

Phenological Gardens



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Purpose

To observe the flowering and leaf stages of selected garden plants throughout the year

Overview

After a phenological garden is planted, students observe the growth of leaves and blooming of flowers on the plants. These plants were selected because each plant blooms at a different time in the year.

Student Outcomes

Students will learn how to identify the different flowering stages during plant growth. Students will make connections between climate and plant blooming.

Science Concepts

Earth and Space Sciences

Soils have properties of color, texture and composition; they support the growth of many kinds of plants.

Weather can be described by measurable quantities.

Weather changes from day to day.

Weather changes over the seasons.

Soil consists of weathered rocks and decomposed organic matter.

Water circulates through the biosphere, lithosphere, atmosphere and hydrosphere (water cycle).

The sun is the major source of energy for the growth of plants.

Life Sciences

Plants have basic needs (water, sunlight, food, etc.).

The behavior of plants is influenced by external cues.

Plants have life cycles.

Plants closely resemble their parents.

All organisms must be able to obtain and use resources while living in a constantly changing environment. Energy for life derives mainly from the sun. Living systems require a continuous input of energy to maintain their chemical and physical organizations.

Geography

Plants help to define the character and spatial distribution of ecosystems on the Earth's surface.

Scientific Inquiry Abilities

Identifying plant phenophases.

Identifying shrub species.

Planting and caring for shrubs.

Identify answerable questions.

Design and conduct scientific investigations.

Use appropriate mathematics to analyze data.

Develop descriptions and explanations using evidence.

Recognize and analyze alternative explanations.

Communicate procedures and explanations.

Materials and Tools

For Site Definition (once only):

Camera

GPS receiver

Compass

Tape measure

Markers to label plants

Pencil or pen

Paper to draw map

Soil equipment for measuring pH

Phenological Garden Site Definition Field Guide

Phenological Garden Site Definition Sheet

Basic GPS Protocol Field Guide

Basic GPS Protocol Data Sheet
Soil Characterization Field Measurement Protocol
Soil Characterization Lab Analysis Protocol

For Observations

Pencil or pen
Phenological Garden Data Sheet
Phenological Garden Field Guide

For Planting and Care

Pail
Bone meal or superphosphate
Fertilizer or compost
Peat moss (for heather)
Wooden or metal stakes
Flagging tape

Level

All

Frequency

Once a day for each plant variety shortly before leaf growth and blooming starts and during the blooming stages. In between blooms, two or three times a week.

Preparation

Familiarity with the different leaf and flowering stages of the plants to be observed in the garden

Prerequisites

None

Phenological Gardens - Introduction

Plants respond to the environment around them. Green plants grow when there is enough sunlight, warmth, moisture, and nutrients. They respond to the temperature and moisture of the air and soil around them. During dry or cold seasons, there is little or no growth. When the conditions are right, such as warmer temperature, more moisture and longer lengths of day, plants start growing and reproducing.

Plants also change the environment around them. They take carbon dioxide from the atmosphere, incorporate the carbon in their leaves and stems, and give off oxygen. They also take moisture and nutrients from the soil and produce new growth. In the process, many chemicals are produced and some of these, along with water vapor, are released into the atmosphere. To know how large an effect plants are having, scientists need to know the length and characteristics of the growing season.

This protocol asks you to observe the flowering of different plants. The plant varieties were chosen because they flower at different times during the year. This allows you and scientists to learn how the growing season is changing from year to year as well as see if there is an overall change in the growing season over a longer length of time. The collection of atmosphere data (such as temperature and precipitation) and soil moisture and temperature data will greatly help you and scientists interpret the phenological garden data.

These plants were also chosen because plants of the same species are genetically identical. That means they respond the same to changes in temperature and moisture and other factors that affect their flowering and growth. Therefore variations observed in the dates of growth stage events can be clearly linked to climate rather than to variations among plants.

How Scientists Use Your Data

The plants selected for your garden are part of a scientific phenological network called Global

Phenological Monitoring (GPM) Program (www.student.wau.nl/~arnold/gpmn.html) Scientists in GPM Program study how the different species respond to changes in climate. The GPM data may be compared with the flowering of ornamental shrubs in your garden to help find relationships among the flowering dates of ornamental shrubs and those of fruit trees. Thus your phenological data are also indicators of the flowering dates of fruit trees and may be linked to the management of agricultural and horticultural practices.

