USA npn National Phenology Network

Phenophase Primer for Flowering Plants

Understanding Plant Phenophases for *Nature's Notebook*

USA-NPN Education & Engagement Series 2024-001 December 2024

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December 2024

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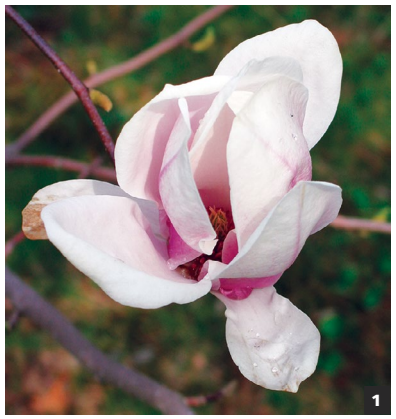
PHENOPHASE PRIMER

INTRODUCTION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All plants progress through a life cycle that brings them from germination through growth, reproduction and senescence to dormancy and/or death. Depending on life strategy, a plant may complete only one cycle before dying if the species has a typical "annual" pattern, or it may complete tens to hundreds of cycles, one per year, if it has a "perennial" pattern (like trees and shrubs).

Within this cyclical pattern there are distinct, observable life stages—also called phenological phases or "phenophases"—that can be tracked and recorded to help us understand the natural history of the plant. We can place the timing of these phenophases within the context of environmental conditions and other information to further understand a plant's relationship to its environment. Some of these factors include the regional climate, local weather events, and how a particular animal species interacts with a plant.

Observers participating in the USA National Phenology Network's (USA-NPN) *Nature's Notebook* program select and observe organisms from a long list of plant and animal species. This national effort to collect repeated observations of seasonally-occurring phenophases—by researchers, natural resources managers, students, and volunteers—supports a wide range of scientific applications and management decisions routinely made by people and communities. Consistent, high quality data are vital to this effort but challenging to acquire from thousands of independent observers distributed across a large nation. We have done our best to promote data quality and consistency by establishing the standardized phenology observation protocols (Denny et al. 2014; Denny and Crimmins 2023) embedded in *Nature's Notebook*, and by providing participants with a variety of self-directed training resources to ensure their understanding of these protocols. If you are a newcomer to *Nature's Notebook*, you should start by registering as an observer and taking our Observer Certification Course to orient yourself to the program and the data collection protocols. For observers with limited experience with plants, our *Botany Primer: Understanding Botany for Nature's Notebook* will be a helpful resource. This *Phenophase Primer for Flowering Plants* explains in much greater detail the botanical terms and concepts referenced within the *Nature's Notebook* plant phenophase definitions. Understanding and faithfully following these definitions is critical to maintaining consistency in the phenology observation data.

For each species on the *Nature's Notebook* list, a suite of phenophases is identified for regular observation. Plant phenophases focus on the pres-


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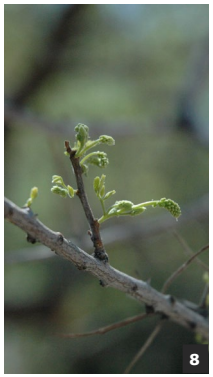
ence and development of leaves, flowers, and fruits. For each phenophase, the observer will be asked a yes-or-no question to report on the presence/absence "status" (for example, "Do you see fruits?"), and an optional, multiple-choice question to estimate a count- or percentage-range representing the "intensity" with which the phenophase is expressed on the plant (for example, "How many fruits are present?").

Many of these phenophases overlap and will occur at the same time on a single plant, such that observers should report a "yes" for more than one phenophase at a time. Some phenophases might occur all year round on a single plant in certain circumstances, and an observer might never report a "no" for the phenophase. Many phenophase questions are straightforward and easy to determine, but some are not due to the complexity of the plant species. Plants, like all organisms, can have complex strategies and anatomies that are hard to read, and thus, make accurate observations challenging.

