



2

THE PLANT FUNCTIONAL GROUPS

SECTION TWO INTRODUCTION

Section 2 of this *Primer* focuses on how the phenophases of an individual plant progress over the course of an annual cycle, and presents an overview of the sequence of phenological events observers should look out for when making their repeated observations. This section is organized by plant “functional group”—groups defined by the USA-NPN to categorize *Nature’s Notebook* plant species by phenological similarities—and includes examples of individual species representing each functional group.

The major functional groups for flowering plants are Cactus, Forb, Grass, Sedge, Rush, and Tree/Shrub. Some of these groups are further divided according to leaf retention characteristics, such as “deciduous” for plants that shed all leaves and enter a dormant period in their annual cycle, and “evergreen” for plants that retain live leaves year round. The complete list of plant functional groups for flowering plants is as follows:

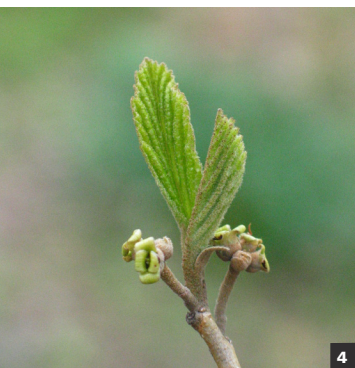
- **Cactus**
- **Forb**
- **Semi-evergreen forb**
- **Evergreen forb**
- **Grass**
- **Sedge**
- **Rush**



- **Deciduous Tree/Shrub**
- **Drought deciduous Tree/Shrub**
- **Semi-evergreen Tree/Shrub**
- **Evergreen Tree/Shrub**

“Functional group pages” begin with a description of the phenological characteristics that define the group, and then list the unique suite of phenophases specified for observation, including the phenophase definitions (covered in Section 1 of this *Primer*) and intensity questions (covered in Module 4 of our Observer Certification Course). These pages are followed by a set of “species pages” describing the sequence and manner in which the phenophases typically unfold for one or more species chosen to represent the functional group. Species were selected to present some of the variation that occurs within the group and to illustrate some situations where observations may prove challenging. Selection was also constrained to species for which the authors were able to acquire detailed photographs, either by taking them ourselves (primarily in Arizona and Maine), or from an online source.

“Species pages” begin with a generalized, annual timeline for the species, depicting onset and end of each phenophase in relation to the others as they might occur on a single plant. The timeline is an attempt to show



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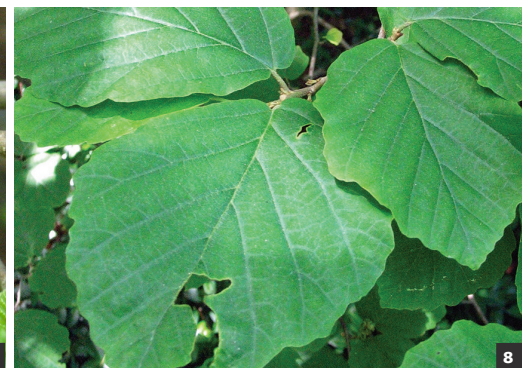
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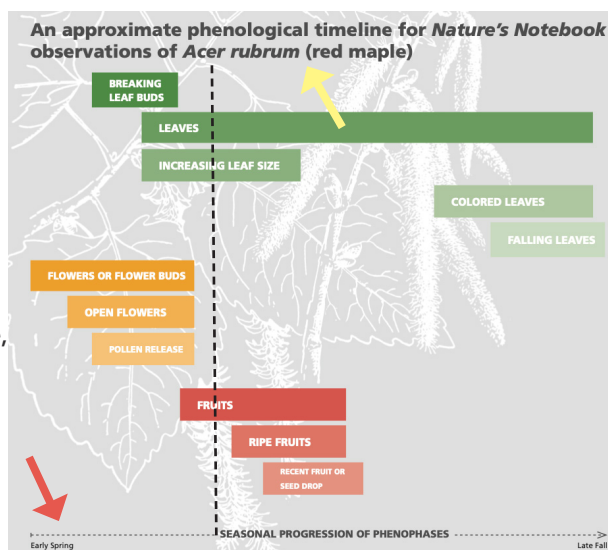


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The "species page" timeline

In the page heading, species is identified by scientific name and common name (yellow arrow). Seasonal extent of the timeline is indicated at the bottom (red arrow). Horizontal colored bars represent individual phenophases;

green for leaf phenophases, orange for flower phenophases, red for fruit. Where bars overlap vertically, phenophases can be expected to occur at the same time. For example, at the point in the season where the black dashed line is drawn, "Leaves", "Increasing leaf size", and "Fruits" will all occur at the same time, but "Breaking leaf buds" and flower phenophases will have ended.



which phenophases might overlap such that an observer would be reporting "yes" for several phenophases at the same time on their plant. Bars labelled with the phenophase name are color-coded, with green indicating leaf phenophases, orange for flower phenophases, and red for fruit phenophases.

While individuals of the species often follow the pattern shown, it is important to note that these timelines are only an approximation of reality. Considering the genetic variation within a species, health of an individual plant, geographic location of the site, microclimates of a landscape, and quirks of weather, it is likely that the phenology of any given individual plant in any given year might differ from its species' timeline as represented in these pages. Also, the graphic limitations of each timeline may misrepresent the actual duration of a phenophase, especially in cases where phenophase duration is very short in reality but the bar needed to be long enough to fit the name of the phenophase.

Following each species' timeline are several pages that provide series of detailed images illustrating the progression of each phenophase. For graphic simplicity and to focus attention on one plant part at a time, leaf, flower and fruit phenophases are grouped separately and presented in that order, even in species where flowers appear before leaves. Therefore, use the timeline in combination with these image series for a more complete understanding of when to expect leaf, flower and fruit phenophases to occur in relation to one another.





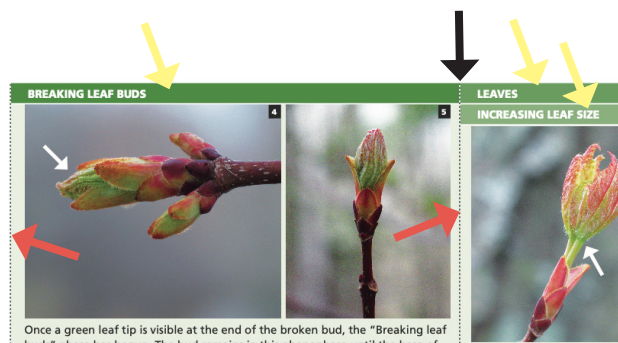
The "species page" image series

Colored bars represent individual phenophases (yellow arrows), with images underneath depicting plant structures in that phenophase. Often arrows or circles are used to point out what to look for in the image (white arrows in this example). Dashed lines indicate the start and end of phenophases (red arrows).

When one phenophase bar ends at the same point another begins (black arrow), it indicates the plant structure will

be in one phenophase or the other, but not both at the same time.

In this example, the leaf bud in the image transitions from "Breaking leaf buds" to "Leaves" once the first leaf unfolds. When bars overlap, a plant structure will be in both phenophases at the same time. In this example, leaves in the image on the right are in both the "Leaves" and "Increasing leaf size" phenophases.

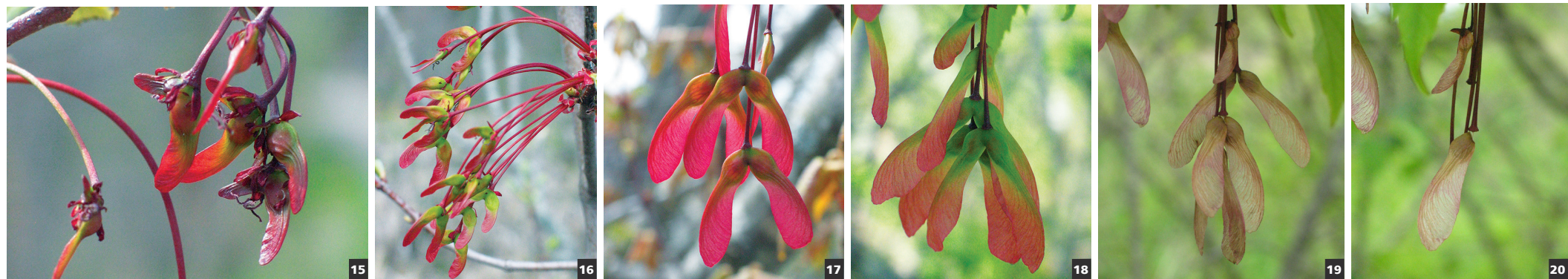


Once a green leaf tip is visible at the end of the broken bud, the "Breaking leaf buds" phase bar begins. The bud remains in this phenophase until the base of

Each image series includes color-coded horizontal bars, mirroring those in the timeline, to indicate which phenophases are depicted in the succession of images. Each series is laid out in two rows on each page and should be followed from top left to top right, then bottom left to bottom right, and in some cases continuing onto the next page. Dashed lines are positioned vertically to help identify when individual phenophases start and end within the image series.

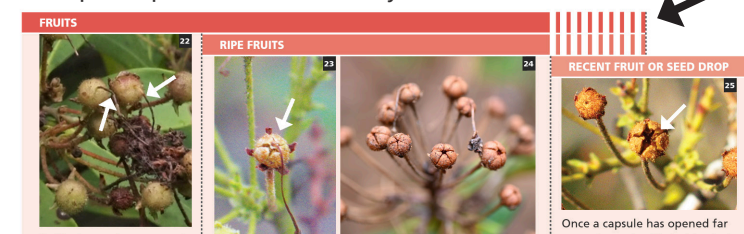
Transitions from one phenophase to the next are shown for an individual plant structure (bud, leaf, flower, fruit), and not at the scale of the whole plant as in the timeline. So when one phenophase bar ends at the same point another begins, it indicates the plant structure will be in one phenophase or the other, but not in both at the same time. For example, each leaf bud on a plant remains in the "Breaking leaf buds" phenophase only until the first leaf from that bud unfolds. After that point, that individual bud is in the "Leaves" phenophase and no longer in the "Breaking leaf buds" phenophase. However, some buds on the plant will be in the "Breaking leaf buds" stage while others are in the "Leaves" stage, so over the whole plant, both phenophases can occur at the same time (as indicated in the timeline).

