station identification, if not, maybe you can catch it from the envelope.
- have all papers the right year?

Data which are incoming by email or SMS (Short Message Service) should be raw checked in the same way as paper data. This could be done by an automatic checking system as well as by operator. If an error is detected, a reply to the observer should be sent. But in any case, a mark should be made in the book of arrivals.

Data from the entry mask on station site (observer site) should have the same checks as the entry mask at the collection center.

The entry mask should have a raw data check system, like

- only a 29th February on a leap year and
- 30th February or 31th April, June, September and November should not be possible.

4.5 Data Quality control

With this process, a deeper and more comprehensive examination of the data must be done. It can only be processed, after the incoming data had passed successful the raw data checking process. Furthermore it is required, that all (or nearly all) data for a species for one area are available.

The data quality control process should include

- a check based on constraints for each species in dependence of altitude and area. If a date exceeds the constraints, the data must be wrong. Constraints are absolute limits.
- a check bases on thresholds for each species in dependence of altitude and area, if a date exceeds, only a warning is given. With this check extreme but perhaps true events should be marked and flamboyant for the checking staff.
- There must be a sequence of phases. For instance, this order is shown with the increase of the BBCH code, starting from germination / sprouting / bud development up to senescence / beginning of dormancy.

The data control software must guarantee, that all data passes this process and the results must be marked in flags. No bypassing of this data process must be allowed and possible. Handbooks and instructions, how to run this process must be written, and the data quality control staff must obey that guidelines.

Quality assurance

To assure the quality of the whole data management process, an owner for each sub-process must be nominated. In small institutes or NMHSs, only one person could be responsible for the whole process. This person(s) is/are responsible for the contents and for the recent technical and scientific status of the handbooks, manuals and rules, which describe the handling of the process. Each aberration and variation must be detected and revised. From time to time an internal and an external audit must take place to guarantee the quality of the quality control process.

The sub-processes which must be controlled are, that

- the necessary station density is guaranteed
- the selected species and phases accord to the historian and recent requests
- the observations were made accurate and in time
- the mailing system works and with the help of the evaluation of the book of arrivals missing reports and messages can be detected and requested if they are missing
- the quality of data entry and data quality control guide to precise and accurate data
- the quality of hard- and software, which guarantees a carefree operation with a lot of security copies of the data and metadata
- your security policy and security activities prevent losing or damaging your database system and keep your complete facilities in the best possible condition

4.6 Organisation of the digital database and paper archive

must be done in such a way, that

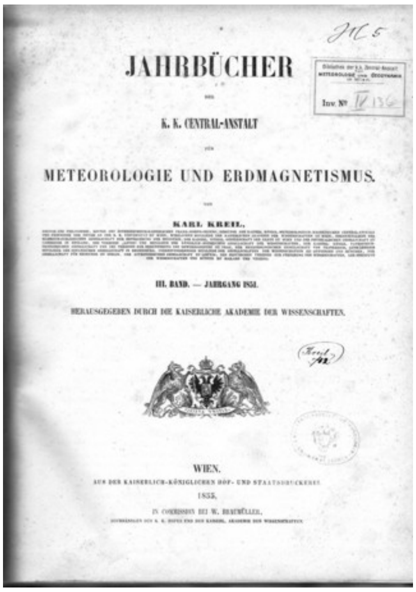
- retrieval of data and metadata both in digital format and paper must be easy. Particularly the digital access must be easy, and applications for standard evaluation should exist. This point is strict related to the database design. The construction of the tables must guarantee an easy and fast access to data.
- the digital database runs behind a firewall in the highest possible secure level having no email and other unnecessary services running. Backups must be made and must be put in a safe, secure and fire proof location remote from the database. Only protected applications permitted to a small group of people have the right to handle data manipulations (insert, update, delete). People, who have write access to the database must agree not to make any transaction beside the operations and practices of the organisation. There should be a policy of not sharing passwords as well as not writing down passwords on paper. Also a changing of passwords is required.
- the paper archive should be administrated in such a way, that only a limited number of staff has access to the paper archive. Loan out of paper must be documented. For security reasons, it is recommended to scan (or make photos with a digital camera) the papers like the way described by the Guidelines on Climate Rescue, 20043, WCDMP-No55.
- the whole facilities up from paper archive to digital database must be protected and sheltered against fire, water, flood, humidity and temperature extremes, insects, pest, etc.

Satellite images

To describe the management of the satellite images is not part of these guidelines for the surface network, but important to mention. The most well known satellite archive for scientific purpose is situated at the NCDC (National Climatic Data Center) in Asheville, USA. (http://www.ncdc.noaa.gov/). More huge satellite archives can be found at the Australian Bureau of Meteorology, CMA (China Meteorological administration), JMA (Japan Meteorological Agency), IKI RAN (Russian Space Monitoring Information Support laboratory of Space Research Institute), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), and others. A simple query in an Internet searching machine leads you easy to these Web Portals.

