

Project BudBreak

MANUAL FOR PLANT PHENOLOGY OBSERVERS

Adapted by David A Weinstein, Ph.D.
Department of Natural Resources
Fernow Hall, Cornell University
Ithaca, New York 14853

April 2007

Acknowledgement

This manual was adapted from one produced by the Wisconsin Phenological Society (<http://www.uwm.edu/~mds/pguide.pdf>). A great debt is owed to the members of that society, as well as Dr. Mark Schwartz, a professor at the University of Wisconsin, Madison, for all the work they put into assembling this material and making it available. Special thanks also goes to Plantwatch, a Canadian organization for observations of plant phenology, for making their forms and materials available (<http://plantwatch.sunsite.ualberta.ca/>).

Support for the creation of this manual came from the New York State Biodiversity Institute.



Photograph courtesy of David Werier

MANUAL

for Plant Phenology Observers

INTRODUCTION *

What is phenology?

Phenology is the biological science concerned with the timing of natural events in plants and animals from year to year and from place to place and their relationship to season, weather, and climate. Its purpose is to record the general development of plants and animals as affected by climate and weather at a certain geographical location. People have observed, and made use of, the seasonal recurrences in plant and animal life long before a name existed for this kind of data collecting, and have found rules that are useful locally, as exemplified by an early American saying, "Plant corn when the new oak leaves are the size of squirrels' ears." Written records have been kept in North America for more than 200 years. Recently, global climate change and related issues have reawakened interest in phenology.

What is the purpose of collecting phenology data?

In order to understand and anticipate seasonal changes in plant and animal life, we need a large body of observations over many years and preferably from many places. With these data records, we can measure how changes in climate may be affecting plant populations.

There are many ways in which beginners' reports

can be useful. The first reports of flowers, if reported from many places every year, provide a good picture of the advancement of spring each year. And, over the years, scattered reports on a trillium here and a red maple there will enable us to construct charts of how these events correspond to changes in climate.

How can people help collect this data?

Plant phenology can be observed on two levels. The beginner or the busy person can help with a few observations. Many beginners, each reporting a few items, can provide a lot of information. The advanced observer with more time or experience can attempt a more ambitious schedule of observations. Some people enhance a special interest such as fishing, beekeeping, or gardening, by observing many events related to that interest. Others select certain events in a specific area such as a wooded lot, a wetland, a field, a prairie, a river or lake, or an urban or rural property and attempt to record certain events in this area over several years. This can be a good way to inventory your property or neighborhood and discover what plants and animals are native there.

It is easy to notice that flowers are in bloom, but it is not so easy to decide when the first flower is "open" or when the first pollen is "shed." Definitions and instructions for recognizing the right time for recording these phases are necessary in order to make the data coming from various locations comparable and can be found in this manual. Keeping accurate notes of natural events can be time-consuming but it carries its own reward because it can lead to an understanding of the environment not otherwise attainable.

What are examples of how phenological data can be used?

(1) We can compare the date that an event, such as the date of first leaf or first flower, occurs in different places in the same year.

Figure 1 is an example of mapping the advancement of spring across the US that uses the first flowering date of the common lilac as the indicator. The lines represent the average leaf out date for the years 1961-1990. From this map we can see that lilac tends to bloom approximately ten days earlier in the southwestern border of NY state compared to in southern Canada on the northern shore of Lake Ontario.