The same principle applies to "Falling leaves"—a leaf that has fallen is no longer in the "Leaves" or "Colored leaves" phenophases—as well as for "Recent fruit or seed drop"—a fruit that has dropped from the plant is no



longer in the “Fruits” or “Ripe fruits” phenophases. However, in species with fruits that have multiple seeds that do not drop all at once, this principle breaks down. In this case, a ripe fruit that has dropped some seeds, but retains others, will still be in the “Ripe fruits” phenophase, but an observer might also notice “Recent fruit or seed drop” from that fruit on the same visit. The potential for this situation in relevant species is reflected by a partial overlap of colored bars in the fruit phenophase image series.

Hashed bars for “Fruits” and “Ripe fruits” (black arrow) extend partway over the “Recent fruit or seed drop” bar in species where a single fruit may drop seeds over time instead of all at once, and thus could be in all three phenophases simultaneously.



Where phenophase bars overlap in the image series, the plant structure will be in those multiple phenophases simultaneously. This occurs for phenophases that were designed to be “nested”. For example, the “Open flowers” phenophase is nested within the “Flowers or flower buds”

phenophase—a flower in the “Open flowers” stage is by definition also in the “Flowers or flower buds” stage—and “Pollen release” is nested within “Open flowers” because a flower releasing pollen is by definition open and still fresh. Similarly, “Ripe fruits” is nested within “Fruits”, and “Young leaves”, “Increasing leaf size” and “Colored leaves” are each nested within the “Leaves” phenophase.

In some cases we have included gray bars in the timeline and image series to indicate conditions that cause unusual timing of phenophases (like a long period of ovary dormancy resulting in the delay of fruit development). We have also included images of pre- and post-phenophase conditions to help observers understand what they will see before a phenophase begins (dormant and swelling buds) and what should no longer be included in a phenophase (spent flowers, empty fruits).

Navigating the phenophase transitions and overlapping phenophases on a plant can be overwhelming for new observers. For more advice and encouragement, refer to the *Nature’s Notebook* Nuggets entitled “Overlapping Phenophases”, “Focus on Leaves”, and “Focus on Flowers and Fruits” (found on the *Nature’s Notebook* FAQ page or by typing “Nugget” in the USA-NPN website search box). Remember that there is variation from individual to individual and your plant will not look exactly like the ones pictured here. But with patience and careful observation over time, you will get to know the nuances of your individual plants and become a confident observer!



TREE/ SHRUB— DECIDUOUS

This functional group includes woody plant species with leaves that are present during the growing season, but that senesce and fall from the plant as they enter a leafless dormant season (typically winter). Leaves develop rapidly at the beginning of the growing season in a single, large flush, then stop growing once they reach mature size. Dormant leaf buds are large enough to observe the process of bud break.

Representative species:

- *Acer rubrum*
(red maple)
- *Quercus rubra*
(northern red oak)
- *Magnolia stellata*
(star magnolia)
- *Hamamelis virginiana*
(American witchhazel)

Breaking leaf buds

One or more breaking leaf buds are visible on the plant. A leaf bud is considered “breaking” once a green leaf tip is visible at the end of the bud, but before the first leaf from the bud has unfolded to expose the leaf base at its point of attachment to the leaf stalk (petiole) or stem.

How many buds are breaking? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

Leaves

One or more live, unfolded leaves are visible on the plant. A leaf is considered “unfolded” once its entire length has emerged from a breaking bud, stem node or growing stem tip, so that the leaf base is visible at its point of attachment to the leaf stalk (petiole) or stem. Do not include fully dried or dead leaves.

What percentage of the potential canopy space is full with leaves? Ignore dead branches in your estimate of potential canopy space. Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more

Increasing leaf size

A majority of leaves on the plant have not yet reached their full size and are still growing larger. Do not include new leaves that continue to emerge at the ends of elongating stems throughout the growing season.

What percentage of full size are most leaves? Less than 25%; 25-49%; 50-74%; 75-94%; 95% or more

Colored leaves

One or more leaves show some of their typical late-season color, or yellow or brown due to drought or other stresses. Do not include small spots of color due to minor leaf damage, or dieback on branches that have broken. Do not include fully dried or dead leaves that remain on the plant.

What percentage of the potential canopy space is full with non-green leaf color? Ignore dead branches in your estimate of potential canopy space. Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more

Falling leaves

One or more leaves with typical late-season color, or yellow or brown due to other stresses, are falling or have recently fallen from the plant. Do not include fully dried or dead leaves that remain on the plant for many days before falling.





1

Flowers or flower buds

One or more fresh open or unopened flowers or flower buds are visible on the plant. Include flower buds or inflorescences that are swelling or expanding, but do not include those that are tightly closed and not actively growing (dormant). Also do not include wilted or dried flowers.

How many flowers and flower buds are present? For species in which individual flowers are clustered in flower heads, spikes or catkins (inflorescences), simply estimate the number of flower heads, spikes or catkins and not the number of individual flowers. Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000



2

Open flowers

One or more open, fresh flowers are visible on the plant. Flowers are considered "open" when the reproductive parts (male stamens or female pistils) are visible between or within unfolded or open flower parts (petals, floral tubes or sepals). Do not include wilted or dried flowers.

What percentage of all fresh flowers (buds plus unopened plus open) on the plant are open? For species in which individual flowers are clustered in flower heads, spikes or catkins (inflorescences), estimate the percentage of all individual flowers that are open. Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more



3

Pollen release *

only included for allergenic species

One or more flowers on the plant release visible pollen grains when gently shaken or blown into your palm or onto a dark surface.

How much pollen is released? Little: Only a few grains are released.; Some: Many grains are released.; Lots: A layer of pollen covers your palm, or a cloud of pollen can be seen in the air when the wind blows.



4

Fruits

One or more fruits are visible on the plant. *Species-specific description included here.*

How many fruits are present? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

Ripe fruits

One or more ripe fruits are visible on the plant. *Species-specific description included here.*

What percentage of all fruits (unripe plus ripe) on the plant are ripe? Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more

Recent fruit or seed drop

One or more mature fruits or seeds have dropped or been removed from the plant since your last visit. Do not include obviously immature fruits that have dropped before ripening, such as in a heavy rain or wind, or empty fruits that had long ago dropped all of their seeds but remained on the plant.

How many mature fruits have dropped seeds or have completely dropped or been removed from the plant since your last visit? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

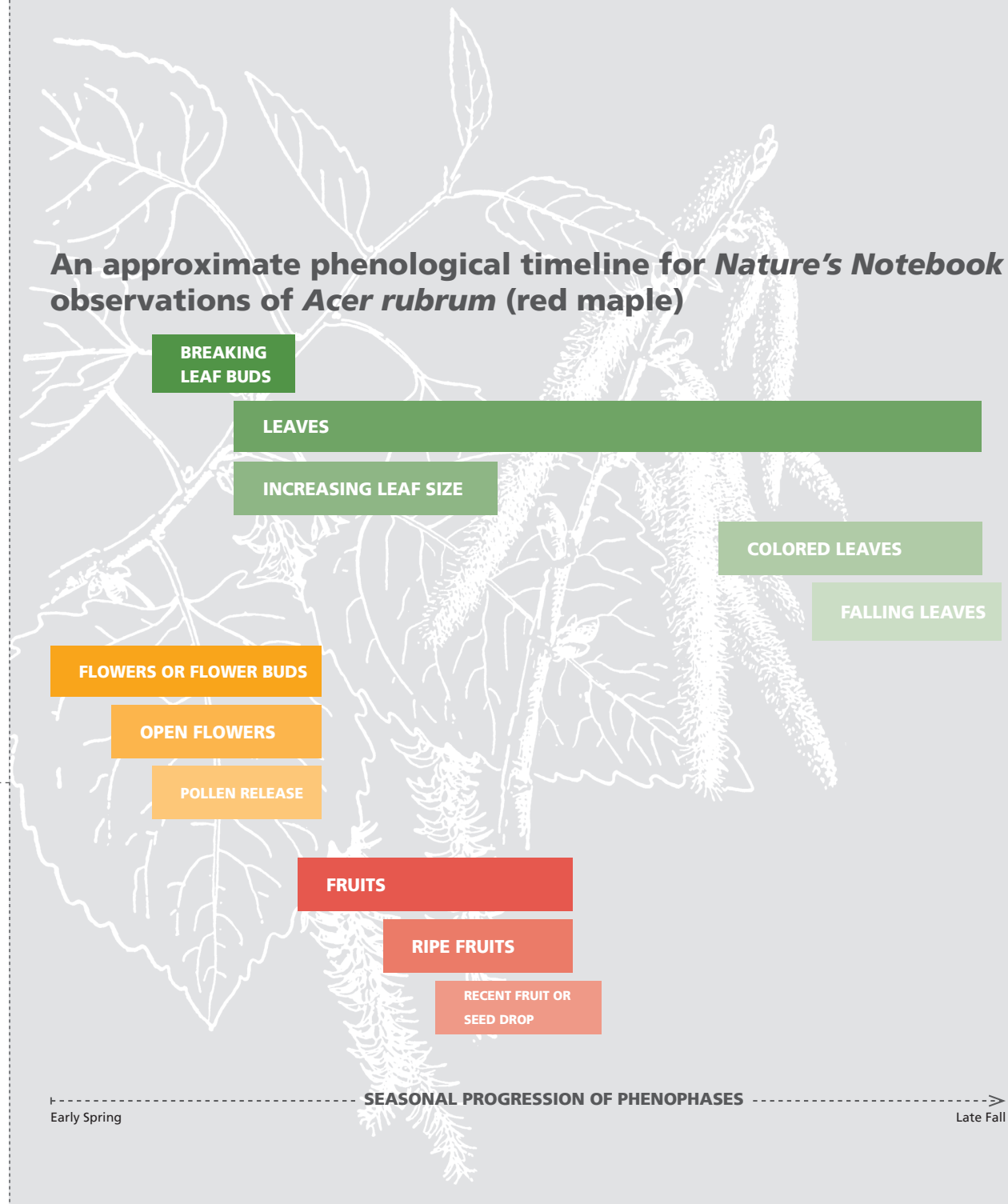


Red maple is widespread in the eastern US and one of the first trees to bloom in spring. It can be monoecious—that is, the separate male and female flowers are found on the same tree—or it can be dioecious—male flowers are found on separate trees from female flowers. Flowers are small and wind-pollinated, typically opening just before the leaf buds break. The fruits are winged samaras that ripen and drop in summer, spiralling like a helicopter rotor as they fall to the ground. In fall, these trees often create colorful displays of red leaves.