The *Phenophase Primer for Flowering Plants* was developed to enable observers to become more familiar with the plant phenophases—and associated complexities—they are asked to evaluate. The content in this *Primer* is based largely on regular questions that the USA-NPN National Coordinating Office staff has received regarding the plant phenology protocols. It is not possible to cover in detail each of the hundreds of plant species included in *Nature's Notebook*, nor all possible contingencies for unusual circumstances. Instead, we present here the basic principles and common points of confusion with photographic examples from as many species as is practical. You, the observer, will need to apply the principles you learn from this *Primer* to other species or situations to the best of your ability. Even if your species is included in the *Primer*, there is variation from individual to individual, so be aware your plant may not look exactly like the one pictured.

The most important part of observing phenology is to catch the transitions between different life stages on a plant—such as that from unbroken leaf buds to at least one bud breaking, or only closed flower buds to at least one open flower—yet, pinpointing the exact instant of transition can be tricky. Every observer will at some point encounter an ambiguous situation in the field, and they will need to make a judgement call as to whether or not a phenophase has begun or which count- or percentage-range to report. Utilize your critical thinking skills and do the best you can. If you are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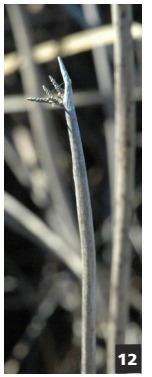
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unsure whether you are correctly capturing a transition, report a "?" for the status and return the next day, and the next, until you are sure of what you are observing. In some cases you may need to do more research, or observe for an entire year, to feel you understand what the transitions look like on your plant. Remember, this is a long-term process, and over time you will become more and more confident of what you are observing.

Ultimately, the goal of this *Primer* is to help observers make more accurate and dependable observations, but if the evaluation of a particular phenophase continues to confuse you, relax and do not overthink the situation! The data you are collecting in this national-scale program is intended to elucidate the timing of general life cycle patterns regionally, or across the US. If your observation of the start or end of a phenophase is off by a few days on one individual plant, it will have very little effect on the big picture. Your observations are meant to be an approximation of what is happening on the ground and not a perfect representation. The valuable time you commit to *Nature's Notebook* is far better spent recording the phenophases for many plants at medium-high accuracy over an extended period of time, rather than fretting over obtaining perfect accuracy for the phenophases of a single plant. Don't stress, just do your best — your efforts are appreciated! Most importantly don't forget to have fun observing the seasonal changes of the species you have chosen to observe!

How to use this *Phenophase Primer*

This *Primer* was designed to have "facing pages", as in a printed book. That is, an even-numbered page and its subsequent odd-numbered page belong together; often the subject covered on the first page continues onto the second page. A digital .pdf document allows you to display both pages together if you desire. This can be set up in Adobe Reader by choosing "View" from the top menu, then "Page Display" and "Two-page View" or "Two-page Scrolling" from the drop-down menu. You may also need to a choose "Show Cover Page" so the single cover page (with no facing page) does not offset the intended page pairing in the rest of the document. This document can be printed, but when used in its digital form—as long as the original file size and resolution have not been reduced—it can be very helpful to zoom in on the images to see them in greater detail.

Each image included within will have the plant species' scientific and common names included in the image credits at the end of the section. In some


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cases, the scientific name is also placed in the lower left hand corner of the image. Keep in mind that plant common names are often regional in nature and can differ from place to place—so that the name provided on these pages may not be the same name you are familiar with in your region or geographical area. As a rule, it makes sense to reference the scientific names rather than common names to eliminate any confusion in plant identification.

The *Primer* is broken down into two sections, created to assist observers in making observations as accurately as possible in *Nature's Notebook.* The first section, "The Phenophases", familiarizes observers with each phenophase using examples from many different plant species. The second section, "The Plant Functional Groups", describes the sequence of phenophases an observer would look for over the annual life cycle of a few species chosen to represent each of the plant functional groups defined by the USA-NPN. A third section, "The Intensity Measures", was originally envisioned to provide guidance in estimating the count- and percentage-ranges that are an optional part of observing with *Nature's Notebook*. Limited resources have required us to postpone development of this section indefinitely; however, an abbreviated version of the envisioned content is included in our Observer Certification Course.