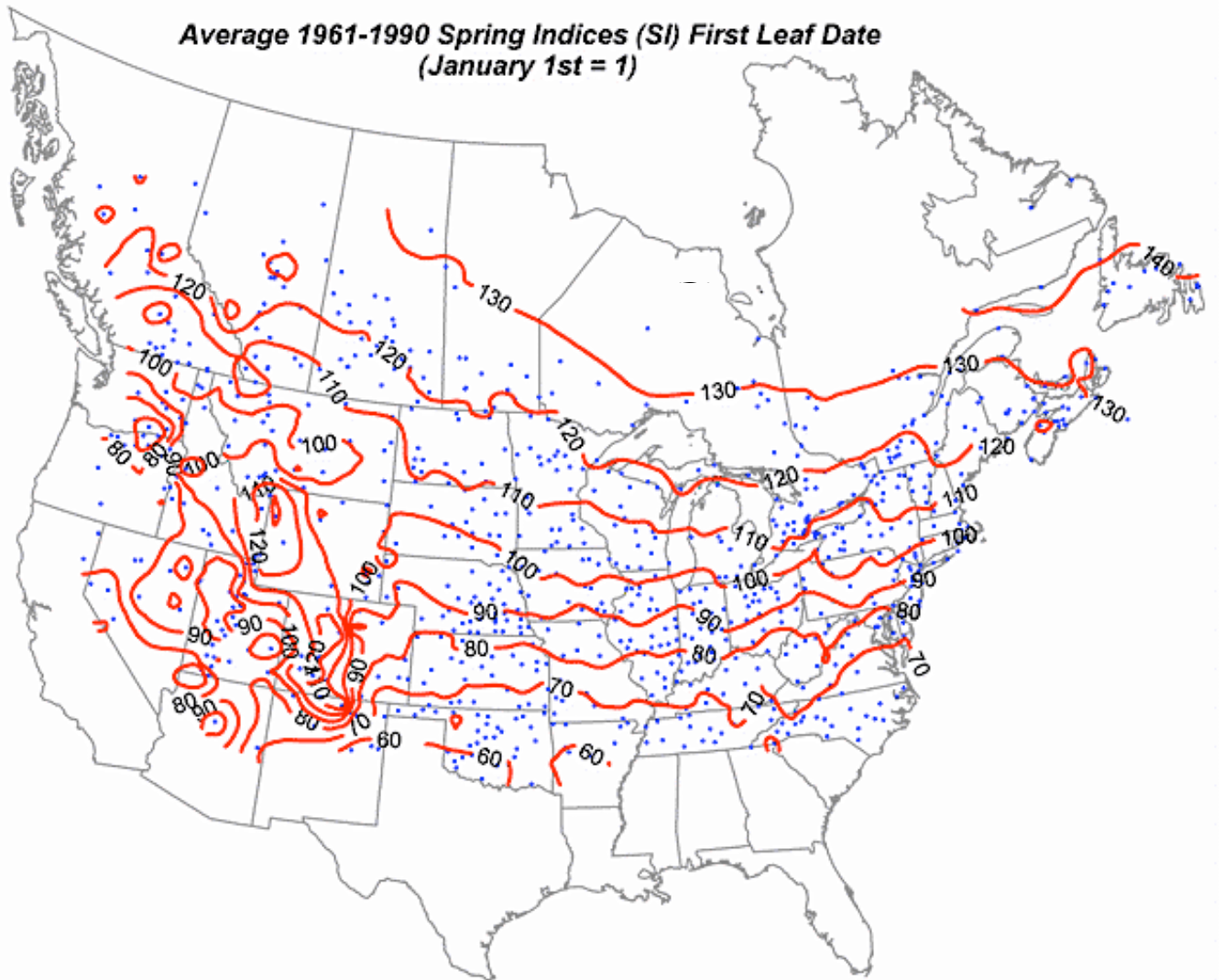


Figure 1. Day of year when lilac first leaves out, average 1961-1990 (Schwartz and Reiter. 2000 International. J. Climatology 20:929-932).

(2) We can compare the dates of first leaf or flower in different years at one location.

Figure 2 shows the trend in the day of first flowering in lilac. Notice the gradual decrease in departure from normal, indicating that trees were flowering on an earlier day of the year. Flowering occurred on average over 5 days earlier in 2003 than in 1955.