Teacher Support

Which Plants You Will Observe and How to Get Them

A GLOBE phenological garden contains a variety of plants that bloom at different times during the year. The plants listed in Table EA-PG-2 are: Witch-hazel (*Hamamelis x intermedia* 'Jelena' and *Hamamelis virginiana* 'Genuine'), Snowdrops (*Galanthus nivalis* 'Genuine'), Forsythia (*Forsythia suspensa* 'Fortunei'), Lilac (*Syringa x chinensis* 'Red Rothomagensis'), Mock-orange (*Philadelphus coronarius* 'Genuine'), and Heather (*Calluna vulgaris* 'Allegro' and 'Long White').

The plants need to come from selected nurseries to make sure that the plants are clones. Clonal plants are needed to make large-scale comparison among the dates of the different developmental phases of the plant. Vegetative propagated plants are cloned plants and they are used to avoid the hereditary variability of plants. Right now, we are establishing nurseries in Beijing and in the United States.

Not all of the plants may grow where you live. So select the ones that do. However, if all the plants can grow where you live, the whole phenological garden is requested.

Measurement Procedures

These plants bloom throughout the year. When one of the plant species is about to bloom, observations should be made every day until all the flowering and leaf stages (phenophases) are recorded. If no plants are blooming and leaves are not growing, observations can be made two or three times a week.



You can select a convenient time during the day to observe the plants. It is preferred that students observe at the same time each day.

The observations of the different phases are carried out on each plant. If a plant dies continue observing the other species and request new plants from the tree nursery. If the plant dies because the climate is not suitable for the plant at the site, do not plant the same species again because it would die again. Keep on observing the other plants.

Phenophases to Observe

It is very important to observe the dates of the phenophases following the definitions below.

Use the pictures of the phenophases included in the protocol to teach students how to correctly identify the growth stages on their shrubs.

BF = Beginning of flowering: This phase occurs when at least 3 places on the plant the first flowers have opened completely.

Witch Hazel (*Hamamelis x Intermedia 'Jelena'*, *Hamamelis virginiana 'genuine'*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

Lilac (*Syringa x chinensis 'Red Rothomagensis'*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

Mock-orange (*Philadelphus coronaries 'genuine'*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

Forsythia (*Forsythia suspense*), and Heather (*Calluna vulgaris*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

Heather (*Calluna vulgaris*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

Snowdrops (*Galanthus nivalis*): The flower is considered open only when the outer leaves have spread and the stamens are visible.

GF = General flowering: This phase occurs when approximately 50% of the flowers are open.

EF = End of flowering: This phase occurs when about 95% of all flowers have died or fallen off.

Additionally for lilac and forsythia, observe:

LU = Beginning of leaf unfolding: The first regular surfaces of leaves become visible in about 3 places on the observed plant. The first leaf of a plant has pushed out of the bud up to its leaf stalk.

FL = Full leaves: This phase occurs when about 95% of all leaves are unfolded.

Connections to Other Measurements

Before you plant your garden, you could either dig a soil pit or collect a soil profile with an auger and perform a soil characterization following the *Soil Characterization Field Measurement Protocol* in the *Soil Chapter*. If the soil profile has been affected by previous plantings, or the addition of water and fertilizer, please mention this in the comment section on the *Soil Characterization Data Sheet*.

Measurements of air and soil temperature, soil moisture, and precipitation could lead to very interesting student research projects exploring relationships between atmosphere and soil measurements, and plant phenology.

Site Selection

Choose a site that represents the natural soil and climate of the region. Use the following guidelines to help you select a site. We realize that you may not be able to locate an “ideal” site. Do the best you can and record any deviations from the ideal in the comment (metadata) section on your *Phenological Garden Site Definition Data Sheet*.

If you think the potential site may not represent the climate of the region, contact GLOBE.

Find a location to plant your shrubs with the following specifications:

- An un-shaded place that is away from buildings, trees, or other obstacles. The minimum distance from the base of any obstacle should be at least 1.5 times the height of that obstacle.
- Away from footpaths, sidewalks, and roads. The distance from a two-lane road



should be at least 8 meters. The distance from a large eight-lane highway should be at least 25 meters.