Use this *Primer* in tandem with our *Botany Primer: Understanding Botany for Nature's Notebook,* the first primer in the series, which carefully details botanical information to assist in identification of the parts of a plant highlighted in *Nature's Notebook*. If resources allow, future primers may be added to the series for conifers and other plants groups, as well as animals.

A special note about Patty Guertin

Patty Guertin was the USA-NPN staff botanist from 2007 until her death from cancer in 2018. She was first and foremost an artist with a remarkable eye for detail, and was drawn into the botanical world by the beauty she found in the complex details of plant life. Patty was meticulous in her work and this *Primer* never would have been attempted without her extraordinary combination of talents in design, botany and patience!

In the early years of the USA-NPN, Patty fielded many questions from


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Nature's Notebook observers unsure about whether they were or were not seeing various phenophases on their plants. She wrote carefully thought-out advice to each one over email, and eventually amassed a collection of richly detailed explanations. From these, we released a series of seasonal "*Nature's Notebook* Nugget" articles over the course of two years, which were the precursor to this *Phenophase Primer*. Each Nugget addresses a topic about which multiple observers had expressed confusion and, in Patty's warmhearted voice, carefully explains how to think about the phenological conundrum and reach a decision on how to proceed with reporting observations. The Nuggets, some of which are referenced in this *Primer*, can be found from the *Nature's Notebook* FAQ page or by typing "Nugget" in the website search box.

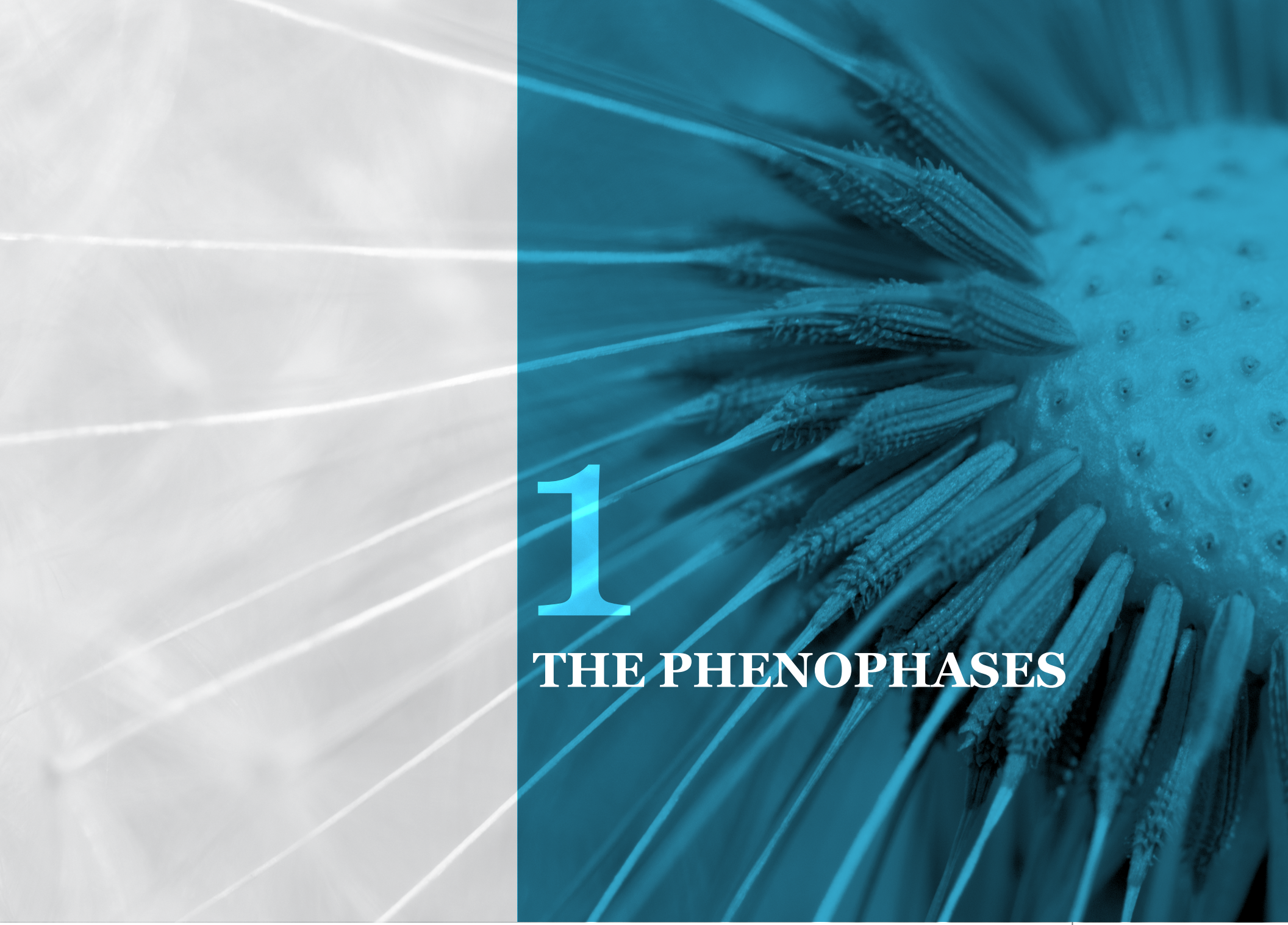
While still writing Nuggets, Patty embarked on the daunting task of compiling this much more comprehensive *Primer*. She put in countless hours researching the natural history and botanical characteristics of various species, taking photographs of plant phenophases at home in Arizona and on visits to both coasts to see her daughters, and meticulously writing and laying out content in the finicky computer software we used to create this document. Although she had help from her co-authors in all of these aspects, the soul of this publication came from Patty as she forged it into a work of art.