Phenological characteristics of note:

- scaled leaf and floral buds are separate
- male and female parts are in separate flowers
- flowering before leaf out
- fruit ripeness indicated by color change

An approximate phenological timeline for *Nature's Notebook* observations of *Acer rubrum* (red maple)



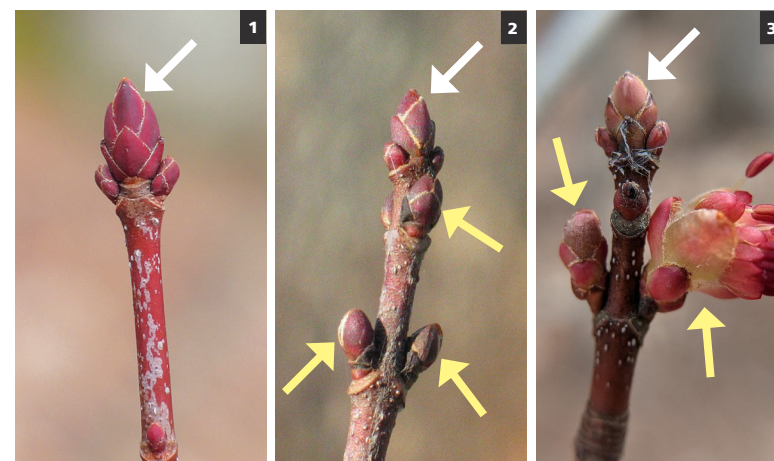
Acer rubrum

(red maple)

Activity begins in spring as dormant buds come to life. Red maples typically have two types of scaled buds—vegetative (leaf) and reproductive (floral). Red maple leaf buds are described as narrower and pointed (Images 1-3, white arrows), whereas floral buds are described as plump and rounded (Images 2-3, yellow arrows). Even when floral buds are present on a twig, typically the bud at the tip of the twig is a leaf bud (Image 2, white arrow). Usually floral buds become active before leaf buds break, in which case the first “yes” observation in the spring will be for “Flowers or flower buds”.

Leaf phenophases

“Breaking leaf buds” begins when leaf tips emerge (Image 4). Then, when at least one breaking leaf bud’s first leaf has unfolded (Image 6), begin reporting “yes” for the “Leaves” phenophase, and continue reporting “yes” until the last leaf has dropped from the plant in fall. You will also be reporting “yes” for “Increasing leaf size” in the spring, and “Colored leaves” in fall. The reddish color of new spring leaves (Images 6-9) is not “typical late-season color” and thus not included in the “Colored leaves” phenophase, so you will report “no” for this phenophase in the spring.



Dormant and swelling buds. While leaf buds (white arrows) are dormant (Images 1-2), or newly active and swelling (Image 3), report “no” for “Breaking leaf buds” until the bud scales slide apart enough that a green or reddish leaf tip emerges at the tip of the bud (Image 4). Floral buds (yellow arrows) are dormant in Image 2 and active in Image 3—the bud on the left is swelling, and the bud on the right has become an open male flower.

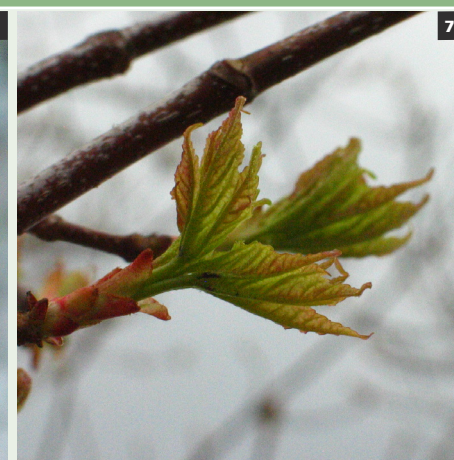
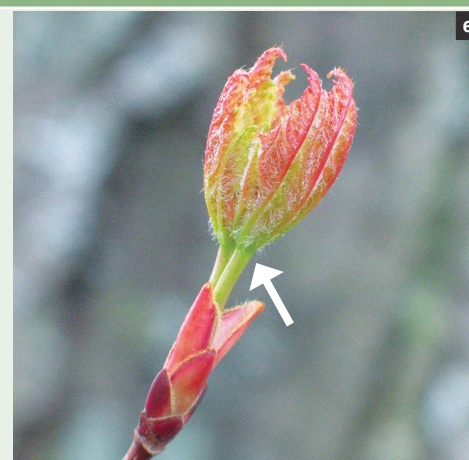
BREAKING LEAF BUDS



Once a green leaf tip is visible at the end of the broken bud, the “Breaking leaf buds” phase has begun. The bud remains in this phenophase until the base of its first leaf is visible where it attaches to the petiole (Image 6, white arrow). Report “yes” for this phenophase until all broken buds have a visible leaf base.

LEAVES

INCREASING LEAF SIZE



Once the leaf base becomes visible, the first leaf from the bud is considered “unfolded”. At this point, the bud has left the breaking stage and entered the “Leaves” and “Increasing leaf size” phenophases.



LEAVES

INCREASING LEAF SIZE

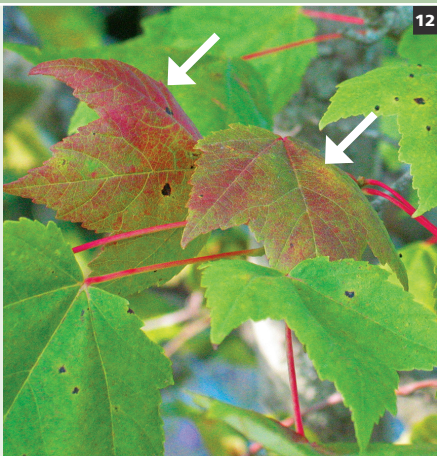


A plant remains in the “Increasing leaf size” phase as new spring leaves grow larger. During this period, leaves are lighter in color, and thinner in texture than they will become when they are full size and mature (Image 11). Although new leaves continue to grow from branch tips all summer, report “no” for “Increasing leaf size” once most of the leaves from the large spring flush have reached full size and stopped growing larger.

Full-size, mature leaves on lower branches. Note that at maturity, red maple shade leaves in the lower part of the tree canopy will be larger, lighter in color and thinner in texture than any sun leaves growing in the treetop.

LEAVES

COLORED LEAVES



When leaves start to senesce at the end of summer, bright red color begins to appear and the “Colored leaves” phase has begun (Image 12). In red maple, a few leaves may even begin to senesce and turn color in midsummer. Later in fall or in the case of drought, the “Colored leaves” you see on your plant may be yellow instead of red (Image 14).

FALLING LEAVES



Fallen leaves under the plant.



Acer rubrum

(red maple)

Flower phenophases

Once the floral buds begin swelling, bud scales start to slide apart and the “Flowers or flower buds” phase has begun. Report “yes” for this phenophase when floral buds begin swelling and continue reporting “yes” until the last flower is withered or dried. If you are unsure whether you see swelling floral buds, wait until you see flower parts emerge from the bud before reporting “yes” for “Flowers or flower buds”.

The “Open flowers” phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried. Because red maple pollen is an allergen, the “Pollen release” phenophase is also included for observation.

Red maple has separate male and female flowers. In some cases, both types will be present on the same plant, and in other cases only male or only female flowers will be present on a plant. If your plant has only male flowers, it will not produce fruits.

FLOWERS OR FLOWER BUDS



As floral buds swell, they get larger and bud scales slide apart until they break open to reveal the reproductive parts inside (Image 18).

FLOWERS OR FLOWER BUDS

OPEN FLOWERS



Male flowers have red anthers that become yellow with pollen (Images 18-19), and female flowers have fuzzy, red stigmas that are slightly curled (Images 20-21).

POLLEN RELEASE



Report “yes” for “Pollen release” only if you can get close enough to male flowers to see pollen grains being released.

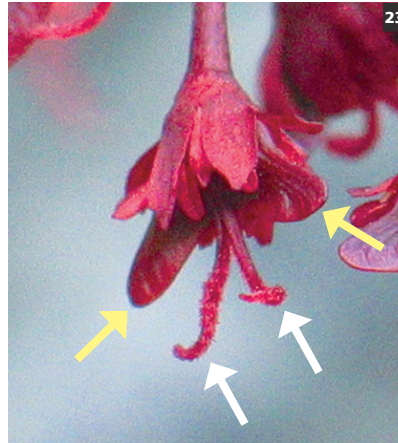
Acer rubrum (red maple)

Fruit phenophases

When a red maple flower's two-part ovary (Image 23) has been fertilized, a two-seeded fruit will begin to develop shortly thereafter (Image 24).

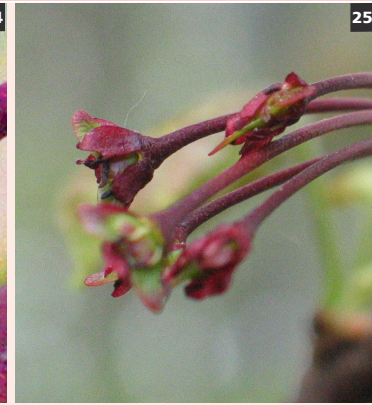
The *Nature's Notebook* fruit definition reads "For *Acer rubrum*, the fruit is two joined seeds in a 'V' shape, each seed having a wing, that changes from green or red to tan or brownish and drops from the plant. A fruit is considered ripe when it has turned tan or brownish and readily drops from the plant when touched."

Remember that if your red maple has only male flowers, it will not produce any fruit.



Open female flower with extended stigmas (white arrows) at the end of a laterally flattened pistil. The pistil has "wings" (yellow arrows) extending from the two-part ovary that will continue to develop as part of the fruit after fertilization.