- Easily accessible.
- Where there is no risk of plants being trampled by people or animals.
- Where excessive amounts of snow do not accumulate from drifting or plowing.
- On a level surface. If you have a hilly landscape, avoid if possible, the low areas that can unduly delay shrub development in the Spring. Avoid places with slopes greater than 3 degrees.
- In soil commonly found in your area. Avoid planting in soil, such as a garden, that has received heavy applications of manure or compost.
- Where there are no special microclimates (such as frost pockets or windy slopes) for plants.
- Avoid places with lots of artificial light.

The plants do not have to be planted in any specified arrangement. Table EA-PG-2 provides guidelines for minimum distances between plants. Larger distances are desirable.

Planting and Care

1. Planting

The best time to establish the phenological garden is in spring or autumn. If you plant the garden in the autumn, you have to wait until the spring after the next to start your observations.

Materials

- Pail
- Bone meal or superphosphate
- Fertilizer or compost
- Peat moss (only for heather)
- Wooden or metal stakes
- Flagging tape

Note: The quality and validity of data depend strongly upon healthy shrubs, so you should observe the following practices to ensure their health. You may want to consult a horticulturist.

1. As soon as you get the plants, soak the roots in a pail of water for a few hours.
2. Dig holes deep enough to just cover the roots and wide enough you can spread roots horizontally. Leave the minimum distance between plants shown in Table EA-PG-2.
3. Mix about 120 ml of bone meal or superphosphate into the soil in which the plant is going to be planted. In heavy clay soils or in very sand soils, add equal parts of compost to backfill soil to improve growing conditions. Heather likes to grow in weak acid soils (pH 5-6). For this reason add peat moss to the soil if you are planting heather.
4. At least once a week for the first month, water the new transplants until the soil is soaked.
5. Apply either a dry fertilizer such as 10-10-10 or a liquid soluble one during the first growing season according to label directions.
6. Place a wooden or metal stake beside each plant to indicate its location and prevent accidental damage.
7. Mark each shrub with flagging tape or some other durable identification. Label the flagging tape with the name of the plant variety for each shrub.



Table EA-PG-2: Guidelines for Minimum Distances for Plants in a Garden.

Common Name	Scientific Name and Variety	Minimum Distance (m)
Witch Hazel	<i>Hamamelis x intermedia</i> 'Jelena'	2.5
Snowdrops	<i>Galanthus nivalis</i> 'Genuine'	0.05 - 0.1 depth: 0.05-0.10
Forsythia	<i>Forsythia suspensa</i> 'Fortunei'	1.5
Lilac	<i>Syringa x chinensis</i> 'Red Rothomagensis'	2.5
Mock-orange	<i>Philadelphus coronarius</i> 'Genuine'	3.0
Heather	<i>Calluna vulgaris</i> 'Allegro'	0.5
Heather	<i>Calluna vulgaris</i> 'Long White'	0.5
Witch hazel	<i>Hamamelis virginiana</i> 'Genuine'	2.5

2. Annual Care

Materials

- 5-10-10 fertilizer or its equivalent
 - Mulch: peat moss, bark, well-rotted sawdust or similar organic matter
1. Spread 50 g of 5-10-10 fertilizer or its equivalent evenly around each plant. Shrub fertilizer stakes may be used instead.
 2. Keep the soil within 30 cm of the base of each plant free of grass and weeds with a mulch of peat moss, bark, well-rotted sawdust, wood chips, or similar organic material.
 3. During a long dry period, you may have to water the plants.
 4. During the first and second years, the plants may need extra care to make sure that they are strong. After that, fertilizers may not be needed. Check periodically to make sure that they are in good health.

3. Pruning

Heather should be pruned once a year in the beginning of spring (in March or April, depending on weather). You can cut the upper half of the plant.

Prune lilacs immediately after bloom in spring because the following year flower buds are formed on new wood that grows after bloom. Avoid fall pruning because it will destroy the buds for the next year. Old, dried-up flowers may be cut off if desired so that the shrubs do not look unsightly.

All other shrubs should be pruned every 5-10 years to maintain good shape.

One or more of the older main stems at the base of the plant may be removed and some, or all, of the remaining stems trimmed back to maintain the size and shape desired. Never remove more than 1/3 of the plant at any one time.