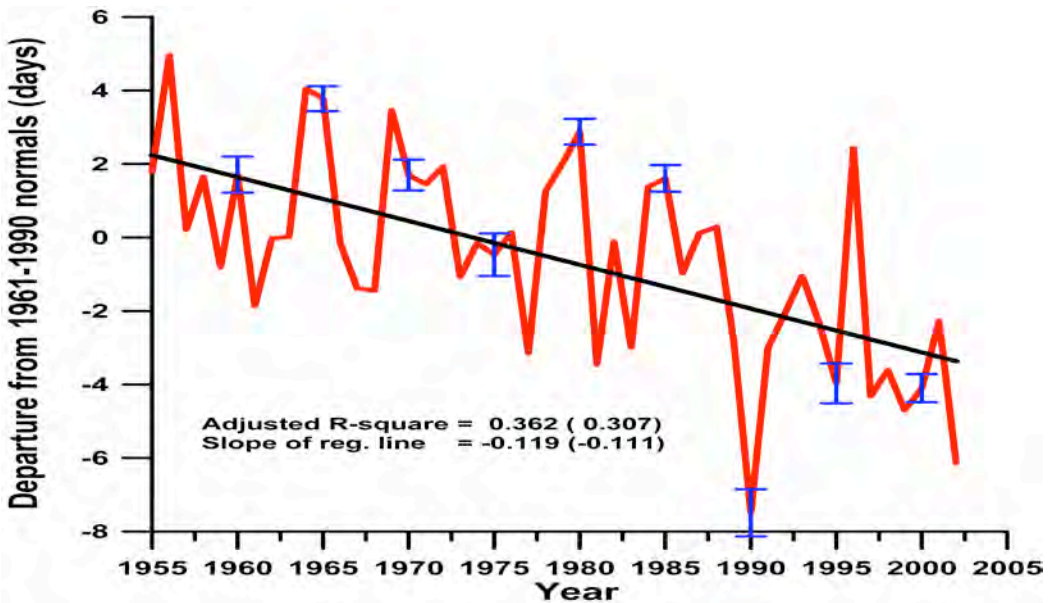


Figure 2. Departure from 1961-1990 normals in day of first flowering in lilac (Schwartz et al. 2006. *Global Change Biology* 12:343-351).

Actual blooming dates during individual years may be plotted against a timeline to see how a given year compares with the average. A nature calendar of blooming dates can be established so that other seasonal events can be plotted against this background of earliness and lateness, such as insect occurrences, pollen collected by bees, mushroom growth, heat accumulation by degree days, frost dates, and so on.

(3) *We can correlate different phenological events.*

Two phenological events are called “correlated” if one occurs with regularity at the same time or the same number of days after the other. For example, a list of carefully observed coincidences between insect events and stages of host plants can prove to be very successful in controlling agricultural and landscape pests.

Observing the life cycle patterns of plants, and the insects and pests associated with them has revealed their phenology has been separated historically by a predictable amount of warming that has occurred so far in the growing season, which can be measured as Growing Degree-Days. The following table shows the values for phenological events in Akron, Ohio.

<i>Plant Or Insect (In Bold)</i>	<i>Event</i>	<i>Growing Degree-Days</i>
Silver Maple	first bloom	34
Red Maple	full bloom	42
Eastern Tent Caterpillar	egg hatch	92
Sargent Cherry	first bloom	127
European Pine Sawfly	egg hatch	144
Inkberry Leafminer	adult emergence	150
Allegheny Serviceberry	first bloom	153
Common Chokecherry	first bloom	182
Eastern Redbud	first bloom	191
Gypsy Moth	egg hatch	192

Source: <http://www.oardc.ohio-state.edu/gdd/>

Guidelines for Reporting Phenological Observations

An observer should remember that the purpose of the observations is to record the general development of plants as a consequence of climate and weather at a discrete geographical location.

STEPS FOR TAKING YOUR OBSERVATIONS ON TREE AND SHRUB SPECIES:

STEP ONE - Choose at least one species from the following list of trees and shrubs. You can make observations on a single plant of this species, but it is even better if you can watch 3 or 4 individual tree or shrubs of the same species.

Trees and shrubs

[Acer negundo](#) (box elder, Manitoba maple)

[Acer rubrum](#) (red maple)

[Amelanchier](#) (saskatoon, june-berry)

[Cercis canadensis](#) (eastern redbud)

[Cornus florida](#) (flowering dogwood)

[Populus tremuloides](#) (quaking aspen)

[Prunus serotina](#) (black cherry)

[Prunus virginiana](#) (choke cherry)

[Robinia pseudoacacia](#) (black locust)

You may, of course, choose to make observations on more than one of these species. Eventually you will be able to choose to monitor any species of your interest. However, until we are ready to put these other species into the data base, it would be very helpful if you could focus on one of these nine tree and shrub species for your observations. That way Project BudBreak will collect a large number of data points on a limited number of species, and we will be able to determine whether members of this representative group are responding to climate change.

STEP TWO - Make your observations

Observe your trees or shrubs every few days (particularly in the spring) and make some quick observations. Jot down notes on a piece of paper so you remember when you get back to your computer.

Judge whether the plant you are observing is in a phenological stage (such as "first flowers have opened completely") by finding **at least three places** on the plant that meet the criteria (so, in this example, three places on the plant where flowers have opened completely).

You will see the phenological events to note listed in the "Observation Form" a few pages later in this manual. Examples of these of phenological events include:

1. The date when the first flowers have opened completely.
2. The date when the buds begin to burst open. The first green is visible on the young spring shoots and the first scales may fall off the buds.
3. The date when the first leaves have pushed themselves completely out of the bud or leaf sheath. The leaves have unfolded completely, so that the leaf stalk or leaf base is visible (sometimes only recognizable by bending back the young leaf). At this point, the individual leaf has taken its ultimate form, but has not yet reached its final size.

