PROTOCOLS FOR PHENOLOGICAL MONITORING OF HERBACEOUS SPECIES

Version 4.0

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Remark: Compared to the published version 3.0, the sections 2.1, 2.2., 4, 4.2, and 5 were revised and adapted to new workflows of the project. Throughout the whole protocol minor textual corrections were made.

Table of Contents

Purpose and Objectives of the PhenObs Project

PhenObs is an international network of Botanical Gardens. Our aim is to investigate the phenology of herbaceous species and how phenology is affected by global change. This knowledge will help us to improve our understanding of the implications of phenological shifts for biodiversity, ecosystem functions and services. We will achieve our aims through the collection of phenological and trait data across a global range of sites using standardised protocols. Specifically, our main research questions are:

• How does the phenology i.e. distinct phenological phases of herbaceous species vary at regional and global scale?

• What are the drivers of variation in plant phenology in herbaceous species across the growing season and in response to variation in climate?

• Can plant phenology be predicted from species' trait composition, provenance, position and extent of the distribution range and species' phylogeny (as proxy for their eco-physiological adaptation)?

• What are the implications of this variation with respect to species performances and assembly, biotic interactions as well as ecosystem processes and services under changing land-use and climate?

1. Definitions of stages

The phenological stages that should be monitored have been selected because they influence key aspects of species performance and fecundity and have important implications for ecosystem functions, services and trophic interactions.

In best circumstances, populations of ~1m² in size have to be selected, which may be also mixed populations with other species. For each species some main data characterizing the site conditions (size of the population, number and density of individuals, information about competition, shading and soil parameters) need to be recorded once.

Recording of a stage should begin when it is visible on at least one individual in a population (geophytes and hemicryptophytes) or three main branches of one individual (sub-shrubs/ chamaephytes).

Some species exhibit stages several times in one year, for example, some *Geranium* sp. produce two flushes of new leaves and flowers in a year. All observations of such events should be recorded. The column "new leaves unfolding" always records new leaves. In case of a second/additional flower period, this event will be listed automatically in the column "Flowers opening" when "yes" is noted after a period with no entries.

1.1 Vegetative phenology

1.1.1 Initial growth

Initial growth is the production of new tissues after a period of no growth. In the case of chamaephytes, this is defined as the time when bud swell can be observed (Figure 1). For geophytes, initial growth is the appearance of vegetative shoots aboveground, for hemicryptophytes this may be growth of a new shoot, leaf or leaf sheath.

Some hemicryptophytes and geophytes have overwintering buds aboveground. These usually appear in autumn and stay dormant until the start of the growing season in spring (e.g. *Paeonia* sp., *Podophyllum* sp., *Asphodelus* sp.). In these cases, the date of the winter-buds swelling as first sign of growth should be recorded like in chamaephytes (see Figures 2-4).

Hemicryptophytic monocots like *Iris* tend to grow very slowly throughout the whole year (so long as it is warm enough) and leaves are never completely senescent. Please record this stage when growth of a new shoot or leaf is visible and not when you observe growth of old leaves (see Figures 5-6).

In populations with many individuals it may happen that you have to note "Initial vegetative growth" more than once. If possible, please note in the comment column how many individuals show this stage at the recording time.

Figure 1: *Genista tinctoria* L. new vegetative growth as the buds swell.

Figure 2a-b. Initial growth. 2a: *Asphodelus albus* Mill. overwintering buds occurred in September 2018; **2b:** *Asphodelus albus* new vegetative growth occurred in December 2018.

Figure 3a-c. Initial growth. 3a: *Paeonia officinalis* L. overwintering buds; **3b:** *Paeonia officinalis* new vegetative growth (late stage, leaf form is nearly visible),which occurred one week before the young leaves were visibly unfolded; **3c:** *Paeonia peregrine* Mill. first new vegetative growth, young leaf tips are usually red in peonies and therefore difficult to detect.

Figure 4a-b. Initial growth. 4a: *Podophyllum peltatum* L. overwintering buds; **4b:** *Podophyllum peltatum,* note the fresh whitish-green tissue at the tip of the bud, which is new vegetative growth.