At the time of her death, Patty had completed about two-thirds of this *Primer*. It has taken me these several years since then to gather the courage to finish what she started, knowing my talents in design, botany and patience are all lesser than hers—some far lesser! Unfortunately I had to cut some of the content that was not very far along—like conifer phenophases and the section on intensity measures—or I would have never finished this project. I was determined to bring this work to a state of completion as my way of honoring my cherished friend and colleague.

With revisions and additional content that had to be developed, some of the words herein are mine instead of Patty's. But I hope the voice of her curious, kindhearted, and gentle soul prevails as you read and study these pages, and I hope that you catch a glimpse of the transcendent beauty she inspired so many of us to find in the plant world!

- Ellen G. Denny

October 2024



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THE PHENOPHASES

CONTENTS

Section 1: The Phenophases

SECTION ONE
INTRODUCTION


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Section 1 of this *Primer* takes a look at each of the *Nature's Notebook* plant phenophases, and presents an overview of what observers are asked to look for when making observations of each phenophase. Within the *Nature's Notebook* program, each phenophase is presented as the question "Do you see [name of phenophase]?" which is followed by a definition for the phenophase. When making an observation on a plant, an observer should answer "yes" if they do see the phenophase occurring on their plant, "no" if they do not see it occurring on their plant, or "?" if they are uncertain whether they see it occurring on the plant.

It is recommended that observers use the "?" until they feel certain of what they see. Observers may also opt to not answer one or more of the phenophase questions if they do not have an adequate comfort level with the species, its natural history, or its phenophase identification.

This section of the *Primer* is designed to help observers gain more confidence in making observations of phenophase status. It includes some of the variation that occurs across plant species, as well as some unusual cases where observation might be particularly challenging. Mostly, it is a collection of photographs—visual information to help an observer understand what they generally should observe for each phenophase.