4. The date when the fruit shows the coloring characteristics of the plant variety (i.e., is ripe), and can be easily removed (i.e., is ready to fall from the plant).
5. The date when approximately 50% of the leaves (including those that have fallen to the ground) have taken on the colors of autumn.

See the Observation Form for the full list.

STEP THREE - come back to your computer, find the web site, and fill in the information on your observations. The first time it might take 10 minutes to fill in the necessary information describing your site location, but after you have been assigned a site location number, it should only take a minute to enter your latest observation, which you do by selecting from a multiple choice menu.

STEPS FOR TAKING YOUR OBSERVATIONS ON FLOWERING HERBACEOUS SPECIES:

Optionally, you can also choose to monitor one or more of the flowering herbaceous species from the following list.

Flowering herbs

[*Caltha palustris*](#) (marsh marigold)

[*Claytonia virginica*](#) (virginia spring beauty)

[*Clintonia borealis*](#) (blue-bead lily)

[*Cornus canadensis*](#) (bunchberry)

[*Fragaria virginiana/vesca*](#) (wild strawberry)

[*Linnaea borealis*](#) (twinline)

[*Maianthemum stellatum*](#) (star-flowered Solomon's seal)

[*Podophyllum peltatum*](#) (mayapple)

[*Trillium grandiflorum*](#) (trillium)

The rules for making phenological observations on herbs are the same as for trees, except that "first flowering" should be reported for a single flower (instead of at least 3 flowers for trees). This is obviously the case for herbs such as trillium that only have one flower.

Native wild flowers and shrubs should be observed in their natural habitat if possible, preferably at a location where a number of plants are growing under normal conditions. For example, an "undisturbed" stand of woodland flowers (such as trillium or bloodroot) would be inside a wooded area and not along a highway through the wood. Plants growing close to a highway must be considered a "disturbed" stand because of the changes in microclimate a highway always produces. Several plants should be available at the observation site because one isolated growing plant may be an especially early or late specimen, and it may not persist through the years.

The items listed on the reporting form represent only a small selection of the numerous observable plant events. Observers who have data on items not listed on the form can report these separately. You may also email reports directly to the Project BudBreak director, David Weinstein, at [**daw5@cornell.edu**](mailto:daw5@cornell.edu). Some observers may wish to try special things - making a series of photographs, measuring the temperature of the air, water, or soil, etc. Keep a copy of your records to insure accuracy and to build up your own personal database.

Below is a temporary observation form. When the web site is complete there will be a log-in page in which you identify yourself with "USER INFORMATION": a first name, last name, email address, and a password you have chosen.

The first time you are making observations, you will fill out the "SITE INFORMATION" for each site from which you are taking observations. This information will be stored so that you do not have to repeat it again.

From there, you'll go directly to the "PHENOLOGY OBSERVATIONS" page. You will fill out this page once for each plant you are observing each time you are observing it.

TEMPORARY OBSERVATION FORM:

USER INFORMATION

First Name _____

Last Name _____

Email address _____

SITE INFORMATION

A site is defined as an area in which all plants are growing under the same micro-climatic conditions. You will use this site name each time you make observations. You may make observations from more than one site if you choose (such as site "backyard"= behind your house, site "hill" is the top of a nearby hill).

Choose a site name or number for this site (20 characters or less) _____

Elevation of this site if known (indicate meters or feet) _____

Find the latitude and longitude by following this procedure:

Go to: <http://teraserver.microsoft.com/>

Type in your street address on left side of screen

For example:

51 Freese Rd

Ithaca

NY

Hit the "GO" button

Choose either "Aerial photo" or "Topo Map"

Copy down Longitude and Latitude from the left side of screen.