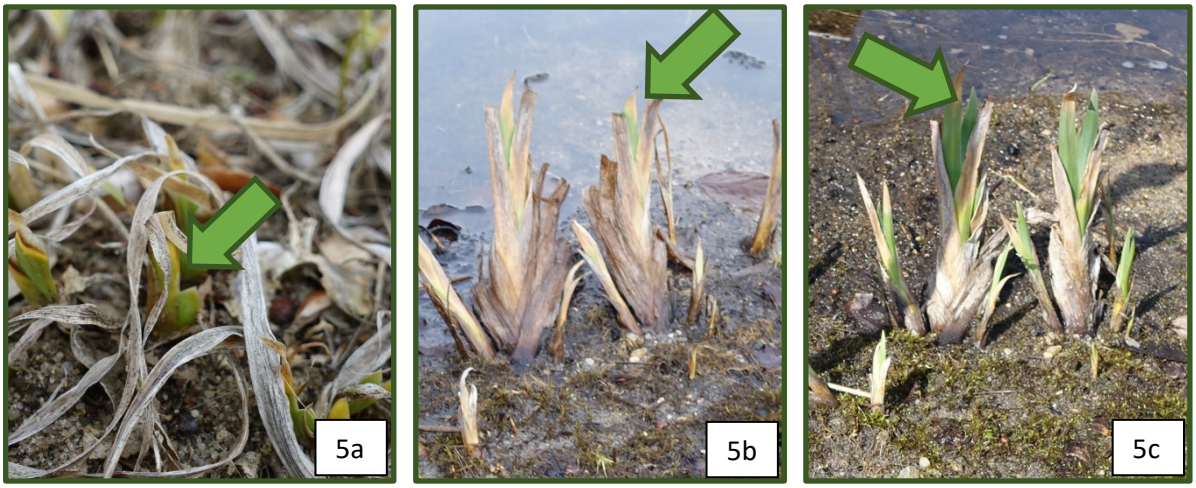


Figure 5a-c. Initial growth. 5a: *Iris pumila* L., the first new vegetative growth is indicated by an arrow; **5b:** In the denser shoots of *Iris pseudacorus* L. growth is detected by the observation of the green meristematic zone emerging from the basal part of older leaves (indicated by the arrow); **5c:** new growth should be recorded not before the tip of a new leaf is visible.

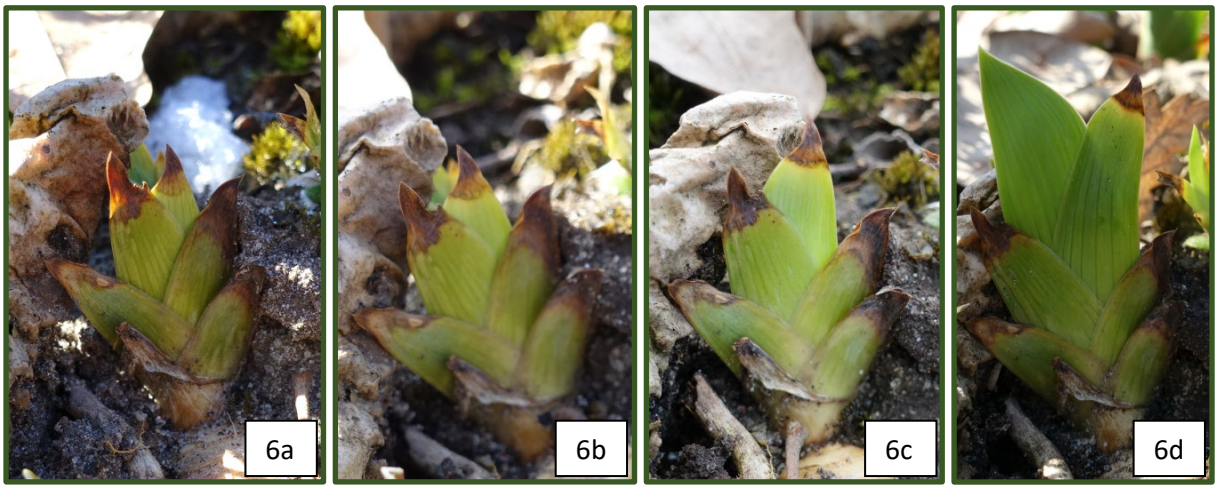


Figure 6a-d. Initial growth. 6a: *Iris germanica* L. on March 18th **6b:** *Iris germanica* on March 27th you can already guess that growing has started – but only when comparing with the picture from the week before; **6c:** on April 3rd it becomes quite clear; **6d:** on April 9th the new leaf is clearly visible, which means the "first shoot"-stage is reached.

1.1.2 Young leaves unfolding

This stage is recorded when young leaves are visible in their typical form, i.e. when the leaf base or petiole (if applicable) and point of attachment are visible. Leaves may still be partly folded and should not yet have reached full size. Newly unfolding leaves should usually (although not always) be bright green and soft (see Figure 7a). Some herbaceous species produce several flushes of new leaves in one year. These should all be recorded. This stage can last for several weeks (every time when you observe new leaves unfolded) and may also appear several times a year. This should always be noted with "yes".