5 Going public – publications, services and products

5.1 Introduction


JAHRBÜCHER

K. K. CENTRAL-ANSTALT

METEOROLOGIE UND ERDMAGNETISMUS.

KARL KREIL.

III. BAND. — JAHRGANG 1851.

HERAUSGEGEBEN DURCH DIE KAISERLICHE AKADEMIE DER WISSENSCHAFTEN.

WIEN.

1855.

Many NHMS have been publishing their phenological data (since their establishment) in yearbooks, monthly climate reviews, weekly bulletins etc. These consist mainly of tables and in general were made for other phenologists, climatologists or meteorologists or at least related scientists.

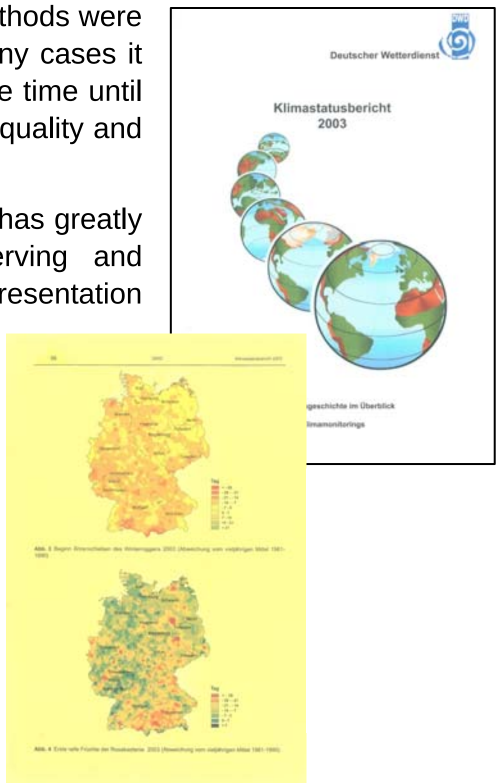
Since the advent of interest in climate and climate impacts by not only climate researchers but of the general public, and with the availability of electronic data processing and publishing/graphic software many NHMSs have started to edit professional-looking and attractive reviews with graphs and maps along with tables.

Periodical and occasional data-publications meet the more general need for data, customer tailored services and products help to strengthen the relationship between the NHMS and their clients.

5.2 Periodical Publications

In the pre-electronic era, traditional (non-automatic) methods were used to prepare monthly or annual reports, and in many cases it took quite a long time to create them. First it took some time until the data were available at the NHMS-center, and then quality and completeness checks need to be applied.

The use of computers and modern telecommunication has greatly simplified and shortened the time between observing and publishing. Data entry, quality control, analysis and presentation format of the output can often be accomplished in one system. Only the final review need be done manually.



„Klimastatusbericht 2003“ of Deutscher Wetterdienst cover and page with phenological maps

The output can be printed on paper, stored on electronic media (e.g., on CD-ROM) or directly put on the NHMS-WebPages or ftp-zone which offers very effective and quick access for the users. The utilization of electronic media has a high cost-performance ratio and has enhanced the attractiveness of many publications by using color-graphs, etc. Some NHMSs are now also publishing (in addition to the classic yearbooks) climate and phenological status reports once a year containing written text and statistics (e.g., comparisons of the actual year with the long term average) and the IPG publish the ARBORETA PHAENOLOGICA once a year.

5.3 Occasional Publications

The publication of periodicals is locked into a rigid schedule whereas occasional non-routine publications can be planned to meet a general but not rigidly-fixed deadline. The users of those publications are manifold including researchers from the climate impact community, from members of the general public whose interests are academic or casual, for environmental agencies, and so on.

Long-term continuous time series are of great value for research on climate change impacts, and frequency distributions of phenological entry dates offer a insight into the variability of phenological phases. Background information on station location, observing rules and applied quality checks improves the value of the phenological data. Supplementary climatological data might also be helpful for the users.

As with climate data, the services should publish phenological data for a selection of representative stations once a decade.

5.4 Services and Products

Services for the media

Good relationships with the media is now essential. The media can help focus the interest of not only the general public but also of politicians and decision makers to climate change and climate change impacts, and as a consequence help the NHMSs to raise their perceived relevance and importance in climate change issues.

Regular and occasional press releases issued on certain specific items are essential in creating a good climate between the media and NHMSs. Keeping personal contacts and having time and an “open ear” for the needs of journalists is necessary.

Services for the general public

In moderate climate regions there is considerable interest in phenology especially in spring (the beginning of the growing season). Putting on the NHMS-webpage phenological information of actual phenological events compared with the long term average, can be very attractive and raise environmental awareness in general, and especially related to weather and climate impacts.

Services and customer tailored products for different users

The user group can be divided into internal and external users. Both the internal and external user needs have to be met by the phenological data provider (which is mostly the climatological department within a NHMS). But how to know what is really needed? Within a NHMS it should be easy to communicate the needs of the user groups (very often the forecast department and/or the agro meteorological service) to the phenological data-provider. To improve the collaboration and effectiveness it is also necessary that the phenological data be delivered on time and in the required format.