Enter the latitude and longitude here:

Latitude _____

Longitude _____

Building Proximity (distance to building) Place an "X" after one choice
(1 meter equals approximately 3 ft):

0 to 5 meters _____

5 to 10 meters _____

10 to 15 meters _____

15 to 20 meters _____

Greater than 20 meters _____

Site sun exposure. Place an "X" after one choice:

Sunny and open area _____

Half shade _____

Shady forest _____

At forest edge _____

Direction forest edge or building wall faces. Place an "X" after one choice:

N _____

NE _____

E _____

SE _____

S _____

SW _____

W _____

NW _____

Is the plant in a garden? Place an "X" after one choice:

Yes _____

No _____

Slope. Place an "X" after one choice:

Flat area _____

Gentle slope _____

Steep Slope _____

Direction slope faces. Place an "X" after one choice:

N _____

NE _____

E _____

SE _____

S _____

SW _____

W _____

NW _____

Comments:

PHENOLOGY OBSERVATIONS:

Month (0 - 12)_____

Day_____

Year_____

Tree or shrub information

If your observation plant is a **tree or shrub**, Place an "X" after one choice:

- Acer negundo (box elder, Manitoba maple) _____
- Acer rubrum (red maple) _____
- Amelanchier (saskatoon, june-berry) _____
- Cercis canadensis (eastern redbud) _____
- Cornus florida (flowering dogwood) _____
- Populus tremuloides (quaking aspen) _____
- Prunus serotina (black cherry) _____
- Prunus virginiana (choke cherry) _____
- Robinia pseudoacacia (black locust) _____

Tree or shrub leaves - If your observation plant is a tree or shrub, place an "X" after one choice:

- Closed bud _____
- Green leaf out but not unfolded _____
- Green leaf out and beginning to unfold _____
- Leaf unfolding up to 25% _____
- Leaf unfolding up to 50% _____
- Leaf unfolding up to 75% _____
- Full leaf unfolding _____
- Stem and/or first leaves fading _____
- Yellowing up to 50% _____
- Yellowing over 50% _____
- Dead _____

Tree or shrub blossoms - If your observation plant is a tree or shrub, place an "X" after one choice:

- Without blossom buds _____
- Blossom buds recognizable _____
- Blossom buds strongly swollen _____
- First flower _____
- In bloom up to 25% _____
- In bloom up to 50% _____
- Full bloom _____
- Fading _____
- Completely faded _____
- Bearing green fruit _____
- Bearing ripe fruit _____
- Bearing overripe fruit _____
- Fruit or seed dispersal _____

Flowering herb information

If your observation plant is a flowering herb, Place an "X" after one choice:

- Caltha palustris (marsh marigold) _____
- Claytonia virginica (virginia spring beauty) _____
- Clintonia borealis (blue-bead lily) _____
- Cornus canadensis (bunchberry) _____
- Fragaria virginiana/vesca (wild strawberry) _____
- Linnaea borealis (twinflower) _____
- Maianthemum stellatum (star-flowered Solomon's seal) _____
- Podophyllum peltatum (mayapple) _____
- Trillium grandiflorum (trillium) _____

Herb leaves - If your observation plant is an herb, place an "X" after one choice:

- Without shoots above ground _____
- First leaf unfolded _____
- Two or three leaves unfolded _____
- Plant fully developed _____
- First leaves turning yellow _____
- Yellowing up to 50% _____
- Dead _____

Herbs blossoms - If your observation plant is an herb, place an "X" after one choice:

- Without blossom buds _____
- Blossom buds recognizable _____
- Blossom buds strongly swollen _____
- Beginning to flower _____
- In bloom up to 25% (if multiple flowers per plant) _____
- In bloom up to 50%(if multiple flowers per plant) _____
- Full bloom _____
- Fading _____
- Completely faded _____
- Bearing green fruit _____
- Bearing ripe fruit _____
- Bearing overripe fruit _____
- Fruit or seed dispersal _____

How do I identify my species?

Twig parts. You can identify the trees and shrubs before they flower by following a key using characteristics of the twigs. Here are the parts of the twigs you will need to be familiar with.

ANATOMY OF A TWIG

terminal bud — a bud that is at the tip of a stem or branch

bud scale — a small modified leaf on the outside of a bud

lateral bud — a bud that is situated along the sides of a branch and not at the tip

lenticel — a corky spot on the bark which originally permitted air to enter the twig