Figure 7a-c. Young leaves unfolding. 7a: *Genista tinctoria* L.; **7b:** *Paeonia officinalis* in a very early version of the leafing-out-stage; **7c:** *Arum maculatum.*

Figure 8a-b. Young leaves unfolding. 8a: *Galanthus nivalis* L.; **8b**: *Iris pseudacorus*, first leaves have emerged from their sheath (*Galanthus nivalis*) and the form is visible in both species.

1.1.3 End of growing season: Senescence

1.1.3.1 Senescence

Senescence is the loss of photosynthetic activity and is assessed after a period of growth. Senescence is recorded when coloured, dropped or dried leaves are observed. If possible, prevent removal of senesced leaves by the gardeners. However, if this occurs please choose “removed” for the maintenance on the week that this occurs. If senescence is due to drought, please note this in the remarks as “drought”.

Some plants, for example *Alchemilla vulgaris* agg. and *Artemisia absinthium* L.*,* produce new leaves at the same time as senescing. It may therefore be possible to record new leaves and senescence at the same time (Figure 9d).

1.1.3.2 Senescence intensity

Senescence intensity is the percentage of leaves at a given date across the entire population (geophytes and hemicryptophytes) or the entire individual (chamaephytes) that are coloured, dried or dropped. This should be estimated to the nearest 5% interval, however if you wish, recording can end once 50% (peak senescence) has been reached (Figure 9). If you do not score senescence every week, please **make sure that you at least record 50% senescence.**

Senescence events caused by draught, insects, etc. should be recorded as well. In these cases please do not stop at 50% senescence.

Please note that for geophytes and hemicryptophytes 50% senescence is recorded when 50% of the leaves in the population are senescent and not 50% of the individuals. These two things may be, but are not necessarily the same.

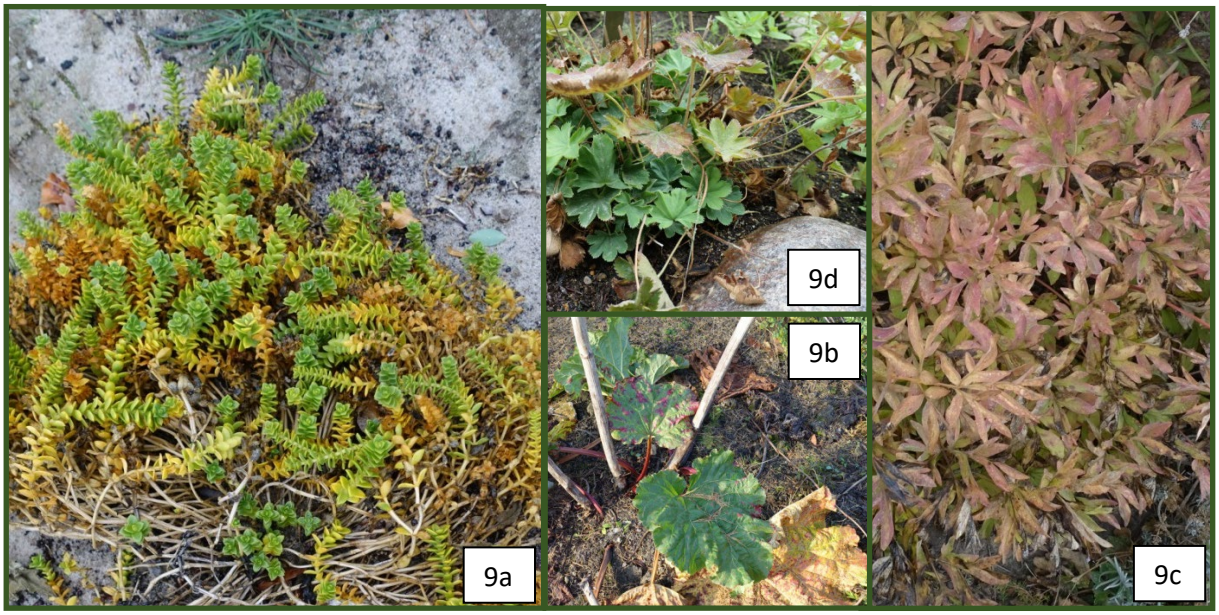


Figure 9 a-d. Senescence. 9a: *Honckenya peploides* (L.) Ehrh.; **9b:** *Rheum rhabarbarum* L.; **9c:** *Paeonia officinalis*, all recorded as 50% senescence intensity; **9d:** *Alchemilla vulgaris* agg. has produced new leaves and is also >50% senesced.