4. Protection Against Disease, Pests, and Severe Weather

These plants are relatively resistant to insects and diseases. Occasionally they may be affected by powdery mildew, leaf spot, scale, or aphids. Control measures rarely are needed except for scales. Should these diseases or insects become serious, regular applications of a pesticide may be necessary. Contact the Agricultural Extension Service in your state, province or county for the latest control recommendations.

In some locations animals, such as rabbits and mice, may severely damage the plants. Wire-mesh guards around the base of the plants help to control such damage.

For winter protection in areas of little snowfall, 5-10 cm (2-4 inches) of mulch around the base of each plant will protect its roots from frost damage. To prevent breakage from ice, wrap stems together loosely with twine or place burlap (such as from a feed bag) on a frame over the plant. Do not use plastic.

Questions For Further Investigation

How does a year with more precipitation than usual affect when the different phenophases occur?

Which has more influence on when the phenophases occur: soil temperature or air temperature?

Does elevation affect when phenophases occur? If so, how?

Are there differences when phenophases occur between coastal and continental areas?

Frequently Asked Questions



1. Should we observe other vegetation in the local region?

For the phenology protocol, please only observe the plants in your phenology garden. But you can also observe the other vegetation in your local region in order to compare the phenophases of the indicator plants in your phenology garden with the natural vegetation in your surrounding.

2. Are these plants invasive?

No.

3. How do these plants pollinate?

All plants in the phenological garden are insect-pollinated. They bloom in different colors to attract the insects. The male and female parts of the plant are in each flower.

4. How does the nature of the soil affect the timing of flowering?

The timing of phenological events is mainly driven by temperature. However, soil characteristics can influence the heating of atmosphere. Soil moisture also can influence the timing of phenophases.

Phenological Gardens

Site Definition Field Guide

Task

To draw a map, take photographs, describe the soil, and locate the latitude, longitude, and elevation of your phenological garden site

What You Need

- GPS receiver
- Basic GPS Field Guide*
- GPS Data Sheet*
- Compass
- Phenological Garden Site Definition Sheet*
- Camera
- Tape measure or meter stick
- Paper to draw map
- Pencil or pen
- Markers
- Soil Characterization Field Measurement Protocol*
- Soil Characterization Lab Analysis Protocol*
- Soil equipment for measuring pH (refer to protocol)

In the Field

1. After the garden is planted, draw a map of the garden showing the locations of each plant. Include on the map:
 - School name and address.
 - Date
 - Directions: North, East, South, West.
 - Distances between plants in meters
2. Label each plant with a marker.
3. Identify the latitude, longitude, and elevation following the *Basic GPS Measurement Protocol*.
4. Stand in the middle of the garden and take photographs in the North, East, South, West directions. Use the compass to determine the directions.
5. Take a photograph of the garden.
6. Identify the soil texture in the top 10 cm following *Soil Characterization Field Measurement Protocol*.
7. Measure the pH of the top 10 cm of soil following *Soil Characterization Lab Analysis Protocol*.
8. Submit map and photos to GLOBE by mailing to the address given in the *Implementation Guide* in the *GLOBE Teacher's Guide*.

Phenological Gardens

Field Guide

Task

To record when the phenophases occur for each shrub in your phenology garden

What You Need

- Phenological Garden Data Sheet
- Tape measure or meter stick
- Pencil or pen

In the Field

1. Examine each shrub.
2. For each shrub, record the dates of the three phenophases. Keep separate records of these dates for each shrub. The three phenophases in order are:

BF = Beginning of flowering: This phase occurs when at least 3 places on the plant the first flowers have opened completely.

Witch Hazel (*Hamamelis x Intermedia 'Jelena'*, *Hamamelis virginiana 'genuine'*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

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Forsythia (*Forsythia suspense*), and Heather (*Calluna vulgaris*): Only look to see if the flowers have opened. It is not necessary to see pollen falling off the stamens.

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Snowdrops (*Galanthus nivalis*): The flower is considered open only when the outer leaves have spread and the stamens are visible.

GF = General flowering: This phase occurs when more than 50% of the flowers are open.

EF = End of flowering This phase occurs when about 95% of all flowers have died or fallen off.

Additionally for lilacs and forsythia:

LU = Beginning of leaf unfolding: The first regular surfaces of leaves become visible in about 3 on the observed plant. The first leaf of a plant has pushed out of the bud up to its leaf stalk.

FL = Full leaves: This phase occurs when about 95% of all leaves are unfolded.