The phenophases are organized first by new growth and leaf phenophases, second by flower phenophases, and third by fruit phenophases. Each of these phenophase types has a specific color used for the title and headings to easily understand their general category: green for the leaf phenophases, orange for the flower phenophases, and red for the fruit phenophases.

Pages are organized sequentially as life stages generally occur in plants, and include "phenophase pages" for each of the *Nature's Notebook* defined phenophases, and "informational pages" for more general information and for life stages that occur between defined phenophases.

"Phenophase pages" are titled with the name of the phenophase, such as "Initial growth" or "Breaking leaf buds". Underneath the title, a specific plant "functional group" will be identified followed by its specific phenophase definition.

Plant functional groups were defined by the USA-NPN to organize species by phenological similarities. The major functional groups for flowering plants are:

Cactus, Forb, Grass, Sedge, Rush, Tree/Shrub


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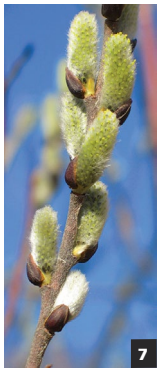
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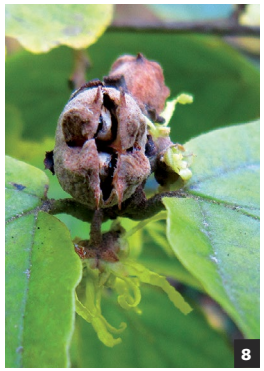
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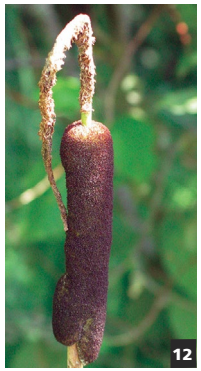
Some of these groups are further divided according to leaf retention characteristics (for example, deciduous and evergreen). They are outlined in Section 2 of this *Primer*.

Some of the *Nature's Notebook* phenophases will have several different phenophase definitions, each specific to a different plant functional group. Other phenophase definitions will include all of the plant functional groups under one definition (see box at right). The page titles found in the Table of Contents and on the footer of each phenophase page will identify the phenophase's name, such as "The Phenophase for Flowers or Flower Buds."

Between-phenophase "informational pages" are included to provide more details about what an observer may see while observing, related to timing and what to expect next. Such between-phenophase pages are identified in the Table of Contents and on a page's footer with a title such as "An Overview of Dormant and Swelling Leaf Buds". The subtitles on these pages are typically a question such as "What do they look like?". The information provided on these pages is intended to help an observer understand other aspects and characteristics of plant growth that occur before and after some of the *Nature's Notebook* phenophases. These pages should help those unfamiliar with the details of plants and their

The "phenophase page" layout

The page's heading "*Nature's Notebook* Phenophase Definition" (white arrow) identifies this page as a "phenophase page". The colored title "Flowers or flower buds" (yellow arrow) identifies the specific phenophase that is the subject of the page. Listed beneath this are the plant functional groups for which the phenophase definition applies: "Cactus, Forb, Tree/Shrub" (red arrow). Immediately below the functional group names is the phenophase definition for those plant functional groups (green arrow).



natural history to better identify when a phenophase is approaching or is completed.

For both the phenophase and the informational pages, many images or groups of images are provided as visual information to support the definition of the phenophase. Short text descriptions accompany the images, as needed, and arrows are included to help focus on phenophase details that may need highlighting (see box on right).

Observers that have already started observing with *Nature's Notebook* will notice that the intensity question that accompanies most of the phenophases does not appear on these pages. Guidance on understanding how to apply these intensity measures is included in our Observer Certification Course, which can be found from your Observation Deck on the *Nature's Notebook* website after you register as an observer.