1.2 Reproductive phenology

Flowers are considered in the sense of a pollination unit, therefore dense inflorescences like the capitula of Asteraceae are evaluated as one 'flower'.

1.2.1 Flowering phenology

1.2.1.1 Flowers/inflorescences open

For the observation of "Flowers opening" the focus is on "functional flowering". This means when the stamen or stigmas are exposed and ready for pollination, irrespective of the exposure of petals or tepals. In the case of dioecious species, for example *Humulus lupulus* L., please observe female flowers (Figure 10b). Flowers are considered open until the stamen and stigma are withered – be aware of persistent perianths in some species (Figure 11) and of loose or tender petals that drop quickly before reproductive parts have withered. It is also important to consider possible diurnal rhythms (*Oenothera*,

some Solanaceae species) and to look especially carefully at species that spread their petals/tepals only on sunny days, for example *Eranthis hyemalis*.

Figure 10a-f. Flowers open. 10a: *Galanthus nivalis*, flower functional organs are not yet ripened; **10b:** *Humulus lupulus*, female flowers; **10c:** *Senecio aquaticus* Kitam., the capitula are considered open; **10d:** *Galanthus nivalis*, flowers are ready for pollination; **10e:** *Oenothera biennis* L., on a sunny day; **10f:** *Paeonia officinalis*, with exposed stamens and stigma.

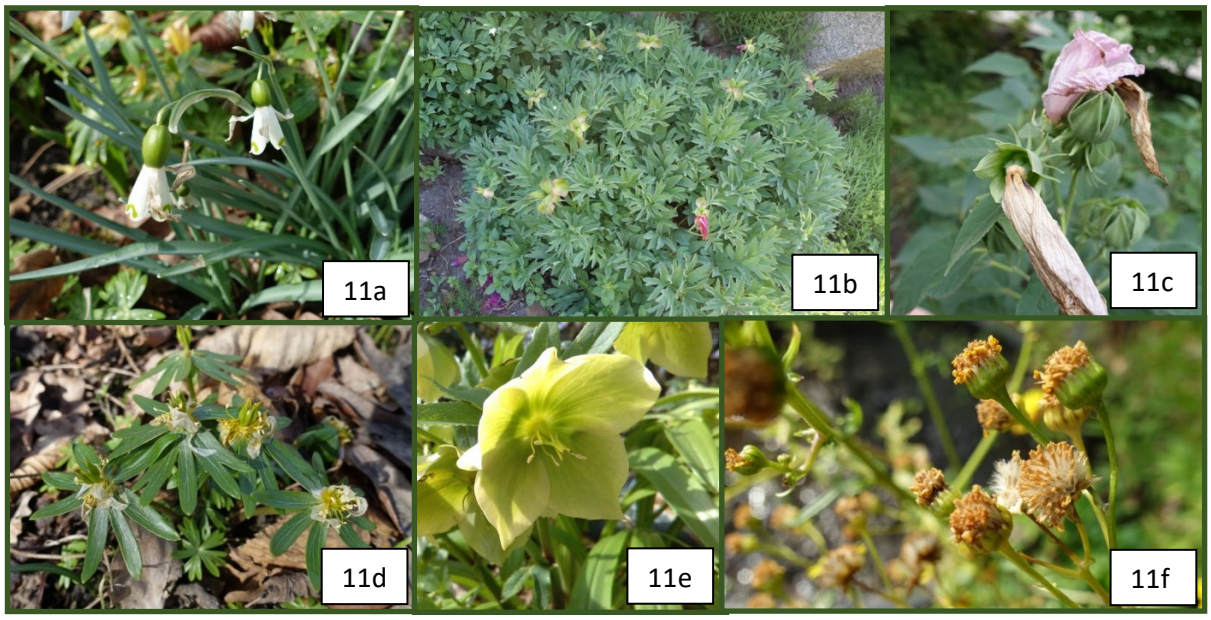


Figure 11a-f. End of flowering. 11a: *Galanthus nivalis*; **11b:** *Paeonia officinalis*; **11c:** *Hibiscus moscheutos* L.; **11d:** *Eranthis hyemalis*; **11e:** *Helleborus orientalis* Lam., be aware of persisting perianth. **11f:** *Senecio aquaticus.*

1.2.1.2 Peak flowering (OPTIONAL)

Peak flowering is the time when the maximum number of flowers is open at once. This could be observed over multiple weeks.