Users outside the NHMS must first get informed about the principal availability of phenological data. External data access depends on the policy of the NHMS, therefore free access of data from the phenological station network differs from country to country. The inventory of the station network by location, geographic coordinates, altitude and data availability (i.e., metadata in a table and map view) should be free without any charge on each homepage of the NMHS or other data provider. Even in Europe, where the NHMS policy is characterized by very limited free access of data and station information, there is a procedure for giving more information without restriction. Ideally, the homepage of the data provider should present at least which data from which location and for which time frame could be used. Some examples of the utilization would also be helpful.

For producing customer-tailored products, understanding of customer needs and requirements is essential. For some time awareness of market demands has been growing and product development has proceeded in two different ways. First, there are value-added products, that produce customer-tailed solutions. With these products the NHMSs earn money and the customers receive exactly that information they want. Costumers are not interested in additional but useless information.

Secondly there are bulk products, which should be provided with less effort and maximum coverage. Such products are paid for by public money and they should be disseminated by a very cheap medium. The best solution is to publish them on your homepage.

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Annex

IPG observation programme

Plant No.	Standard Programme *Art*, Herkunft ***Species*, provenance**	Plant No.	Expanded Programme *Art*, Herkunft ***Species*, provenance**	***English name*** ***Englischer Name***
1 1 1	***Larix decidua***, Germany			***European larch***
		1 1 2	*Larix decidua*, E-France	
		1 1 3	*Larix decidua*, S-Poland	
		1 1 4	*Larix decidua*, Czech Republic	
		1 1 5	*Larix decidua*, N-Italy	
1 2 1	***Picea abies*** (early), German*y*			***Norway spruce***
1 2 2	*Picea abies* (late), Germany			
1 2 3	*Picea abies* (northern), Norway			
		1 2 4	*Picea abies* (late), E-Poland	
		1 2 5	*Picea abies* (average), E-Poland	
		1 2 6	*Picea abies*, E-Germany	
		1 2 7	*Picea abies*, E-France	
		1 2 8	*Picea abies*, N-Scandinavia	
		1 2 9	*Picea omorika*, Croatia	*Serbian spruce*
1 3 1	***Pinus sylvestris***, Poland			***Scots pine, Fir***
		1 3 2	*Pinus sylvestris*, E-France	
		1 3 3	*Pinus sylvestris*, N-Scandinavia	
2 1 1	***Betula pubescens***, Germany			***White birch, Downy birch***
		2 1 5	*Betula pendula*, N-Poland	*Silver birch*
		2 1 6	*Betula pendula*, N-Scandinavia	
2 2 1	***Fagus sylvatica*** (Hardegsen), Ger*.*			***Common beech***
2 2 2	*Fagus sylvatica* (Düdelsheim), Ger.			
2 2 3	*Fagus sylvatica* (Trippstadt), Ger.			
		2 2 4	*Fagus sylvatica*, Denmark	
		2 2 6	*Fagus orientalis*, Balkan	*Oriental beech*
2 3 1	***Populus canescens***, Germany			***Grey poplar***
2 3 5	***Populus tremula***, Germany			***Trembling poplar, Aspen***
		2 3 6	*Populus tremula*, E-Poland	
		2 3 7	*Populus tremula*, S-Finland	
		2 3 8	*Populus tremula*, Ireland	
		2 3 9	*Populus tremula*, Greece	
2 4 1	***Prunus avium*** (Bovenden), Ger.			***Wild Cherry***
2 4 2	*Prunus avium* (Lutter), Ger.			
2 5 1	***Quercus petraea*** (Zell/Mosel), Ger.			***Sessile oak***
		2 5 3	*Quercus petraea*, Croatia	
2 5 6	***Quercus robur*** (Wolfgang), Ger.			***Common oak***

2 5 7	*Quercus robur* (Barlohe), Ger.	**2 5 8**	*Quercus robur*, Croatia	
2 6 1	***Robinia pseudoacacia***, USA			***Locust, Common robinia***
2 7 1	***Sorbus aucuparia***, Czech Rep.	**2 7 2**	*Sorbus aucuparia*, N-Scandinavia	***Mountain ash***
2 8 1	***Tilia cordata***, Germany			***Small-leaved lime***
3 1 1	***Ribes alpinum***, Austria			***Alpine currant***
3 2 1 **3 2 3** **3 2 4** **3 2 5** **3 2 6**	***Salix aurita***, Germany ***Salix acutifolia***, Germany ***Salix smithiana***, Germany ***Salix glauca***, Greenland ***Salix viminalis***, Germany			***Roundear willow*** ***Pussy willow*** ***Smith's willow*** ***Grey leaved willow*** ***Basket willow***
3 3 1	***Sambucus nigra**,* Germany			***Common elder***
4 1 1 **4 2 1** **4 3 1**	***Corylus avellana '****P.Müller.Platz**'*** ***Forsythia suspensa*** *'Fortunei'* ***Syringa x chinensis*** *'Red Rothomagensis'*			***Hazelnut*** ***Forsythia*** ***Common lilac***