3. In the autumn, measure the height of each plant except snowdrops. This is done once a year only.
4. If plants are watered or pruned, record each date.
5. If fertilizer is used, record date of application and type of fertilizer.

Note: It is important to report if a plant appears to be in poor health

Phenological Gardens

Site Definition Data Sheet

School Name: _____ Class or Group Name: _____

Name(s) of student(s) filling in Data Sheet: _____

Date: _____

Site name (give your site a unique name): _____

Coordinates: Latitude: _____ N or S (check one)

Longitude: _____ E or W (check one)

Elevation: _____ meters

Source of Location Data (check one): GPS Other

If other, describe: _____

Nearest Atmosphere Site: ATM- _____

Distance to ATM Site: _____ meters;

Direction to Site: N NE E SE S SW W NW

Elevation Difference (Atmosphere Site – this site): _____ meters (this value may be positive or negative)

Nearest Soil Moisture Site: SMS- _____

Distance to Soil Moisture Site: _____ (meters);

Direction to Site: N NE E SE S SW W NW

Elevation Difference (Atmosphere Site – this site): _____ meters (this value may be positive or negative)

Plants in Garden

Shrub	Planted in Garden? Yes or No	Date planted
Witch Hazel 'Jelena'		
Witch Hazel 'Genuine'		
Lilac		
Mock-Orange		
Forsythia		
Heather 'Allegro'		
Heather 'Long White'		
Snowdrops		

Soil Texture in the top 10 cm (from *Soil Characterization Field Measurement Protocol*): _____

Soil pH in the top 10 cm (from *Soil Characterization Lab Analysis Protocol*): _____

Soil pH method (check one): paper meter

Photo Number and Orientation

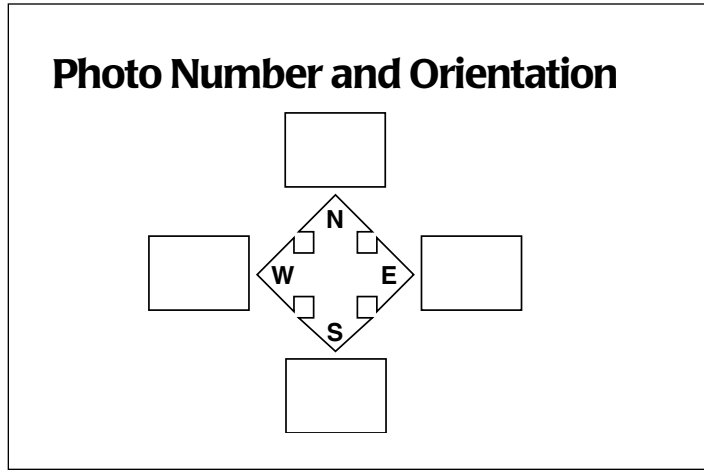


Photo of Garden

Comments (Metadata): _____

Phenological Gardens

Data Sheet

School Name: _____ Class or Group Name: _____

Name(s) of student(s) filling in Data Sheet: _____

Site Name: _____

For witch hazel, mock-orange, heather and snowdrops, record the dates for the following flowering stages:

Shrub	Flowering Stage		
	BF	GF	EF
Witch Hazel 'Jelena'			
Snowdrops			
Mock-Orange			
Heather 'Allegra'			
Heather 'Long White'			
Witch Hazel 'Genuine'			

BF = Beginning of flowering

GF = General flowering

EF = End of flowering

For lilac and forsythia, record the dates for the following flowering and leaf growth stages:

Shrub	Flowering Stage			Leaf Stage	
	BF	GF	EF	LU	FL
Lilac					
Forsythia					

LU = Beginning of leaf unfolding

FL = Full leaves

Height and health of each plant. Measure in the Autumn.

Shrub	Height (cm)	Health of Shrub Healthy = H Unhealthy = U Dead = D	If shrub died, did you replace it with another shrub? (yes or no)
Witch Hazel 'Jelena'			
Snowdrops	not necessary to measure the height		
Mock-Orange			
Heather 'Allegro'			
Heather 'LongWhite'			
Lilac			
Forsythia			

Was fertilizer used on the plants this year?_____ If yes, date of application: _____

Type of fertilizer _____

Record dates plant(s) were watered:_____

If plants are pruned, record date(s):_____

Comments (Metadata): _____