FRUITS



The flower's stigmas have dried (Image 24, white arrows) and the green ovary (yellow arrow) is showing signs it has been fertilized and is beginning to swell. The ovary has entered the "Fruits" phenophase, but do not worry if you do not catch these first subtle signs of swelling—they can be difficult to see.

FRUITS

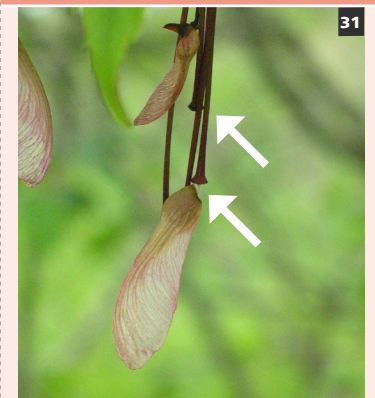


RIPE FRUITS



A fruit is ripe when it has dried and turned tan.

RECENT FRUIT OR SEED DROP



Missing seeds (white arrows) since the last visit in Image 30 indicate recent drop.

As the two-seeded red maple fruits continue to develop, they gradually change in size and color—although color can differ from plant to plant. A fruit is considered ripe when it has turned from green or red to tan or brownish.





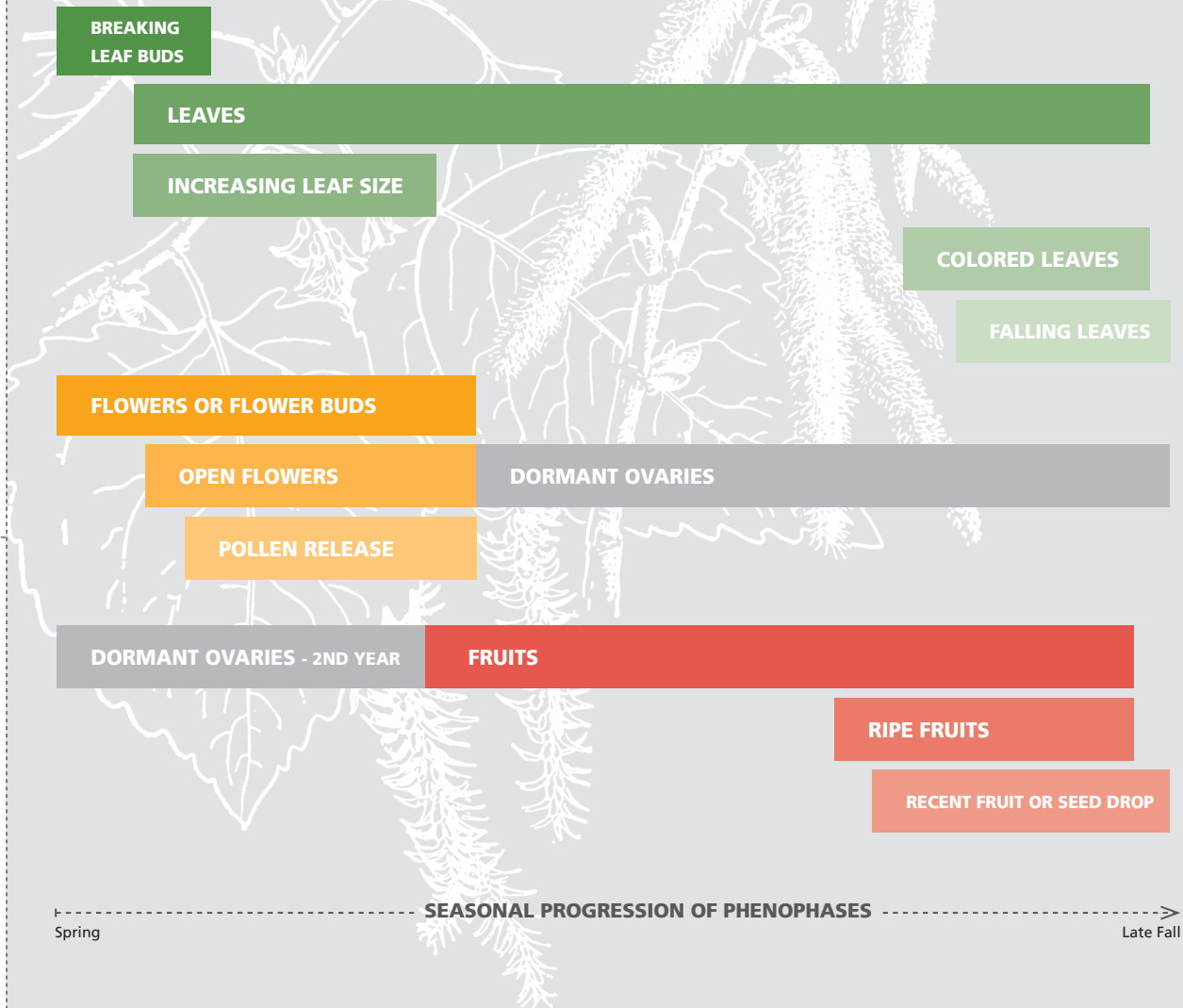
Northern red oak is a dominant tree of forests in the northeastern US. It is monoecious—that is, the male and female flowers are separate on the same plant. Flowers are wind-pollinated and arranged in catkins, typically emerging just after leaf out. Every few years, it produces a massive crop of acorns that is synchronized across the region—a phenomena called “masting”.

The species has an unusual reproductive strategy—its fruits take two years to mature. Once pollinated, fertilization is delayed and ovaries sit dormant for a year. They are fertilized the following spring and fruits mature the in fall.

Phenological characteristics of note:

- scaled mixed buds contain both leaves and flowers
- male and female parts are in separate flowers arranged in catkins
- leaf out before flowering
- fruit abortion is common
- fruit ripeness indicated by color change
- “marcescent” leaves remain on the plant after senescence

An approximate phenological timeline for *Nature’s Notebook* observations of *Quercus rubra* (northern red oak)



Quercus rubra

(northern red oak)

Activity begins in spring as dormant buds come to life. Northern red oaks typically have two types of buds—vegetative (leaf) and mixed buds that produce both leaves and flowers. The buds look similar and only differ in size, although size is not always a reliable characteristic to determine what a bud contains. Leaves generally appear first from mixed buds, with flowers following shortly thereafter.

Leaf phenophases

“Breaking leaf buds” begins when leaf tips emerge (Image 4). Then, when at least one breaking leaf bud’s first leaf has unfolded (Image 5), begin reporting “yes” for the “Leaves” phenophase, and continue reporting “yes” until the last leaf has dropped from the plant in fall. You will also be reporting “yes” for “Increasing leaf size” in the spring, and “Colored leaves” in fall. The reddish color of new spring leaves (Images 5-6) is not “typical late-season color” and thus not included in the “Colored leaves” phenophase, so you will report “no” for this phenophase in the spring.



Dormant and swelling buds. While the buds are dormant (Image 1), or newly active and swelling (Images 2-3), report “no” for “Breaking leaf buds” until the bud scales slide apart enough that a green or reddish leaf tip emerges at the tip of the bud (Image 4).

BREAKING LEAF BUDS



Once a leaf tip is visible at the end of the broken bud, the “Breaking leaf buds” phase has begun. The bud remains in this phenophase until the base of its first leaf is visible where it attaches to the petiole (Image 5, white arrow). Report “yes” for this phenophase until all broken buds have a visible leaf base.

LEAVES

INCREASING LEAF SIZE



Once the leaf base becomes visible, the first leaf from the bud is considered “unfolded”. At this point, the bud has left the breaking stage and entered the “Leaves” and “Increasing leaf size” phenophases.

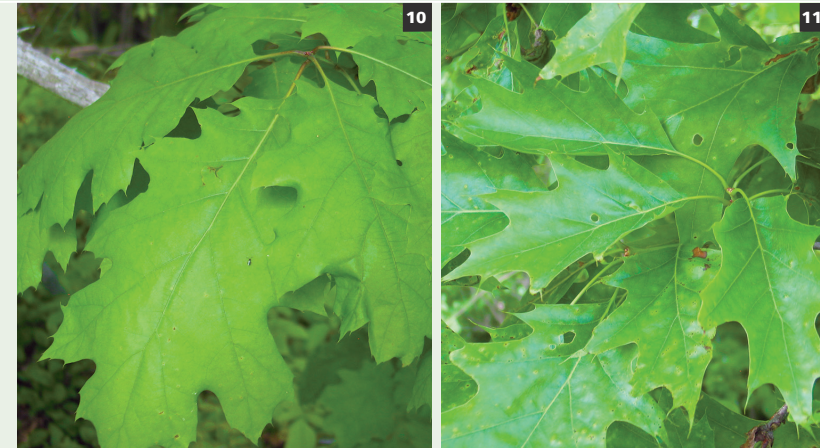


LEAVES

INCREASING LEAF SIZE



A plant remains in the “Increasing leaf size” phase as new spring leaves grow larger. During this period, leaves are lighter in color, and thinner in texture than they will become when they are full size and mature (Images 10-11). Although new leaves continue to grow from branch tips all summer, report “no” for “Increasing leaf size” once most of the leaves from the large spring flush have reached full size and stopped growing larger.



Full-size, mature leaves in shade (Image 10) and in sun (Image 11). Note that at maturity, shade leaves in the lower part of the tree canopy will be larger, lighter in color and thinner in texture than any sun leaves growing in the treetop.

LEAVES

COLORED LEAVES



When leaves start to senesce at the end of summer, yellow or red color begins to appear and the “Colored leaves” phase has begun (Image 12). In northern red oak, leaves turn various shades of yellow, orange, red and brown, and it is characteristic for some dead, brittle leaves to remain on the plant for an extended period of time. As long as leaves still feel leathery and pliable, report “yes” for “Colored leaves” and “Leaves”. Report “no” for these phases when all leaves still on the plant are dry and brittle (Image 16).

FALLING LEAVES



Fallen leaves under the plant.

Dead, brittle “marcescent” leaves often remain on the plant all winter.