For many pages, white, yellow or black arrows or circles will highlight the specific area of focus for the phenophase. Blue arrows are used to display a progression of the phenophase and the entire image is to be considered. On some pages, the arrows have colors and focus on specific activities, such as red arrows for male activity and orange arrows for female activity. In these cases of specific activity, a note within the page's text will alert the reader to these activities. Diagrams are also provided, as necessary, for details that might be too tiny or complex to easily see or understand for the plant.

An overview of vegetative (leaf) phenophases

How are they related to one another?

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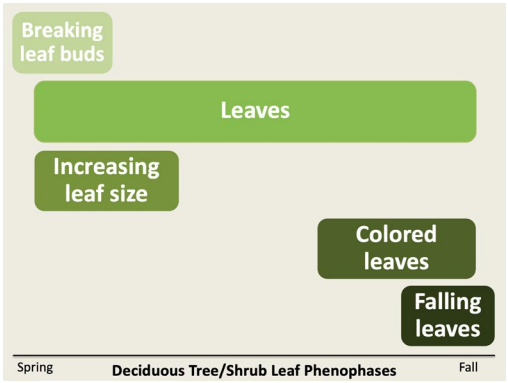

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The vegetative phenophases for *Nature's Notebook* plant species are organized into two broad categories

1. Growth *before* the first leaf has unfolded. These phenophases characterize the period when a plant begins to respond to seasonal signals, but before it exposes much tender leaf tissue to a potentially damaging environment, such as freezing temperatures.

2. Growth *after* the first leaf has unfolded. These phenophases characterize the period when a plant is photosynthesizing, including a ramping up at the beginning of the growing season and a slowing down at the end.

Each plant functional group has a specific set of phenophases to be observed, each type differing from one another. Thus, not all phenophases listed here will be included in any one species' suite of phenophases to observe. Refer to a species' profile page or its datasheet in *Nature's Notebook* for the species' pertinent phenophases.

Before the first leaf has unfolded—includes the *Nature's Notebook* phenophases:

- "**Initial growth**" is a phenophase that observers will watch for when their chosen plant is an annual or perennial forb or grass, sedge or rush. It captures the first growth and emergence of leaves from a germinating seed or from a dormant plant at the beginning of a plant's active seasons (Image 1). Occurrence of this phase ends when each of a plant's shoots (or buds in a few cases) have at least one leaf unfolded.
- "**Breaking leaf buds**" is a phenophase that observers will watch for when their chosen plant is a tree or shrub whose buds are covered with bud scales or display a particular unfolding of protective leaves. It captures the first emergence of leaves from a bud of a dormant plant at the beginning of a plant's active seasons (Image 3). Occurrence of this phase ends when each of a plant's buds have at least one leaf unfolded.

You will notice that many species of desert and dryland regions, such as cacti, are not assigned the "Breaking leaf buds" phenophase because their buds are structurally different or they have buds that are too small to see. For these species, the first phenophase that *Nature's Notebook* will ask an observer to report is "Young leaves", which begins after the first leaf has unfolded.

After the first leaf has unfolded—includes the *Nature's Notebook* phenophases:

- "**Leaves**" is a phenophase that observers will watch for in all species except evergreen forbs, trees and shrubs (which by definition *always* have leaves present). It captures the entire period of time that live leaves are present on the plant, from the unfolding of the first leaf to the dropping or dying of the last leaf.

  Depending on the species, there might be other vegetative phenophases that observers are asked to watch for while these live, unfolded leaves are present on the plant. These other vegetative phenophases are nested within the "Leaves" phenophase, so the observer should be reporting "yes" for "Leaves" if they are reporting "yes" for any of these other phenophases (see Diagram 2 for example overlap of vegetative phenophases for a deciduous tree).