leaf scar — the scar left on a twig when a leaf falls

bud scale scar — the scar left on a twig when a bud scale falls

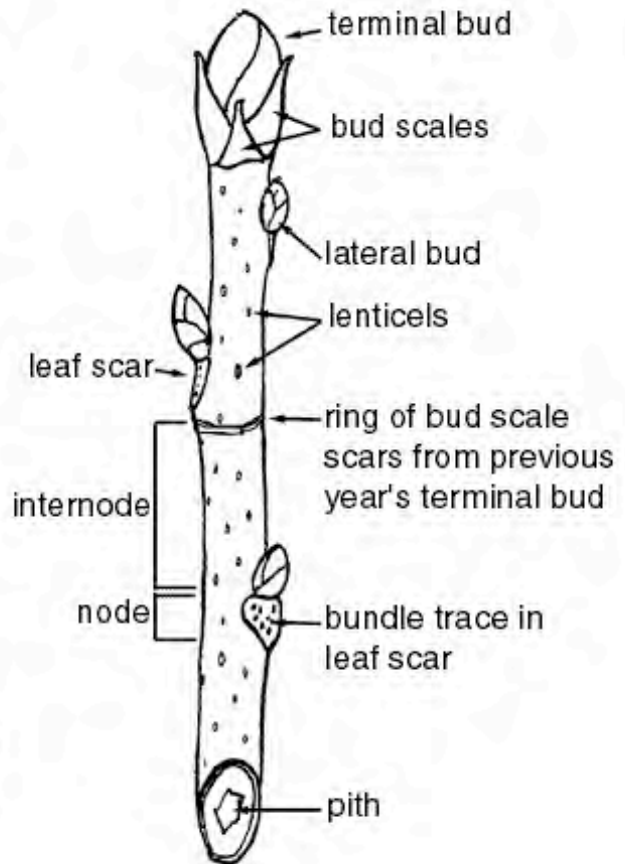
bundle trace — dot-like scars within a leaf scar, representing the broken ends of ducts which led to the leaf stalk

node — the place on a twig where a leaf is attached

internode — the part of a twig between two nodes

pith — central, usually soft portion of a twig, *chambered piths* are divided into empty compartments by cross partitions

thorns and spines (not pictured) — sharp-pointed, rigid structures arising from the twig or leaf



Identification key. You can use a twig key, such as the one found at the web site of Virginia Tech University, <http://www.cnr.vt.edu/dendro/dendrology/>. Here is an example of a page from this key:

Twig Key

So far you have made the following choices...

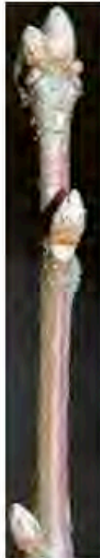
- [Located in NY and zone 3](#)
- [deciduous leaves](#)
- [alternate arrangement](#)
- [tree](#)
- [lacking spines](#)

Let's narrow our choices by looking at the buds.

[more than three end buds](#)

[three or fewer end buds](#)

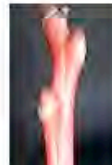
[very small, not obvious, or no apparent buds](#)



[My twig has more than three end buds](#)



[My twig has three or fewer end buds
\(they may not be true end buds\)](#)



[My twig has very small, not obvious, or no apparent buds](#)

Twig pictures. The following pages contain pictures of the buds of each of the focus tree species for our observations. Paying attention to the bark can also provide good clues. If you still have trouble identifying your trees before they make leaves, you might want to wait until they make leaves this year, identify them (it is much easier to identify trees by their leaves), mark them with a tag and a record of their species name, and begin your observations then. We will be collecting observations for a long time, so missing the first year is not so terrible.

Scientific name:

Common name: [Acer negundo](#)

[Acer rubrum](#)

[Amelanchier arborea](#)

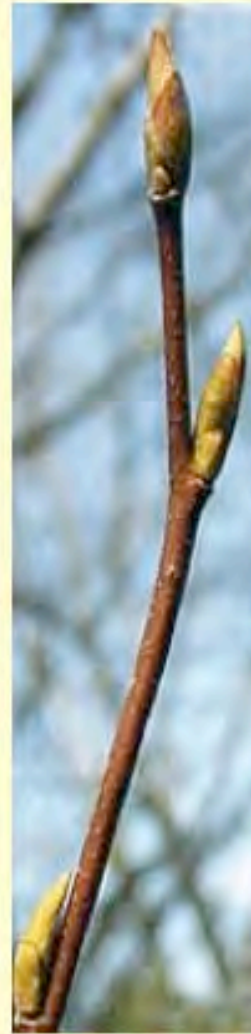
[Cercis canadensis](#)

[Box Elder](#)

[Red maple](#)

[Serviceberry](#)

[Redbud](#)



<http://www.cnr.vt.edu/dendro/dendrology/ident.htm>

Scientific name:

[Cornus florida](#)

[Populus tremuloides](#)

[Prunus serotina](#)

[Prunus virginiana](#)

[Robinia pseudoacacia](#)

Common name:

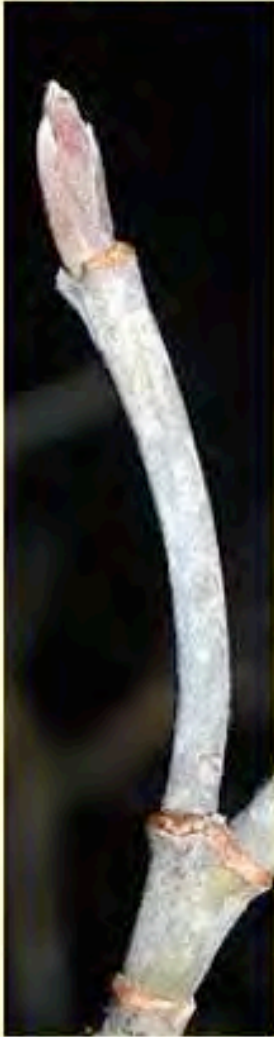
[Flowering dogwood](#)

[Tembling aspen](#)

[Black cherry](#)

[Choke cherry](#)

[Black locust](#)



<http://www.cnr.vt.edu/dendro/dendrology/ident.htm>

Identifying herbs. You obviously will not be able to identify the herbaceous species until they emerge from the ground. Once they do, you can identify them by their leaves using a guide such as Peterson's "A Field Guide to Wildflowers" (Houghton Mifflin Co., Boston) or Newcomb's "Wildflower Guide" (Little Brown and Co., New York). While these guides are oriented to identifying plants by their flowers, you can look up the pictures of leaves to acquaint yourself with the plants before they flower.

What and Where Shall I Observe?

When selecting events for observation consider the following criteria:

- (a) **Convenience of Location.** Select places where you frequently go (every one to three days is best): at home, at your place of work, or where you walk almost daily. Select only a few events to observe unless you have enough spare time because keeping accurate records can be rather time-consuming.
- (b) **Ease of Observation.** Select plants that are easy to access or have branches that fall down to eye-level.
- (c) **Permanence.** Locate a site likely to remain intact for many years so that annual comparisons can be made. Avoid places right next to heated buildings, eroding soil, pesticide use, or other disruptions.
- (d) **Distribution through the season.** If you have the time, try to follow events throughout the growing season, with some in early spring, some in summer, and some in fall.

When Shall I Observe?

Watch regularly before the event occurs. For example, find sprouts or buds not yet open but ready to burst. With experience you will learn when to start. But don't be overconfident, some seasons will surprise you!

If possible, choose good weather for observation. In cold, wet, or windy weather flowers may not be visible, although fully developed; animals may hide even though present. By watching closely you can often deduce that an event must have started a day or two earlier during bad weather, or since the previous observation.

Carry a form and pencil with you when you go out to observe. It takes a while to get into the habit of stopping right then and there to jot down the event before you forget what day you actually saw it.

Keep accurate notes. If you think that the event occurred before you noticed it, make a note of the circumstances and write down the most likely date, such as "May 7", and not just "Between May 5 and 10," for example.

Frequently Asked Questions

Q. I was visiting a friend's house and noticed that their lilac was blooming. Would you like me to report this?

A. Absolutely not! Unless you see a plant every day then you can not be assured when it first bloomed. It may have opened up many days ago and if you report the wrong date this will give us the wrong results.

Q. I have an old journal where I used to record the blooming dates of wildflowers. Is this information useful?

A. This kind of historic information is invaluable. Observations from the past can be directly compared to the observations we are presently collecting. This allows us to make an assessment on how changes in climate are affecting plant phenology. We need to look at long term trends in order to be accurate with our findings.

Q. I have a red maple in my yard, but it is fairly close to the house. Is it still useful to observe when the flowers open?

A. If you observe the same maple tree in the same way year after year these results become a key source for data. To observe the same tree, shrub, or herb year after year give us the best comparison and results!

Q. I can only identify one of the Project BudBreak species. Can I still participate in the program?

A. Even one observation is valuable information. We only want you reporting on plants that you are certain of.

Q. I am observing at my school and in the woods behind my house. These locations are pretty close to one another, so can I report both plants at the same location?

A. It is very important that each plant you observe has its own unique location. We need to have very specific latitude and longitude values in order to compare the observations. Each location you report from will have different elevation, slope and amount of exposure to sunlight. All of these factors influence bloom time and help in the interpretation of the observation. So, if you think the plants are growing under different conditions, report them as two different locations.