GPM observation program

Table 1 Standard program

Species	variety	Rootstock	Minimum distance (m)
Almond *Prunus dulcis*	Perle der Weinstraße	St. JulienA	3.0
red currant *Ribes rubrum*	Werdavia (white variety)	own rooted	1.5
sweet cherry *Prunus avium*	Hedelfinger, type 'Diemitz'	GiSelA 5	3.0
Morello *Prunus cerasus*	Vladimirskaja	own rooted	3.0
Pear *Pyrus communis*	Doyenne de Merode	OHF 333	3.0
Apple *Malus domestica*	Yellow Transparent	Malus transitoria	2.5
Apple *Malus domestica*	Golden Delicious	M26	3.0
European chestnut *Castanea sativa*	Dore de Lyon	seedling	detached

Table 2 Flowering phase of GPM observation program

Species	variety	Rootstock	Minimum distance (m)
Witch hazel	Jelena	-	2.5
snowdrop *Galanthus nivalis*	genuine	-	-
Forsythia	Fortunei	own rooted	1.5
Lilac *Syringa vulgaris*	Rothomagensis	own rooted	2.5
Mock orange	genuine	own rooted	3.0
Heather	Allegro	own rooted	0.5
Heather	Long white	own rooted	0.5
Witch hazel	genuine	own rooted	2.5

The objects under observation do not have to be planted in a specified order. The optimum growing site is without doubt open ground without obstacles, traffic routes, detrimental (e.g. game bite) or favorable influences (e.g. artificial light) or influences of the other objects under observation. As such conditions are certainly the exception, minimum standards have to be defined. The above-mentioned minimum distances are only valid when the objects under observation have been planted by taking account of the direction in which the different species of the GPM program are set against each other (for more details see 44). If the object under observation stands near obstacles the following applies: The minimum distance from the base of any obstacle (building, tree, wall, ...) should be at least 1.5 times the height of the obstacle, however, two times from the edge of the woods. The distance from a two-lane road should be at least 8 m, from an eight-lane highway, however, at least 25m. Larger distances are desirable and consequently “no problem“.

European backbone program

When establishing a new network in European some of the following plants and phases should be observed (E. Bruns and A. v. Vliet, 2003 and E. Bruns personal communication)

Table 1 Forest and ornamental trees and bushes

Species	Phenophases (BBCH-code)
Aesculus hippocastanum	Beginning of bud breaking (BBCH07), Leaf unfolding (BBCH11), First flowers open (BBCH60), First ripe fruits (BBCH86), Colouring of leaves (BBCH94), 50% of leaves fallen (BBCH95)
Alnus glutinosa	Leaf unfolding (BBCH11), First flowers open (BBCH60)
Betula pendula (*B.verrucosa, B.alba*)	Leaf unfolding (BBCH11), First flowers open (BBCH60), Colouring of leaves (BBCH94), 50% of leaves fallen (BBCH95)
Cornus mas	First flowers open (BBCH60),First ripe fruits (BBCH86)
Corylus avellana	First flowers open (BBCH60), First ripe fruits (BBCH86), 50% of leaves fallen (BBCH95)
Fagus sylvatica	Leaf unfolding (BBCH11), First ripe fruits (BBCH86), Colouring of leaves (BBCH94), 50% of leaves fallen (BBCH95)
Fraxinus excelsior	Leaf unfolding (BBCH11), First flowers open (BBCH60)
Larix decidua	Beg. of unfolding of needles (BBCH10)
Picea abies (*P.excelsa*)	Beginning of May sprouting (BBCH10), First flowers open (BBCH60)
Pinus silvestris	First flowers open (BBCH60)
Prunus spinosa	First flowers open (BBCH60)
Quercus robur (*Q.peduncula*)	Leaf unfolding (BBCH11), First ripe fruits (BBCH86), Colouring of leaves (BBCH94), 50% of leaves fallen (BBCH95)
Robinia pseudoacacia	First flowers open (BBCH60), Full flowering (BBCH65)
Rosa canina	First flowers open (BBCH60), First ripe fruits (BBCH86)
Salix caprea	First flowers open (BBCH60)
Sambucus nigra	Leaf unfolding (BBCH11), First flowers open (BBCH60), First ripe fruits (BBCH86), 50% of leaves fallen (BBCH95)BBCH95)
Sorbus aucuparia	Leaf unfolding (BBCH11), First flowers open (BBCH60), First ripe fruits (BBCH86)
Syringa vulgaris (purple, white, 'Red Rothomagensis')	First flowers open (BBCH60)
Tilia cordata	Leaf unfolding (BBCH11), First flowers open (BBCH60), Colouring of leaves (BBCH94), 50% of leaves fallen (BBCH95)