1.2.1.3 Flowering Intensity (OPTIONAL)

Flowering intensity is the percentage of open flowers in relation to the maximum possible flowering aspect.

1.2.4 Ripe Fruits

Fruits are considered ripe, when the diaspores are ready to be dispersed (separated from the mother plant) or harvested.

For dehiscent fruits this is when fruits are open.

For indehiscent fruits this stage is recorded when fruits have reached their final size, form, colour and consistency. Be aware, that in several species fruits are ripe when they are still green (e.g. some *Hepatica, Anemone* and *Ranunculus* sp.). *Galanthus* and *Leucojum* fruits hardly change colour and the seeds are still very pale even at the ideal harvesting stage (Figure 12c).

Sterile fruits should not be included, since they do not fulfil any functional role in terms of species reproduction or ecosystem service. Especially in Botanical Gardens the collection of fruits needs to be considered. Fleshy fruits might be harvested by visitors and animals as well. Therefore, keep an eye on "empty peduncles" (*Rubus* and *Ribes* sp.). But also other types of fruits can be attractive for visitors - or harvested by the gardeners for propagation.

Figure 12a-e. Ripe fruits. 12a: Ripe fruit of *Rubus idaeus* L.; **12b:** *Paeonia officinalis* and **12c:** *Galanthus nivalis* showing the pale green berry and peduncle just withered; **12d:** *Hibiscus moscheutos* L. and **12e:** *Phlomis tuberose* L. which have inconspicuous fruits, the ripe nutlets are hidden inside the persisting calyx.

2. Data entry for phenological monitoring

2.1 PhenObs Web interface

Phenological observations are recorded on a weekly basis. This should ideally be on the same day each. While observing the species in the gardens, the individual phenological events are entered directly into the web interface developed for PhenObs (https://phenobsapp.idiv.de/). All you need is a smartphone or tablet, but not necessarily a permanent connection to the internet. If no mobile device is available, the data can also be recorded using printed table sheets, which are then subsequently transferred to the web interface. To be able to use the web interface, the PhenObs coordinator must create the corresponding botanical garden and any number of associated accounts.

2.2 Data entry

Precise manuals for the web interface can be found under the following link: https://phenobsapp.idiv.de/help/ .

Table 1. A description of the data entered in each field while adding a collection

	Description
Date	The current date in the format dd/mm/yyyy.
Garden	Name of the "sub-garden" created by the PhenObs coordinator.
Creator	Logged in web interface user.
Plant	Species name in accordance with the list created by the PhenObs coordinator.
Initial vegetative growth/ Young leaves unfolding/ Flowers opening/ Peak flowering/ Ripe fruits/Senescence	Should be recorded as either "yes", "no", "missed" or "unsure".
Flowering intensity/ Senescence intensity	Recorded in 5-percentage steps between 0-100%.
Maintenance	Record here if a plant has been cut partly, cut total, covered natural (e.g. snow, litter), covered artificial (by gardeners), transplanted (to another place in the garden) or removed.
Remarks	Any general remarks for example damage by pests, disease or drought.

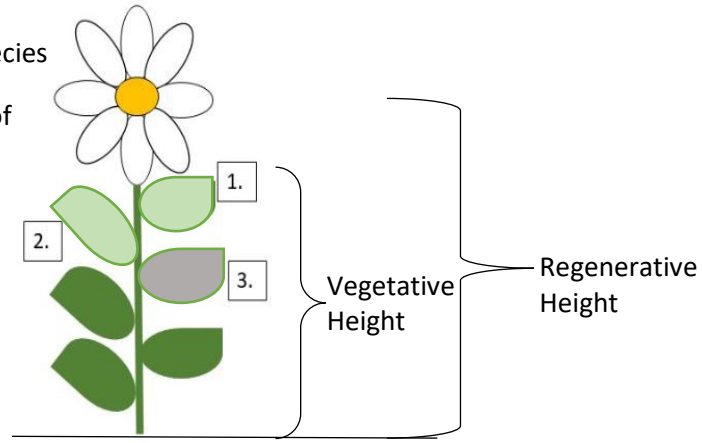
- The different stages can be recorded with "yes", "no", "missed" or "unsure". For example, one might ask: "Can I see open flowers?"? or "Can I see ripe fruits?". If for whatever reason the very first week when a stage occurs was missed, record as "missed" until the stage is over for that species. With the data of the first and last week of a phase it is possible to calculate the length of the period. If the first date is missed, it is still possible to record the end. This can, for example, happen, if data are missed due to snow, during which time a species had produced its' first vegetative growth.