GLOSSARY

Here are some definitions those botanical and climatological terms likely to be found in the newsletters and publications.

ANTHER: The part of the plant which develops and contains pollen.

DEGREE DAYS: A numerical indicator for the occurrence of plant and insect events taking into consideration the accumulation of temperature effects during the developmental phase. Degree Days are obtained by summing up for each calendar day the excess of the mean daily temperature above a base (or threshold) value. For example, if the base temperature is 50 degrees F and the mean temperature of the day is 55 degrees F, then 5 degrees will be added to the accumulation; if the temperature is 45 degrees F, the day would contribute zero to the degree day accumulation.

EXPOSURE: The general surrounding of a site with special reference to its openness to winds and sunshine.

FIRST LEAF: The date when the widest part of the newly emerging leaf has grown beyond the ends of its opening winter bud scales.

FIRST POLLEN SHEDDING: The date when the pollen-carrying anthers (of silver maple, birch, male aspen, oak, white pine, ragweed, etc.) release a small cloud of pollen at a slight touch of the branch. Pollen is usually yellow.

FIRST FLOWER: The date when petals are open on individual flowers to such a degree that stamens are visible. On flower clusters (lilac, spirea) at least one of the small individual flowers should be open on several clusters.

PEAK BLOOM: The date when almost all the flowers in the observation area are open. Clusters have few unopened flowerlets.

HOPKINS' RULE or HOPKINS' LAW (1918): Phenological events vary at the rate of 4 days for each degree of geographic latitude, 5 days for each degree of geographic longitude and 1 day for each 100 feet of altitude, being later northward, eastward and upward.

ISOPHANES (or ISOPHENES): Lines on a geographical map through points where a given phenological event occurs at the same date.

LAKE EFFECT: The effect of any lake in modifying the weather about its shore and for some distance downwind. In the United States this term is applied specifically to the region about the Great Lakes.

MICROCLIMATE: Climatic conditions (temperature, humidity, wind) in the air layer near the ground as affected by terrain slopes, trees, shrubs, buildings, and other "disturbances."

Microclimate can differ significantly from the climatic normals of a region since these are established by instrument readings above level, uniform ground (at 6 ft. for temperature, about 25 ft. for wind).

PHENOLOGY: A branch of biological sciences (ecology) concerned with the timing of natural events in plants and animals from year to year and from place to place and their relationship to season, weather, and climate.

PHENOLOGICAL ALMANAC, also often called **PHENOLOGICAL CALENDAR:** A listing of sequential phases established over many seasons at one location used to guide agricultural activities or to predict subsequent phases in the same region. Examples: In Wisconsin plant corn when the oak leaves are the size of a squirrel's ear. In Vermont expect the trout will rise to fly when the shadberry blooms. In Montana make the first cutting of alfalfa within 10 days of lilac bloom to eliminate the wintering brood of alfalfa weevil before the eggs hatch.

PHENOLOGICAL CALENDAR: Using phases of selected plants observed for many years to establish the beginning and end of natural seasons and sub-seasons such as pre-spring, early spring, high spring, etc. Contrary to the universal astronomical calendar, a phenological calendar is valid only within a limited area.

PHENOLOGICAL GARDEN: A network of genetically identical plants (or groups of plants species).

PHENOPHASE or PHENOLOGICAL EVENT: Annually occurring stages observable in individual organisms.

SEASONALITY: Annual recurrence within a limited interval of calendar days (or periods of the solar year) of certain biotic as well as abiotic phases, events or group of events.

YEAR DAYS: Number of days after January first.

Phenological Literature:

Schwartz, M. D. 1998. Green-wave phenology. *Nature* 394: 839-840.

Schwartz, M. D. and Reiter, B. E. 2000. Changes in North American spring. *International Journal of Climatology* 20: 929-932.

Schwartz, M. D. (Editor) 2003. *Phenology: An Integrative Environmental Science*. Kluwer, The Netherlands

Schwartz, M. D., R. Ahas, and A. Aasa. 2006. Onset of spring starting earlier across the Northern Hemisphere. *Global Change Biology* 12:343-351

Useful Internet sites:

<http://www.uwm.edu/~mds/enanet.html>

<http://atlas.nyflora.org/>

<http://plants.usda.gov/>

<http://www.ces.ncsu.edu/>

<http://web.syr.edu/~mhough/>

<http://www.cnr.vt.edu/dendro/dendrology/> (contains a nice key to identify trees in winter)