Table 2 Herbs

Species	**Phenophases (BBCH-code)**
Anemone nemorosa	First flowers open (BBCH60)
Chrysanthemum leucanthemum (*Leucanthemum vulgare*)	First flowers open (BBCH60)
Colchicum autumnale	First flowers open (BBCH60)
Dactylis glomerata	First flowers open (BBCH60)
Galanthus nivalis	First flowers open (BBCH60)
Taraxacum officinale	First flowers open (BBCH60)
Tussilago farfara	First flowers open (BBCH60)

Table 3 Fruit trees and bushes, and grapevine

Species	**Phenophases (BBCH-code)**
Malus domestica	First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69), Fruits ripe for picking (BBCH87), 50% of leaves fallen (BBCH95)
Prunus armeniaca (*Armeniaca vulgaris*)	First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69), Fruits ripe for picking (BBCH87)
Prunus avium (*Cerasus avium*)	First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69), Colouring of leaves (BBCH94)
Prunus cerasus	First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69)
Pyrus communis	First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69), Fruits ripe for picking (BBCH87)
Ribes rubrum (*R.sylvestre*)	First flowers open (BBCH60), Fruits ripe for picking (BBCH87)
Vitis vinifera	Beginning of bud burst (BBCH07), Leaf unfolding (BBCH11), First flowers open (BBCH60), Full flowering (BBCH65), End of flowering (BBCH69); Beginning of ripening (BBCH81) *or* berries developing colour (BBCH83) or/and softening of berries(BBCH85), beginning of leaf-fall(BBCH94) *and/or* 50% of leaves fallen(BBCH95)

Table 4 Crops

Species	**Phenophases (BBCH-code)**
Meadow	first cut (silage winning), First cut (hay winning),
Beta vulgaris (only sugar beet)	Drilling (BBCH00), Sprouting (BBCH10), close stand (**BBCH35**), harvest
Helianthus annuus	Sowing (BBCH00), Emergence (BBCH10), Beginning of heading (BBCH51), beginning of flowering – ray florets extended, disc florets visible in outer third of inflorescence (BBCH61), Fully ripe (BBCH89), Harvest
Hordeum vulgare	Sowing (BBCH00), Emergence (BBCH10), Heading (BBCH55), Beginning of milk ripeness (BBCH75), Yellow ripe (BBCH85), Fully ripe (BBCH89), Harvest

Examples of observation sheets

GPM observation sheet

Global Phenological Monitoring (GPM)

Observation Sheet 2006

Station: Mean sea level: Country: Observer (Organisation):

Latitude (in ‘ and ‘‘): Longitude (in ‘ and ‘‘): Soil:

observation object	SL	UL	BF	RF/RP	CL	FL
almond 'Perle der Weinstraße'						
Red currant 'Werdavia' (white variety)						
sweet cherry 'Hedelfinger', typ 'Diemitz'						
morello 'Vladimirskaja'						
pear 'Doyenne de Merode'						
apple 'Yellow Transparent'						
apple 'Golden Delicious', typ ‘Golden Reinders‘						
European chestnut 'Dore de Lyon'						

	SL	UL	BF	FF	EF	
witch hazel / Hamamelis x Intermedia 'Jelena'						
snow drops / Galanthus nivalis 'genuine‘						
forsythia / Forsythia suspensa 'Fortunei'						
lilac / Syringa x chinensis 'Red Rothomagensis‘						
mock-orange / Philadelphus coronarius 'genuine‘						
heather / Calluna vulgaris 'Allegro'						
heather / Calluna vulgaris 'Long White'						
witch hazel / Hamamelis virginiana 'genuine‘						

SL = sprouting of leaves, **UL** = unfolding of leaves, **BF** = beginning of flowering, **FF** = full flowering, **EF** = end of flowering, **RF** = first ripe fruits, **RP** = fruit ripe for picking, **CL** = colouring of leaves, **FL** = falling of leaves

Please fill in the white fields, Remarks / information please note down on the backside of the observation sheet

Slovenia: Hidrometeoroloski Zavod R. Slovenije

HIDROMETEOROLOŠKI ZAVOD R SLOVENIJE

FENOLOŠKO POROČILO

Ime postaje: ____________________

Ime in priimek opazovalca: ____________________

Št. 1 2 3 leto 4 5

mesec: ____________

I. NEGOJENE ZELNATE RASTLINE

Zap. št.	IME RASTLINE	6	datum prvih cvetov (11)
1	MALI ZVONČEK Galanthus nivalis L.	01001	
2	LAPUH Tussilago farfara L.	01002	
3	POMLADANSKI ŽAFRAN Crocus napolitanus hort. ex Mordant.	01003	
4	REGRAT Taraxacum officinale L.	01004	
5	IVANJŠČICA Leucanthemum ircutianum (Tucz)	01005	
6	JESENSKI PODLESEK Colchicum avtomnale L.	01006	
7	NAVADNA AMBROZIJA Ambrosia artemisiifolia L.	01008	