- If unsure whether a stage is observed or not, record “unsure”. This can later be amended to a “yes” if necessary and will serve as a reminder to look closely at this species the following week.
- If plants have been pruned or cut back this should be recorded as “cut” in the maintenance field for the week when this occurred.
- Any coverage of snow or artificial winter cover should not be removed from plants but its existence should be noted in the remarks.
- Irregularities, for example pest infestations, damage by drought or picking of fruits by birds or visitors should be recorded in the remarks.

3. Trait measurement protocols

What to collect in the garden:

1. **3 leaves of 5 individuals/ramets** per species (labelled as 1-5, according to the number of individuals), → 2 leaves each for leaf traits and one dried and pressed for stomata, i.e. 15 leaves per population.
2. **Height of 5 individuals/ramets**, ideally the same as for 1.



All plant trait measurements follow the standardised protocol by Pérez-Harguindeguy et. al (2013). Plant traits selected for study reflect key aspects of a species performance in different environments and were identified in previous studies as relating to phenology (Bucher et al. 2018, König et al. 2018).

The trait data should be submitted once and are not monthly or yearly repeat measures. Trait samples should be collected on healthy plants at a time when the species are flowering.

Where sampling 5 individuals/ramets per species is not possible due to low population size, collect leaves from as many ramets/individuals as there are available without increasing the number of leaves per individual/ramet. The leaves should be young and photosynthetically active yet fully expanded and free from signs of damage or pathogens. The individuals should be labelled 1-5.

Aim of the project is to measure at least plant specific leaf area (SLA), leaf nutrients, vegetative height, and regenerative height. Optional, fresh mass can be recorded to calculate leaf dry matter content (LDMC). Stomatal traits as well as collected seeds for seed size and shape are a big bonus, but not mandatory necessary.

3.1 Leaf traits (specific leaf area (SLA) and leaf nutrients)

To measure SLA and leaf nutrients two fresh leaves are collected, including stipules, petiole or rachis, from five ramets per species (total leaves 10, but separated into 5 pairs of leaves). Each pair of leaves should be placed into a plastic bag with a piece of moist tissue, sealed to prevent desiccation and labelled with the species name and the number of the individual to not confuse the leaf pairs. Leaves may be stored in a cool (but not freezing) place in this way for up to 48 hours before scanning (Pérez-Harguindeguy et. al 2013).

Optional (but recommended to measure), fresh mass can be recorded to calculate leaf dry matter content (LDMC).
Fresh leaf pairs should be scanned together **at a resolution of 300 dpi**. Be aware that the leaf parts do not overlap and you use a white background for the scan. Images should be saved as a .tiff including the species name, leaf pair number (1-5), garden and date. For example, **humulus_lupulus_1_jena_08_05_2019.tiff**. Images should be saved in a folder named after your Botanical Garden. The folder can then be uploaded to a shared cloud space. A link for this will be sent to members.

Each leaf pair should then be placed in a paper envelope (but see 3.4, if you are able to provide fresh weight for LDMC) that has been labelled with the file name of their scan e.g.**humulus_lupulus_1_jena_08_05_2019**. These should be dried at 60°C for 72 hours, or in the sun until all moisture is removed. Leaf samples can be posted in paper bags or envelopes to Jena where they will be weighed to record the dry weight. The same leaves will be used for the analysis of leaf nutrients (C and N).

Exceptions: If the leaves of a species are very small, please increase the number of leaf samples so that sufficient dry weight is available for nutrient analysis (minimum ~3 mg in total weight).

3.2 Vegetative Height

Plant vegetative height is the distance between the upper boundary of the main photosynthetic tissues of a plant and the ground level, expressed in cm (refer to picture in the box). The height recorded should correspond to the top of the general canopy of the plant, disregarding any exceptional branches. Do not move or stretch the plant. Measure 5 individuals, preferably the same from which the plant samples have been taken from. Height should be recorded on the template provided and send to phenobs@uni-jena.de.

3.3 Regenerative Height

Plant regenerative height is the distance between the upper boundary of the inflorescence of a plant and the ground level, expressed in cm. The height recorded should correspond to the top of the general inflorescences of the plant, disregarding any exceptional flowers. As for vegetative height, measure 5 individuals. Height should be recorded on the template provided and send to phenobs@uni-jena.de.