Quercus rubra

(northern red oak)

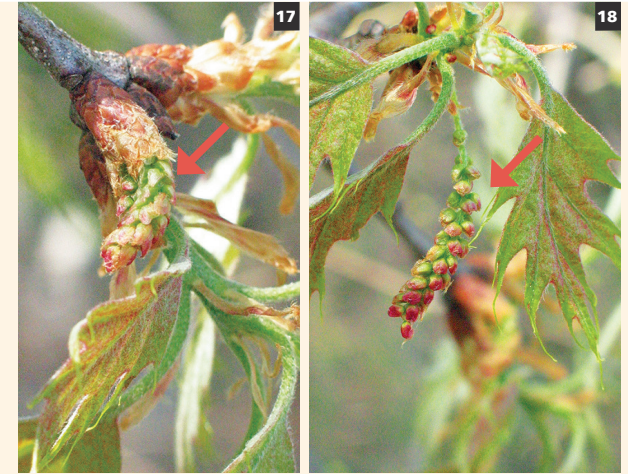
Flower phenophases

Northern red oak is a monoecious species with separate male and female flowers on the same plant. Both are arranged in catkins, yet they look very different. Male catkins, when fully formed, are long and dangly, containing many flowers. They emerge from mixed buds just after leaves emerge from the same bud (Image 17). Female catkins are tiny, containing only a few flowers, and are difficult to spot. They emerge from stem nodes on the newly-growing, green twig at the point where a new leaf is attached (Image 19, orange arrows). Once you see either sex's flower buds, report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

The "Open flowers" phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried. Where flowers are out of reach, the small reproductive parts are hard to see, so begin reporting "yes" for "Open flowers" when male catkins are hanging loosely (Image 21).

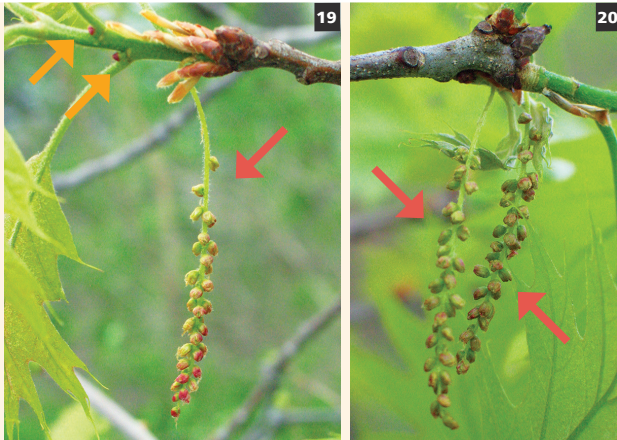
Because northern red oak pollen is an allergen, the "Pollen release" phenophase is also included for observation.

FLOWERS OR FLOWER BUDS



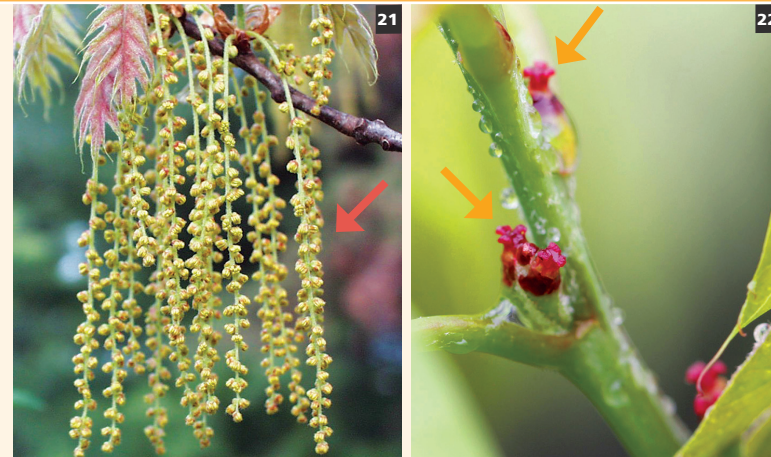
Male catkins will emerge from the bud shortly after the leaves (Image 17, red arrow). They are initially compact and stiff.

FLOWERS OR FLOWER BUDS



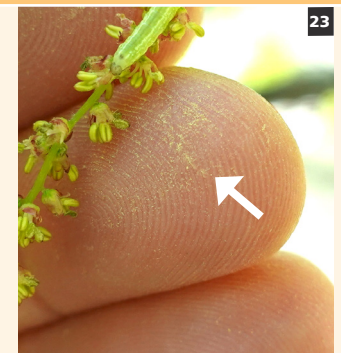
Male catkins eventually unfold to become longer (Images 19-20, red arrows). Female flowers will be very difficult to see (Image 19, orange arrows). If they are out of reach, do not worry about reporting on them.

OPEN FLOWERS



Once male catkins are hanging loosely (Image 21), the individual flowers are open with anthers exposed. Female flowers are open when pistils are exposed (Image 22), but these will be hard to see.

POLLEN RELEASE



Report "yes" for "Pollen release" only if you can get close enough to male flowers to see pollen grains being released.



Quercus rubra

(northern red oak)

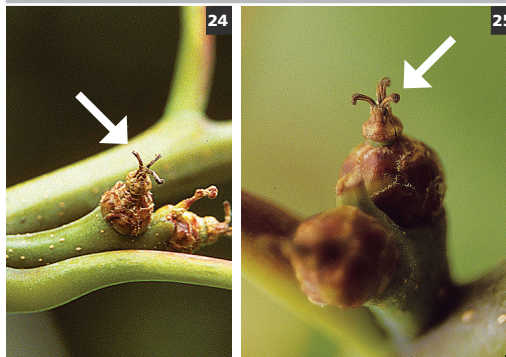
Fruit phenophases

After female northern red oak flowers have been pollinated, the ovaries remain dormant until the following spring when fertilization occurs. At this time the fruits—acorns—begin to develop and will mature in the fall.

The *Nature's Notebook* fruit definition reads "For *Quercus rubra*, the fruit is a nut (acorn), partially covered with a 'cap', that changes from green to green-brown to brown, red brown or dark brown. A fruit is considered ripe when it has turned brown, red brown or dark brown."

Northern red oak commonly discontinues the growth of some fruits, aborting them before they mature. These will appear as tiny acorns on the plant that stopped getting larger (Image 31, white arrow), or small immature fruits dropped from the plant (Image 34).

DORMANT OVARIES



Once pollinated, female flower stigmas dry out (white arrows) and the tiny ovaries sit dormant on the plant for many months. The ovaries will not be fertilized and begin fruit development until the following spring.

FRUITS



Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger after its year-long dormancy (Image 26). If these small fruits are out of reach, you may not be able to see them at all until they grow a little larger.

FRUITS



As the fruit develops and gets larger, a green acorn emerges from the cap (Image 28). Acorns will gradually change color from green to green-brown (Images 30-31) before reaching their ripened color of brown, red brown or dark brown. Small, underdeveloped fruits are most likely aborted fruits that will never mature (Image 31, white arrow). If you are unsure whether a fruit has been aborted, continue to include it in the "Fruits" phenophase. Once it dries out and has clearly stopped developing, it should no longer be included.

RIPE FRUITS



A fruit is ripe when it has turned brown, red brown or dark brown.

RECENT FRUIT OR SEED DROP



Mature, fully developed fruit will drop from the plant not long after they become ripe.



Dropped fruits that are small, green and immature should not be included in the "Recent fruit or seed drop" phenophase.



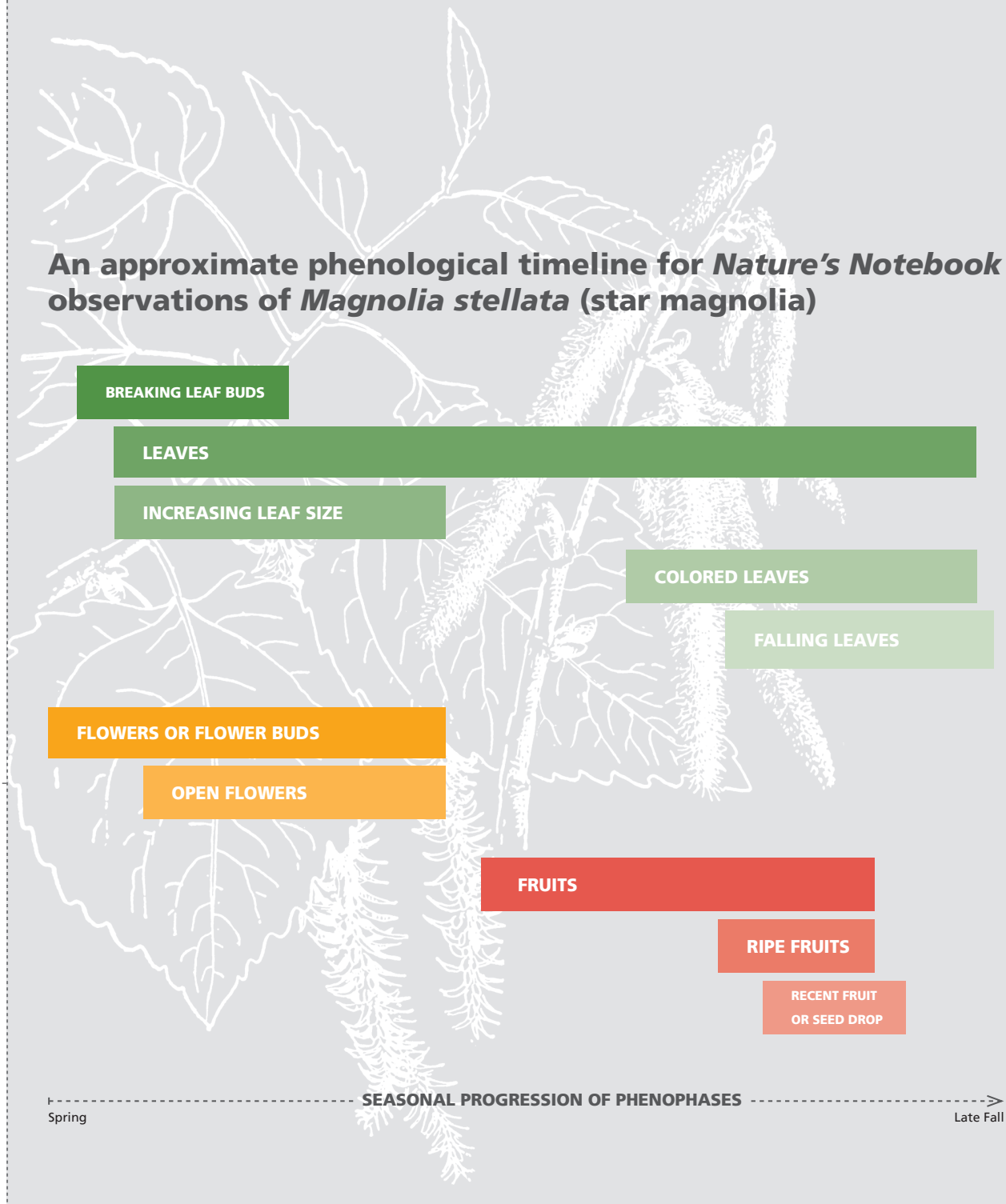


Star magnolia is an ornamental shrub or small tree with large white or pinkish flowers that bloom in spring. It belongs to an ancient family of flowering plants and has some primitive characteristics, such as flower petals and sepals that had not yet evolved into separately distinguishable parts of the perianth of the flower. These numerous, showy floral appendages are called “tepals”—the term for undistinguishable sepals and petals. Fruit clusters appear after flowering, but often only a few of the fruits in the cluster will develop and ripen in fall.