II. GOZDNO DREVJE IN GRMIČJE

Zap. št.	IME DREVESA ALI GRMA	6	DATUM: prvih listov (11)	prvih cvetov (15)	splošno cvetenje (19)	prvi zreli plodovi (semena) (23)	splošnega rumenenja listja (27)	splošnega odpadanja listja (31)	POJASNILA
1	DIVJI KOSTANJ Aesculus hippocastanum L.	02001							
2	ROBINIJA Robinia pseudacacia L.	02002	6 6 6 6						
3	LIPA Tilia platyphyllos Scop.	02003				6 6 6 6			
4	LIPOVEC Tilia cordata Mill.	02004				6 6 6 6			
5	ČRNI TOPOL Populus nigra L.	02005			6 6 6 6	6 6 6 6			
6	VELIKI JESEN Fraxinus excelsior L.	02006			6 6 6 6	6 6 6 6			
7	DOB Quercus robur L.	02007			6 6 6 6	•			• odpadanje želoda
8	GRADEN Quercus sessiliflora Salisb.	02008			6 6 6 6	•			• odpadanje želoda
9	HRAST ... Quercus sp. ...				6 6 6 6	•			• odpadanje želoda
10	NAVADNA BREZA Betula pendula Roth.	02009			6 6 6 6	6 6 6 6			
11	ČRNA JELŠA Alnus glutinosa Gaertn.	02010		•					• pričetek prašenja mačic
12	TREPETLIKA Populus tremula L.	02011			6 6 6 6	6 6 6 6			
13	BUKEV Fagus sylvatica L.	02012			6 6 6 6	•			• odpadanje bukovega žira
14	IVA Salix caprea L.	02013	6 6 6 6						
15	RDEČI BOR Pinus sylvestris L.	02014	•						• mladi poganjki
16	ČRNI BOR Pinus nigra Arnold.	02029	•						• mladi poganjki
17	SMREKA Pice abies (L.) Karsten.	02015	•						• mladi poganjki
18	JELKA Abies alba Mill.	02016	•						• mladi poganjki
19	ŠPANSKI BEZEG Syringa vulgaris L.	02017							
20	ČRNI BEZEG Sambucus nigra L.	02018				•			• plodovi so črni
21	ŠIPEK Rosa canina L.	02019	6 6 6 6						
22	ENOVRATI GLOG Crataegus monogyna Jacq.	02020	6 6 6 6						
23	ČRNI TRN Prunus spinosa L.	02021							
24	NAVADNA LESKA Corylus avellana L.	02022	6 6 6 6	•		o			• prašenje mačic o plodovi so okusni
25	RUMENI DREN Cornus mas L.	02023	6 6 6 6						
26	VRESA Calluna vulgaris (L.) Hull.	02024	6 6 6 6						
27	ŽUKA Spartium junceum L.	02025	6 6 6 6						
28	ROŽMARIN Rosmarinus officinalis L.	02030	•						• brstenje
29	LOVORIKA Laurus nobilis L.	02031	6 6 6 6						

SMA - Bio- und Umweltmeteorologie
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ISM - Biometeoroliga e meteorologia ambientale

KULTURPFLANZEN PLANTES CULTIVÉES PIANTE COLTIVATE		Beginn der Blüte Début de la floraison Inizio della fioritura	Vollblüte Pleine floraison Piena fioritura	Bemerkungen Remarques Osservazioni
Kirschbäume * Prunus avium *	Cerisiers * Ciliegi *	61.	62.	
Birnbäume * Pyrus communis *	Poiriers * Peri *	63.	64.	
Apfelbäume * Pyrus malus *	Pommiers * Meli *	65.	66.	
		Vollblüte Pleine floraison Piena fioritura	Weinlese Vendanges Vendemmia	
Weinrebe * Vitis vinifera *	Vigne * Vigna *	67.	68.	
		Beginn Début Inizio		
Heuernte	Fenaison Fienagione	69.		

KRÄUTER HERBACÉES ERBACEE		Vollblüte Pleine Floraison Piena fioritura	Bemerkungen Remarques Osservazioni
Huflattich Tussilago farfara	Pas-d'âne Farfaro	53.	
Buschwindröschen Anemone nemorosa	Anémone sylvie Anemone	54.	
Wiesen-Knaulgras Dactylis glomerata	Dactyle aggloméré Erba mazzolina comune	55.	
Löwenzahn Taraxacum officinale	Dent-de-lion Dente di leone	56.	
Wald-Weidenröschen Epilobium angustifolium	Epilobe à feuilles étroites Garofano maggiore	57.	
Wiesenschaumkraut Cardamine pratensis	Cardamine des prés Cardamina dei prati	58.	
Wucherblume/Margerite Leucanthemum vulgare	Grandes marguerites Margherita	59.	
Herbstzeitlose Colchicum autumnale	Colchique Colchico	60.	