3.4 Leaf dry matter content (OPTIONAL)

Leaf dry matter content (LDMC) is the dry mass (mg) of a leaf divided by its water-saturated fresh mass (g). This can be measured on the same leaves or leaf pairs that were scanned for SLA measurement, however it is imperative that leaves are fully rehydrated before weighing (Pérez-Harguindeguy et. al, 2013). Once rehydrated, weigh with a 4-point balance before scanning, drying and posting. Please record the fresh weight and write it down on the paper bags before posting. Fresh weight should be recorded on the template provided and send to phenobs@uni-jena.de.

3.5 Stomatal traits (OPTIONAL)

Only one leaf from 5 individuals/ ramets per species is required to measure stomata on the upper and lower leaf side, ideally the same individuals/ramets that the scanned leaves were taken from, and labelled with the same number.

Prepare the samples yourselves as follows. Apply clear nail polish to an approximately 1 cm^2 area of the leaf avoiding veins as much as possible (good results are produced useing Maybelline 40s dry clear nail polish). This needs to be done **once for the upper surface and twice for the lower surface** of the leaf. When the nail polish is dry, some clear adhesive tape has to be attached onto the nail polish. The nail polish will stick to the tape and can then be peeled off from the leaf. Transfer the tape onto a microscope slide labelled with the species name and the number of the individual. Upper and lower stomatal imprints may be put on the same slide, yet make sure you clearly indicate which imprint has been taken from the upper and which from the lower surface. A more detailed description of the method can be found in Hilu and Randall, 1984. The microscope slides should be posted to Jena for measuring. For some hairy species, this method is not appropriate, so you could try to either shave the leaf or omit that species.

3.6 Seed traits (OPTIONAL)

To characterize seed mass and size 20-50 ripe seeds are needed. At least 5 individuals should be sampled if possible. Criteria for ripeness are change of colour in the fruit or separation of the dispersal unit from the mother plant (see 1.6). After removal of fruit and leaf remnants seeds are kept in paper bags in a dry and cool environment (15°C/ 15% humidity, if possible). Please note the year, garden, species name, number of individual (1-5) and date on every bag. Example: 2019_jena_humulus lupulus_1_ 10_08_2019

4. Site characteristics data entry protocols

Each garden should monitor climatic conditions daily. Air and soil temperature and soil humidity should be recorded at regular intervals (e.g. hourly) on a local scale, from which it is possible to derive a daily minimum, maximum and mean value. This may be done by an on-site weather station, or alternatively with data loggers provided by PhenObs (TOMST loggers). If you require a data logger, please email **phenobs@uni-jena.de** and four loggers (two TMS-4 and two "thermologger") and one adapter will be posted as soon as possible. These data loggers should be installed on a representative place in the garden and need to be read at least once per year.

4.1 Garden characteristics

These should be entered to the provided template and send to **phenobs@uni-jena.de**. Please name this file with the name of your garden, for example **jena_garden_characteristics.xlxs.**

Table 3. Description of each field of the gardens characteristics file.

	Description
Garden	Name of the Botanical Garden.
Mat	Mean annual temperature based on at least a 25 year record in degrees centigrade (e.g. from Deutscher Wetterdienst).
Map	Mean annual precipitation based on at least a 25 year record in mm (e.g. from Deutscher Wetterdienst).
Lat	Latitude of the garden in decimal degrees.
Lon	Longitude of the garden in decimal degrees.
elevation	Elevation in metres above sea level.

4.2 Species list and species specific site characteristics

Gardens should characterise the site conditions for each species monitored in the garden. The provided template for these data should be send to **phenobs@uni-jena.de**. The name of this file should contain the name of the garden, for example **jena_species&site_data.xlxs.**

Table 4. Description of each field of the species-specific site characteristics file.

	Description
Botanic Garden Name	Name of the garden. Should match the name given in the web interface.
Species	The genus and species name should be entered and must match **EXACTLY** those entered in the web interface.
Sub_garden	The area of the garden where each species is located e.g., systematics garden, medicinal plants area, etc. If possible this should match the sub gardens from the web interface.
Size	An estimate of the total above ground area in square metres covered by either the population or the individual. This should be assessed at peak flowering season.
Light	Refer to the condition in the middle of the vegetation season of your garden "sun", "part-shade" or "shade", all lower case.
Competition	Are plants facing competition with other species? "monoculture" or "mixture", all lower case
Soil_depth	This should be recorded in cm and may be measured using a metal rod.
Soil_type	For example "gardensoil","sandysoil", "rockysoil", "other".
Soil_remarks	Any other comments on the soil type e.g. proportion of sand, clay or loam.
Water	Do species receive supplementary water throughout the year? y (yes) or n (no), all lower case.
Fertiliser	Are species fertilised? y (yes) or n (no), all lower case.
Fertiliser_remarks	Any comments on fertilisation e.g. type or amount received.
Mulch	Do species receive mulch? y (yes) or n (no), all lower case.
Mulch_remarks	Any other comments on application of mulch e.g. timing and depth
Slope	In which direction is the bed located? "flat", "northfacing", "southfacing","eastfacing", "westfacing"
General remarks	Any other comments regarding the individual species in the study
Data_Collector	Name of person that collected the data