Phenological characteristics of note:

- single-scaled mixed buds contain both leaves and flowers
- single large flower has male and female parts
- flowering before leaf out
- individual fruits arranged in unusual cone-like clusters
- “dehiscent” capsule-like fruits split open and drop seeds when ripe

An approximate phenological timeline for *Nature’s Notebook* observations of *Magnolia stellata* (star magnolia)



Magnolia stellata

(star magnolia)

Activity begins in spring as dormant buds come to life. Star magnolias typically have three types of fuzzy buds—vegetative (leaf), reproductive (floral) and mixed buds that produce both leaves and a single flower. Leaf buds are generally smaller and narrower (Image 1, white arrow) than the large, plump floral and mixed buds (Image 1, white circle). Usually floral and mixed buds open before leaf buds, in which case the first “yes” observation in the spring will be for “Flowers or flower buds”.

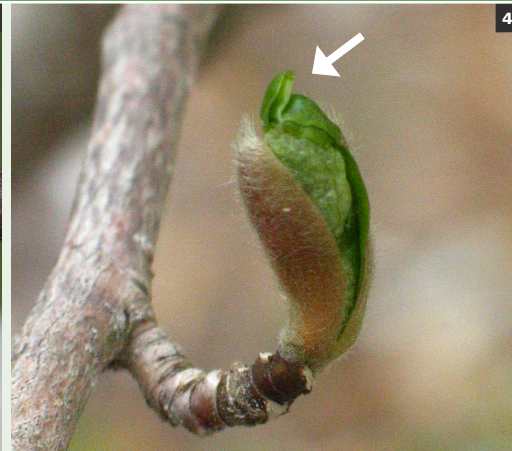
Leaf phenophases

“Breaking leaf buds” begins when leaf tips emerge (Images 3-4). Then, when at least one breaking leaf bud’s first leaf has unfolded (Image 5), begin reporting “yes” for the “Leaves” phenophase, and continue reporting “yes” until the last leaf has dropped from the plant in fall. You will also be reporting “yes” for “Increasing leaf size” in the spring, and “Colored leaves” in fall.



Dormant and swelling buds. While the buds are dormant (Image 1), or newly active and swelling (Image 2), report “no” for “Breaking leaf buds” until the fuzzy bud scale breaks open enough that a green leaf tip emerges alongside the developing flower in a mixed bud (Image 3) or at the tip of a leaf bud (Image 4).

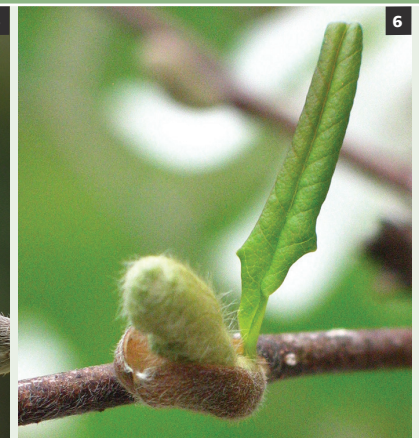
BREAKING LEAF BUDS



Once a green leaf tip is visible at the end of a broken mixed bud (Image 3) or leaf bud (Image 4), the “Breaking leaf buds” phase has begun. The bud remains in this phenophase until the base of its first leaf is visible where it attaches to the petiole (Image 5, white arrow). Report “yes” for this phenophase until all broken buds have a visible leaf base.

LEAVES

INCREASING LEAF SIZE

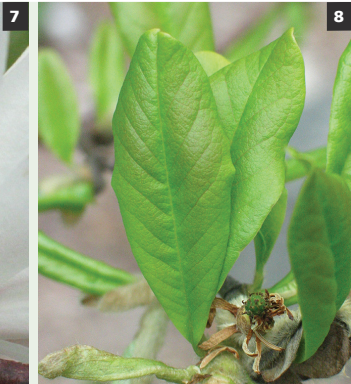
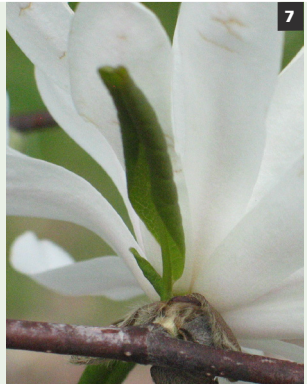


Once the leaf base becomes visible, the first leaf from the bud is considered “unfolded”. At this point, the bud has left the breaking stage and entered the “Leaves” and “Increasing leaf size” phenophases.



LEAVES

INCREASING LEAF SIZE



A plant remains in the “Increasing leaf size” phase as new spring leaves grow larger. During this period, leaves are thinner in texture than they will become when they are full size and mature (Image 10). Although new leaves continue to grow from branch tips all summer, report “no” for “Increasing leaf size” once most of the leaves from the large spring flush have reached full size and stopped growing larger.

Full-size, mature leaves.

LEAVES

COLORED LEAVES



When leaves start to senesce at the end of summer, yellow color begins to appear and the “Colored leaves” phase has begun (Image 11). In star magnolia, leaves change from pale yellow to golden yellow to brownish before they fall from the plant.

FALLING LEAVES



Fallen leaves under the plant.



Magnolia stellata

(star magnolia)

Flower phenophases

Once the floral or mixed buds begin swelling, the fuzzy bud scale starts to split open and the “Flowers or flower buds” phase has begun. Report “yes” for this phenophase when floral or mixed buds begin swelling and continue reporting “yes” until the last flower is withered or dried. If you are unsure whether you see swelling floral or mixed buds, you can wait until you see flower parts emerge from the bud before reporting “yes” for “Flowers or flower buds”.

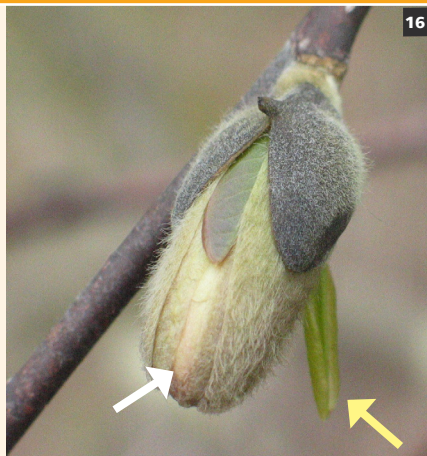
The “Open flowers” phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried.

FLOWERS OR FLOWER BUDS



As floral or mixed buds swell, they get larger and the fuzzy, tough, outer bud scale splits open to reveal a thinner, inner bud scale which eventually splits open to reveal the white or pinkish flower inside (Image 16, white arrow).

FLOWERS OR FLOWER BUDS



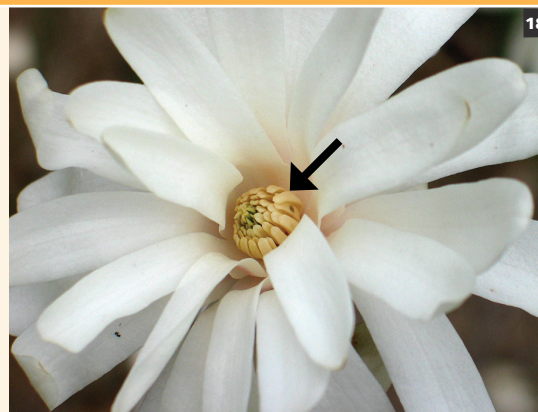
16



17

When mixed buds open, the first leaf tip (Image 16, yellow arrow) usually emerges before the flower opens, so “Breaking leaf buds”—and often the “Leaves” phenophase—will begin before the “Open flowers” phase begins.

OPEN FLOWERS



18

Male and female reproductive parts (black arrow) are clustered in the center of the white flower “petals”—technically called “tepals” in magnolias.



19

Spent flower. The tepals have withered and the flower is no longer fresh.



Magnolia stellata

(star magnolia)

Fruit phenophases

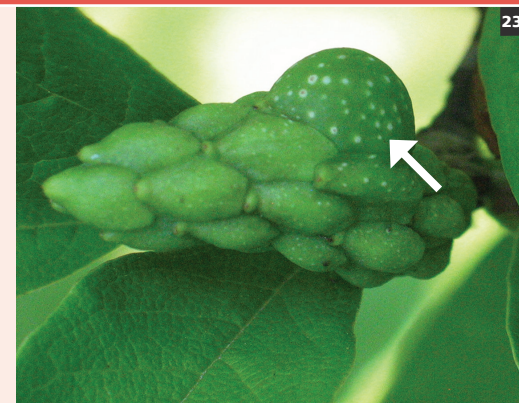
When a star magnolia flower has been pollinated, a cone-like fruit cluster will begin to develop within a few weeks. Often only a few of the ovaries in the cluster will ripen and produce seeds.