* Sorte notieren - Noter la sorte - Annotare la varietà

ab 1996

Jahr
Année
Anno ___________

PHAENOLOGISCHE BEOBACHTUNGEN
OBSERVATIONS PHÉNOLOGIQUES
OSSERVAZIONI FENOLOGICHE

Station - Station - Stazione ___________________________

Gemeinde - Commune - Comune ___________________________

Kanton - Canton - Cantone ___________________________

Beobachter - Observateur - Osservatore ___________________________

Meereshöhe - Altitude - Altitudine ___________________________

Exposition - Exposition - Esposizione ___________________________

- Bitte das Formular sofort nach der letzten Eintragung zurücksenden:
- A retourner immédiatement après la dernière inscription s.v.p.
- Il formulario dev'essere rispedito immediatamente subito dopo l'ultima registrazione

Schweizerische Meteorologische Anstalt
Bio- und Umweltmeteorologie
Postfach 514
CH-8044 Zürich

SMA - Bio- und Umweltmeteorologie
ISM - Biométéorologie et environnement
ISM - Biometeoroliga e meteorologia ambientale

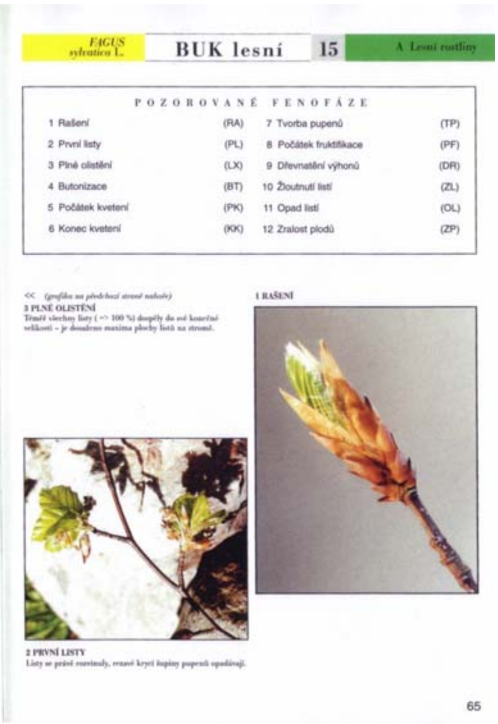
Zusammenfassung der phänologischen Beobachtungen
Résumé des observations phénologiques
Riassunto delle osservazioni fenologiche

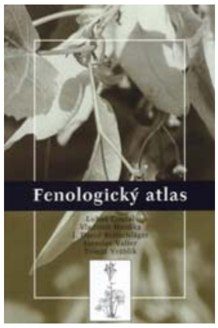
BÄUME UND STRÄUCHER ARBRES ET ARBUSTES ALBERI E ARBUSTI		Blattentfaltung Déploiement des feuilles Spiegamento delle foglie	Beginn der Blüte Début de floraison Inizio della fioritura	Vollblüte Pleine floraison Fioritura	Fruchtreife Fruits mûrs Frutti maturi	Blattverfärbung Coloration des feuilles Colorazione delle foglie	Blattfall Chute des feuilles Caduta delle foglie	Bemerkungen Remarques Osservazioni
Rosskastanie Aesculus hippocastanum	Marronnier Castagno d'India	1.	2.	3.		4.	5.	
Buche Fagus sylvatica	Hêtre Faggio	6.				7.	8.	
Bergahorn Acer pseudoplatanus	Erable de montagne Acero montano	9.				10.		
Vogelbeere Sorbus aucuparia	Sorbier des oiseleurs Sorbo degli uccellatori	11.	12	13.	14.	15.	16.	
Haselstrauch Corylus avellana	Noisetier Nocciolo	17.	18.	19.				
Sommerlinde Tilia platyphyllos	Tilleul à grandes feuilles Tiglio nostrano	20.	21.	22.		23.		
Roter Holunder Sambucus racemosa	Sureau à grappes Sambuco montano		24.	25.	26.			
Schwarzer Holunder Sambucus nigra	Sureau noir Sambuco nero		27.	28.	29.			
Winterlinde Tilia cordata	Tilleul à petites feuilles Tiglio riccio	30.	31.	32.		33.		
Lärche Larix decidua	Mélèze Larice	34.				35.	36.	
Fichte Picea abies	Epicéa Abete rosso	37.						
Robinie Robinia pseudoacacia	Robinier Robinia	38.	39.	40.			41.	
Hängebirke Betula pendula	Bouleau commun Betulla bianca	42.	43.	44.		45.	46.	
Edelkastanie Castanea sativa	Châtaignier Castagno domestico	47	48.	49.	50.	51.	52.	