5. Species list and selection

The pilot study (Nordt et al. 2021) helped to establish a first set of species that are present in the German monitoring gardens. The species list, however, should not be limited to those species. Secondly, every garden has a different layout and it is sensible to allow each garden to tailor the species monitored according to a weekly walk that will make an efficient use of time. The following guidelines can assist in species selection:

The data gathered from the gardens aim to answer the following questions:

Can phenology of species be predicted from phylogeny, habitat and functional traits? In order to answer these questions, it is necessary that species are sampled as evenly as possible across clades and that roughly equal numbers of species from different habitats for example grassland, forest, marsh, alpine etc… are sampled.

Investigations about **phenological variation between gardens and years** and the relationship of this to species-specific traits and environmental variation are focussed as well; the PhenObs webpage hands more details on the main research questions (https://www.idiv.de/de/web/phenobs.html). For inclusion in these analyses, it requires that species monitored are present in at least two or more gardens in the study (see species list: https://www.idiv.de/en/phenobs/protocols-data-policy.html). Although aiming for a high amount of overlap in species monitored between gardens, additions to the list are welcome. If on your weekly monitoring route, there are several other herbaceous species located in the vicinity of ones on the list, it would be great to have these also monitored.

In summary:

- All species included in the phenological monitoring should be herbaceous (or dwarf shrubs).
- Species should be roughly evenly sampled across clades and habitats.
- There should be overlap in the species monitored across gardens, however every species added to the list has positive effects on the project.
- The ultimate aim is to monitor a **globally distributed, large and balanced** sample of herbaceous species.

For any questions, please contact **phenobs@uni-jena.de**

6. Glossary - Life forms

Chamaephyte, in Raunkiaer's system (Raunkiær, 1905) a plant with resting buds in 10-50 cm distance to ground level; this categorie includes dwarf-shrubs, sub-shrubs and herbaceous species e.g. *Vinca* sp., *Vaccinum* sp..

Hemicryptophyte, in Raunkiaer's system (Raunkiær, 1905) a plant with a growing point that survives adverse seasons as a resting bud at or near the level of the soil, as in tussocks and rosettes. These may have stem leaves, stem and basal leaves or only basal leaves e.g. *Geum* sp.*, Geranium* sp.*, Plantago* sp.

Geophyte, in Raunkiaer's system (Raunkiær, 1905), a plant whose growing point survives adverse seasons as a resting bud on an underground organ, such as a rhizome, bulb, tubor or root e.g. *Galanthus* sp.*, Eranthis* sp.

7. References

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Appendix

Appendix 1. Affiliated gardens and people

The people and affiliations for all involved in the pilot study and workshop from which these protocols have been developed, given in alphabetic order of the Botanical Garden. A full list of contributing gardens is provided on the webpage.

Affiliation	Name
Beijing Normal University	Dr. Yongshuo H. Fu
Berlin Botanic Garden	Birgit Nordt
Berlin Botanic Garden	Prof. Albert-Dieter Stevens
Boston University	Prof. Richard Primack
Chicago Botanic Garden	Dr. Jessamine Finch
Frankfurt Botanical Garden	Dr. Katja Heubach
Friedrich Schiller University Jena	Dr. Solveig Franziska Bucher
Friedrich Schiller University Jena	Dr. Emma Jardine
Friedrich Schiller University Jena	Prof. Christine Römermann
Friedrich Schiller University Jena	Desiree Jakubka
Friedrich Schiller University Jena	Maria Sporbert
Helmholtz Centre for Environmental Research	Prof. Aletta Bonn
Martin-Luther University	Prof. Isabell Hensen
NC Botanic Garden	Dr. Damon Waitt
Norwegian Institute for Nature Research	Dr. Graciela Rusch
Polar Alpine Botanical Garden Institute, Murmansk	Dr. Ilona Blinova
Ringve Botanic Garden	Dr. Vibekke Vange
Royal Botanic Garden Edinburgh	Dr. Antje Ahrends
Royal Botanic Garden Edinburgh	Christine Thompson
University of Leipzig	Dr. Martin Freiberg
University of Vienna	Barbara Knickmann

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