The *Nature's Notebook* fruit definition reads "For *Magnolia stellata*, the fruit is capsule-like, grouped with many others into a cone-like cluster, and changes from green to red or red-brown to tan, dark brown or gray and splits open to expose the seeds. A fruit is considered ripe when it has turned tan, dark brown or gray and has split open to expose the seeds. Do not include empty capsules that have already dropped all of their seeds."



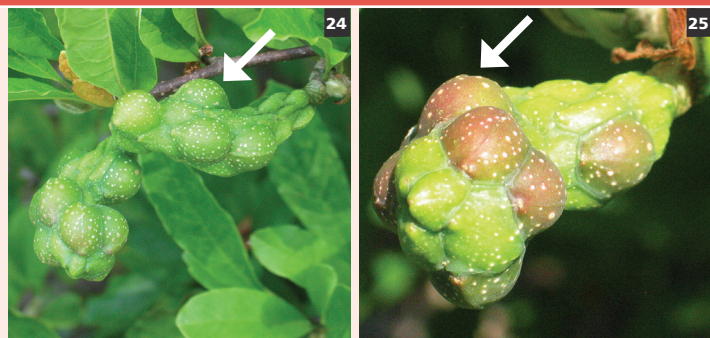
A fruit cluster develops from the center of a spent flower and begins to elongate and grow plumper as the individual ovaries swell (Images 20-21). Often development of the entire cluster ceases and the cluster withers, turns gray (Image 22) and eventually drops from the plant. For this reason, in star magnolia it is recommended not to report "yes" for the "Fruits" phenophase until it is clear an ovary has been fertilized and a seed is growing inside (Image 23).

FRUITS



A single ovary in this fruit cluster has been fertilized and is clearly growing larger (Image 23, white arrow). This ovary has entered the "Fruits" phenophase.

FRUITS



As the fertilized fruits in a cluster continue to develop, they gradually get larger and the cluster becomes lumpy, eventually changing to a reddish color. Each lump is considered a separate fruit. A fruit is considered ripe when it has turned from green to tan, dark brown or gray and has split open to expose the single red-orange seed.

RIPE FRUITS

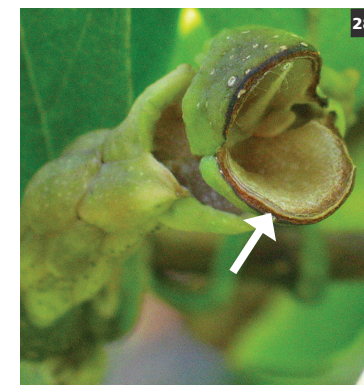


A fruit is ripe when it has split to expose a single red-orange seed.

RECENT FRUIT OR SEED DROP



Seeds will drop from the plant not long after the fruit becomes ripe.



Empty capsule-like fruits that have dropped their seed (white arrow) should not be included in the "Fruits" or "Ripe fruits" phenophases.



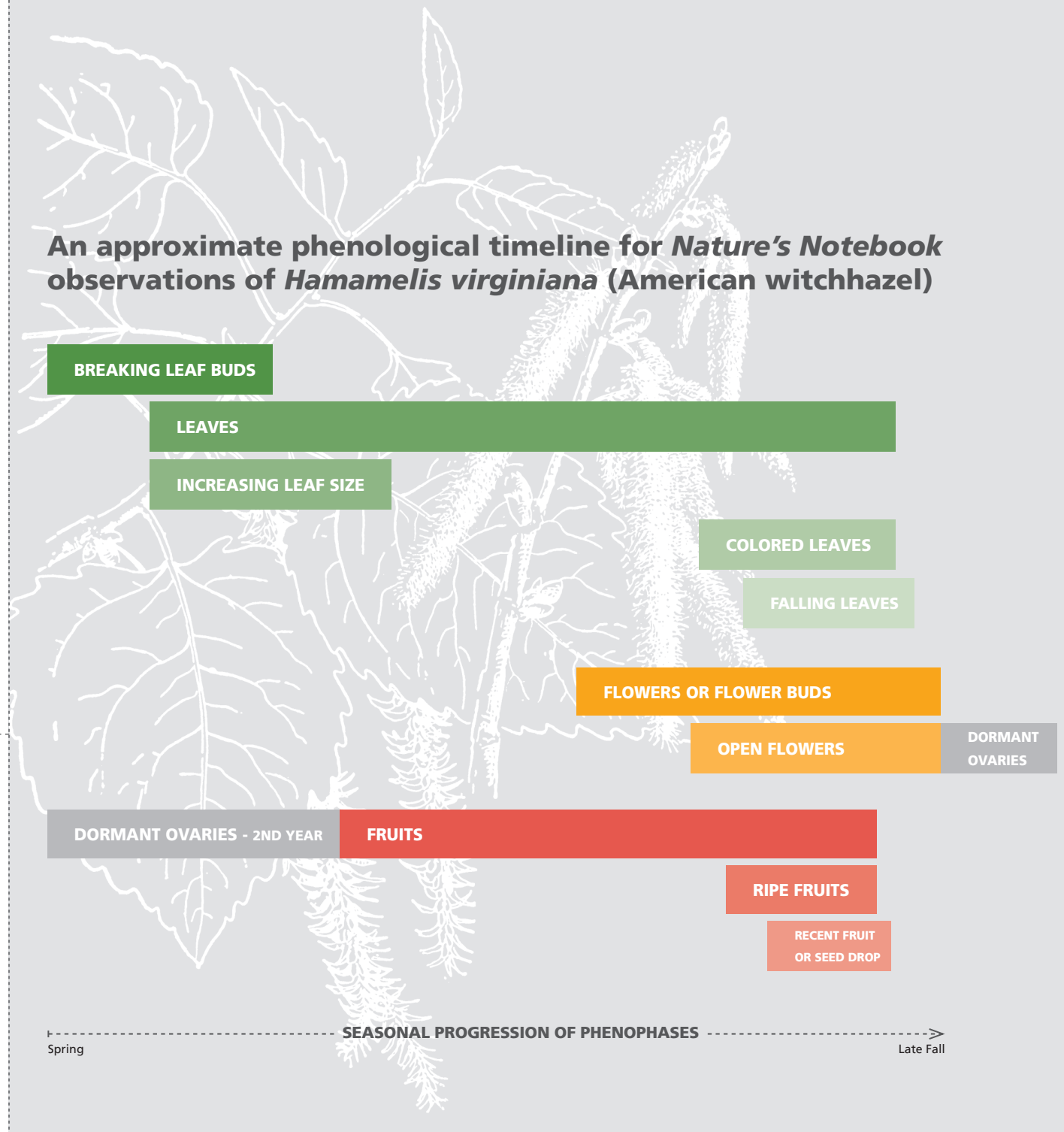


American witchhazel is a shrub or small tree found in the forest understory of the eastern US. Its naked leaf buds open in spring, but flower buds do not appear until summer. The slender-petaled, yellow flowers are insect-pollinated and bloom in fall as leaves on the plant are turning color and falling. Although pollinated, ovaries remain unfertilized and dormant over the winter and into spring. Once fertilized, fruits develop in summer and the fuzzy, green capsules ripen and release seeds in fall.

Phenological characteristics of note:

- naked leaf buds
- flowering in fall
- overwintering dormant ovaries
- “dehiscent” fruit capsules split open and drop seeds when ripe

An approximate phenological timeline for *Nature’s Notebook* observations of *Hamamelis virginiana* (American witchhazel)



Hamamelis virginiana

(American witchhazel)

Activity begins in spring as dormant buds come to life. American witchhazel has overwintering leaf buds, but they differ from many deciduous plants in that the buds are “naked”. That is, they don’t have hard scales that cover and obscure its new leaves. Instead they have tiny leaves tightly folded together (Image 1, white arrow). Also during the winter, the branches of witchhazel contain the pollinated, but unfertilized, ovaries of the previous year’s flowers (Image 1, white circle). These remain dormant until later in the year.

Leaf phenophases

“Breaking leaf buds” begins when a bright green leaf surface becomes visible (Image 3). Then, when at least one breaking leaf bud’s first leaf has unfolded enough to appear more or less like a small version of an adult leaf (Image 5), begin reporting “yes” for the “Leaves” phenophase, and continue reporting “yes” until the last leaf has dropped from the plant in fall. You will also be reporting “yes” for “Increasing leaf size” in the spring, and “Colored leaves” in fall.



Dormant and swelling buds. While the naked leaf buds are dormant (Image 1, white arrow), or newly active and swelling (Image 2), report “no” for “Breaking leaf buds” until a bright green leaf surface becomes visible between the unfolding halves of a tiny, brownish leaf blade (Image 3).

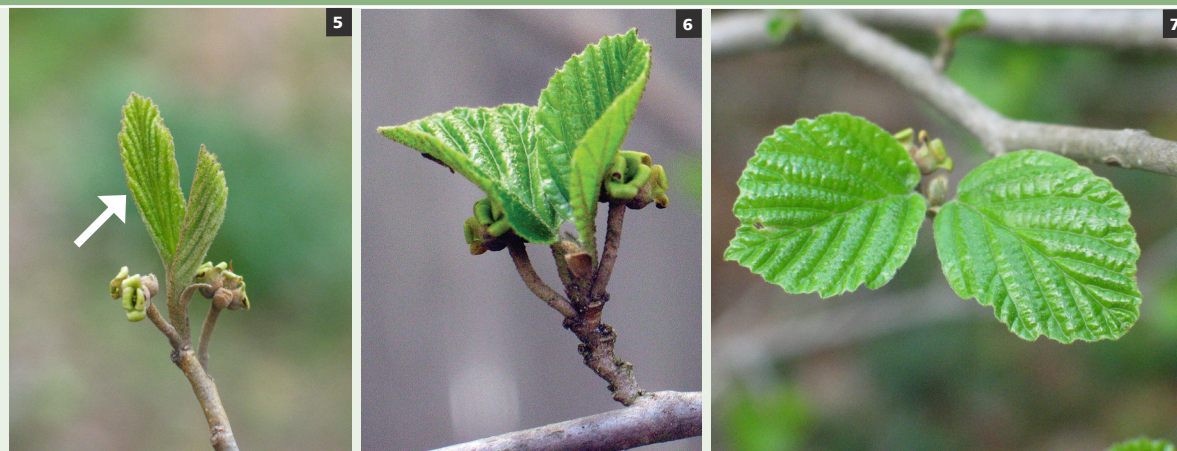
BREAKING LEAF BUDS



Once a bright green leaf surface becomes visible as the naked bud swells, the “Breaking leaf buds” phase has begun. The bud remains in this phenophase until its first leaf has unfolded enough to appear more or less like a small version of an adult leaf (Image 5, white arrow). Report “yes” for this phenophase until all broken buds have a leaf unfolded to that degree.