Samples of phenological manuals

Deutscher Wetterdienst (1991)

Czech Hydrometeorological Institute (2004)





MeteoSwitzerland (2004)

Schwarzer Holunder

Holler, Deutscher Flieder

Blüte

Datumsmethode

- *Beginn der Blüte:* Bei drei Blütenständen des Strauches, bzw. bei jeweils drei Blütenständen an drei Sträuchern des Bestandes, haben sich die ersten Blüten vollständig geöffnet, d.h. die Kronzipfel stehen jeweils mit einem Winkel von 90° vom Blütenstängel ab.
- *Allgemeine Blüte:* 50% der Blüten am Strauch bzw. im Bestand sind offen, d.h. die Zipfel der Kronblätter stehen mit einem Winkel von 90° vom Blütenstängel ab, oder die Blüten sind bereits wieder verwelkt.

Prozent-Schätzmethode

Der aktuelle Anteil der offenen Blüten (d.h. die Zipfel der Kronblätter stehen mit einem Winkel von 90° vom Blütenstängel ab, oder die Blüten sind bereits wieder verwelkt) ist abzuschätzen.

Fruchtreife (Farbbild 12, S. 111)

Datumsmethode

- *Allgemeine Fruchtreife:* 50% der Einzelfrüchte des Strauches bzw. des Strauchbestandes haben ihr normales Reifestadium erreicht, d.h. sie sind schwarz und platzen bei leichtem Druck auf.

Prozent-Schätzmethode

Der aktuelle Anteil der reifen Früchte, die ihr normales Reifestadium erreicht haben, d.h. schwarz sind und bei leichtem Druck aufplatzen, ist abzuschätzen.

94 SAMBUCUS NIGRA L. sambuco nero 95

Sureau noir

grand sureau

Floraison

Méthode de la date

- *Début de la floraison :* sur l'arbuste observé, les premières fleurs de trois inflorescences se sont entièrement ouvertes ; les lobes de chaque corolle s'écartent perpendiculairement à la tige de la fleur. Dans un peuplement, cela doit être le cas sur trois arbustes.
- *Floraison générale :* 50 % des fleurs de l'arbuste ou du peuplement sont ouvertes (les lobes de chaque corolle s'écartent perpendiculairement à la tige de la fleur) ou déjà fanées.

Méthode d'estimation du pourcentage

Il s'agit d'estimer le pourcentage actuel des fleurs ouvertes (chez lesquelles les lobes de la corolle s'écartent perpendiculairement à la tige de la fleur) ou déjà fanées.

Maturité des fruits (photo couleur 12 ; p. 111)

Méthode de la date

- *Maturité générale des fruits :* 50 % des fruits de l'arbuste ou du peuplement ont atteint leur stade de maturité normal ; ils sont noirs et éclatent lorsqu'on les presse légèrement.

Méthode d'estimation du pourcentage

Il s'agit d'estimer le pourcentage actuel des fruits mûrs ayant atteint leur stade de maturité normal (noirs et éclatant lorsqu'on les presse légèrement).

Abbildung 22: Blüte des Schwarzen Holunders
Die kleinen Einzelblüten wachsen im Blütenstand fast auf einer Ebene dicht beisammen. Gezeichnet ist der Blütenstand bei 50% offenen Blüten. Die vergrösserte Detailzeichnung stellt eine geschlossene, eine sich öffnende und eine offene Blüte dar.

Figure 22 : Floraison du sureau noir
Les différentes petites fleurs de l'inflorescence poussent serrées les unes contre les autres, presque sur un plan. Le dessin montre l'inflorescence au moment où 50 % de ses fleurs sont ouvertes. Le détail agrandi représente une fleur fermée, une s'ouvrant et une ouverte.

Farbbild 11A: Blattverfärbung der Sommerlinde (gilt auch für die Winterlinde) "Fleckenverfärbung" im Frühherbst.

Farbbild 11B: Blattverfärbung der Sommerlinde (gilt auch für die Winterlinde) Kronenausschnitt mit 50% Blattverfärbung (die abgefallenen Blätter mitgezählt!).

Farbbild 12: Fruchtreife des schwarzen Holunders. Ein Fruchtstand mit abgefressenen/abgefallenen, einer mit reifen Beeren. Im Hintergrund sind zwei weitere mit noch grünen, unreifen Beeren.

Farbbild 13: Fruchtreife des roten Holunders. Auf dem Bild sind 90% der Beeren reif.

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Photo couleur 11A : Coloration des feuilles du tilleul à grandes feuilles (également valable pour le tilleul à petites feuilles) 50 % des feuilles ont changé de couleur : extrait d'une branche (coloration par taches en début d'automne).

Photo couleur 11B : Coloration des feuilles du tilleul à grandes feuilles (également valable pour le tilleul à petites feuilles) 50 % des feuilles ont changé de couleur : extrait de la couronne (feuilles tombées incluses !).

Photo couleur 12 : Maturité des fruits du sureau noir. Une grappe avec des baies rongées ou tombées, une avec des baies mûres. A l'arrière-plan deux grappes avec des baies vertes.

Photo couleur 13 : Maturité des fruits du sureau rouge. Sur la photo, 90% des baies sont mûres.