LEAVES

INCREASING LEAF SIZE



Once the leaf blade has unfolded enough to appear more or less like a small version of an adult leaf, the first leaf from the bud is considered “unfolded”. At this point, the bud has left the breaking stage and entered the “Leaves” and “Increasing leaf size” phenophases.



LEAVES

INCREASING LEAF SIZE



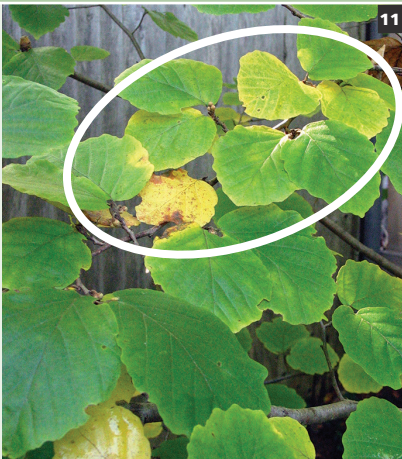
A plant remains in the “Increasing leaf size” phase as new spring leaves grow larger. During this period, leaves are lighter in color, and thinner in texture than they will become when they are full size and mature (Image 10). Although new leaves continue to grow from branch tips all summer, report “no” for “Increasing leaf size” once most of the leaves from the large spring flush have reached full size and stopped growing larger.



Full-size, mature leaves.

LEAVES

COLORED LEAVES



When leaves start to senesce at the end of summer, yellow color begins to appear and the “Colored leaves” phase has begun (Image 11). In American witchhazel, leaves change from pale yellow to bright yellow or brownish-yellow before they fall from the plant.

FALLING LEAVES



Fallen leaves under the plant.



Hamamelis virginiana

(American witchhazel)

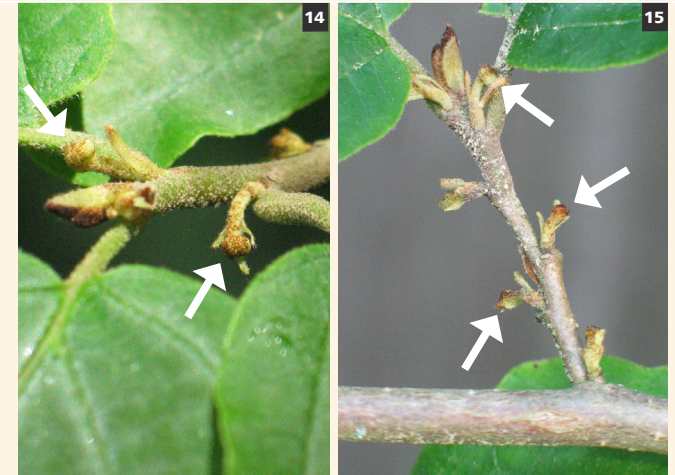
Flower phenophases

American witchhazel has a rather unique flowering strategy. Flower buds form in summer after the leaves are full-sized, and flowers open in the fall as the leaves are changing color or after leaf fall. Flowers are pollinated, but fertilization is delayed. As flowers wilt, their ovaries enter a dormant period over winter until spring or early summer. At that time, ovaries are fertilized and begin to swell, marking the beginning of the “Fruits” phenophase. These fruits are developing as the “Flowers or flower buds” phenophase begins again.

Once the small, round flower buds, usually three to a cluster, appear growing from twigs (Images 14-15), the “Flowers or flower buds” phase has begun. Report “yes” for this phenophase until the last flower is withered or dried.

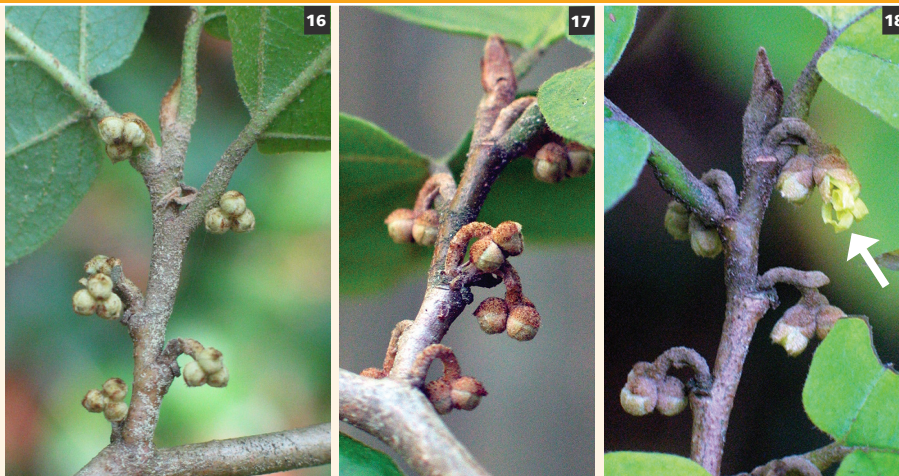
The “Open flowers” phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried.

FLOWERS OR FLOWER BUDS



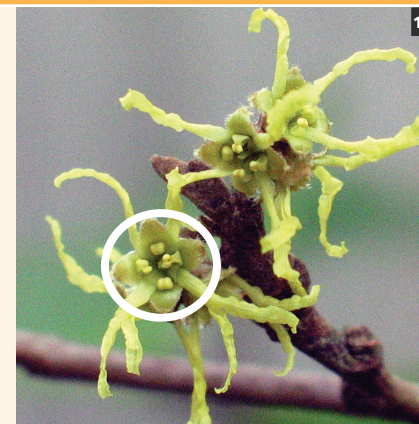
Tiny flower buds emerge from leaf axils or along twigs (white arrows) after leaves have grown to full size.

FLOWERS OR FLOWER BUDS



As flower buds grow larger, it becomes apparent they are clustered in groups of three. Yellow petals emerge from the flower buds (Image 18, white arrow) before reproductive parts are visible.

OPEN FLOWERS



Male and female reproductive parts (white circle) are clustered in the center of a cup-like calyx from which the four strap-like petals emerge.



Spent flowers. The petals have withered and the flowers are no longer fresh but the cup-like calyxes remain (white arrows).



Hamamelis virginiana

(American witchhazel)

Fruit phenophases

After American witchhazel flowers have been pollinated in the fall, the ovaries remain dormant until the following spring or early summer when fertilization occurs. At this time the fruits begin to develop and will mature in late summer or early fall.

The *Nature's Notebook* fruit definition reads "For *Hamamelis virginiana*, the fruit is a fuzzy capsule that changes from green to brown and splits open, sometimes explosively, to expose the seeds. A fruit is considered ripe when it has turned brown and has split open to expose the seeds. Do not include empty capsules that have already dropped all of their seeds."

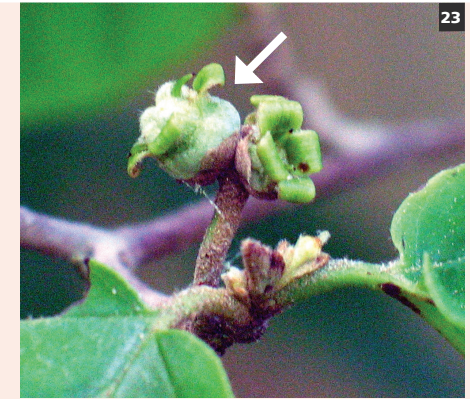
Be aware that not all over-wintering ovaries will develop into fruits.

DORMANT OVARIES



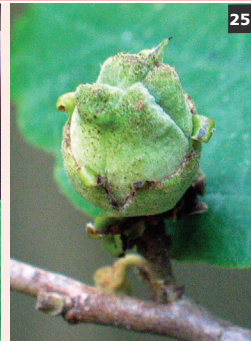
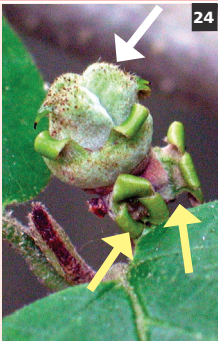
Once flowers have wilted, the cup-like calyx containing the ovary sits dormant on the plant over the winter (Image 21) and into the spring or early summer (Image 22).

FRUITS



Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger after its long dormancy (white arrow).

FRUITS



As the fertilized fruit continues to develop, it gradually gets larger and fuzzy and changes to a brown color. A fruit is considered ripe when it has turned from green to brown and has split open to expose the one or two shiny, black seeds inside. In Image 24, notice that only one of the ovaries in the cluster of three has developed into a fruit (white arrow). The other two appear to be unfertilized (yellow arrows) and should not be included in the "Fruits" phenophase.

RIPE FRUITS

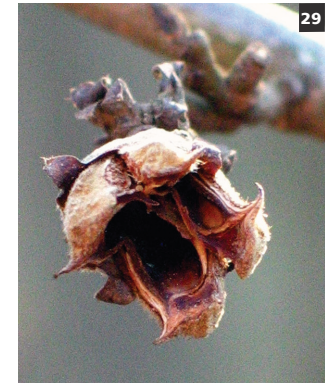


A fruit is ripe when it has split open to expose the two (or sometimes only one) shiny, black seeds inside. Often seeds are expelled as soon as the capsule opens, in which case you may never see and be able to report "yes" for "Ripe fruits" present on the plant.

RECENT FRUIT OR SEED DROP



Seeds usually drop from the capsule shortly after it opens. Report "yes" to "Recent fruit or seed drop" if you see an empty capsule that has split and lost its seeds since your last visit.



Empty capsules that have dropped their seeds should not be included in the "Fruits" or "Ripe fruits" phenophases.