- "**Young leaves**" is a phenophase that observers will watch for in evergreen and semi-evergreen forbs, trees and shrubs that have old and new leaves on the plant at the same time. It captures the period of active leaf growth (Image 4). Occurrence of this phenophase ends when the size, color and/or texture of all of the newer leaves are no longer distinguishable from those of the older leaves on the plant.
- "**Increasing leaf size**" is a phenophase that observers will watch for in deciduous trees and shrubs that tend to have a single, large flush of new leaves at the beginning of the growing season. It captures the period of time when this first flush of leaves is actively growing to full size, and it represents "green-up"—the period of time it takes the deciduous plant to ramp up to full photosynthetic capacity. Occurrence of this phenophase ends when most of the leaves of that first major flush appear to be full size.

  Note that growth of new leaves at the end of each branch generally occurs throughout the growing season. This type of growth should be ignored for this phenophase.
- "**Colored leaves**" is a phenophase that observers will watch for in deciduous, drought deciduous and semi-evergreen trees and shrubs. It captures the period of time when leaves begin to deteriorate and lose their green color, in some species turning brilliant shades of yellow, orange or red (Image 5). Often it represents the period of time when the deciduous plant is ramping down photosynthetic capacity towards the end of the growing season. However, this phenophase may also occur during times of extreme drought or insect infestations. Occurrence of this phenophase generally ends when either all the leaves have dropped off the plant, or if some remain on the plant, when they have dried up and become brittle. This phenophase may go back and forth between "yes" and "no" during the season of leaf fall if all colored leaves drop off the plant yet green ones remain and subsequently turn color.

  Note that sometimes a reddish color will appear in new leaves or mature, healthy-looking leaves early in the year to protect tender leaves from intense sunlight. This type of coloring should be ignored for this phenophase.
- "**Falling leaves**" is a phenophase that observers will watch for in deciduous, drought deciduous and semi-evergreen trees and shrubs. It captures the period of time when live leaves are dropping off the plant as they senesce. Observers most likely will not actually see leaves falling off the plant while they are observing, but if they notice that leaves have fallen since their last observation, they should report "yes" for this phenophase. Occurrence of this phenophase ends for the season when no live leaves are left on the plant (although dried, dead leaves might still be attached). As with "Colored leaves", this phenophase may go back and forth between "yes" and "no" during the senescent season.

  Note that summer wind storms may cause a few handfuls of healthy green leaves to fall from the plant. These non-senescing fallen leaves should be ignored for this phenophase.

  Also note that while "Young leaves", "Increasing leaf size" and "Colored leaves" occur simultaneously and are nested within the "Leaves" phenophase, the last observation of "Falling leaves" in a season will most likely occur alone (see Diagram 2). That is, no leaves are left on the plant ("Leaves" is not occurring), but the leaves that were present at the last observation have now fallen ("Falling leaves" did occur).


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Nature's Notebook
PHENOPHASE DEFINITION

Initial growth

Forb

New growth of the plant is visible after a period of no growth (winter or drought), either from above-ground buds with green tips, or new green or white shoots breaking through the soil surface. Growth is considered "initial" on each bud or shoot until the first leaf has fully unfolded. For seedlings, "initial" growth includes the presence of the one or two small, round or elongated leaves (cotyledons) before the first true leaf has unfolded.

This phenophase is also covered in detail in the *Nature's Notebook* Nugget: Initial Growth, which can be found on the USA-NPN website (usanpn.org).


Podophyllum peltatum 1


Fragaria virginiana 2


Symplocarpus foetidus 3

Perennial forbs

At the beginning of a plant's active season, observers will watch the plant for new sprouts or the emergence of leaves from underground rhizomes, bulbs or corms, crowns, or at stem nodes located along above-ground stolons (row 1). For some species, "Initial growth" begins with a flower—rather than leaf— structure breaking through the soil surface, such as the fleshy hood (spathe) enclosing skunk cabbage flowers that appear early in spring (Image 3).


Raphanus sp. 4


Proboscidea parviflora 5


Lactuca sativa 6

Annual forbs

For seedlings of annual plants, new growth from the seed first appears as cotyledons (seed leaves)—one or two depending on the species—or new leaf growth if the cotyledon is hidden below ground (row 2). When new "true" leaves emerge from between the cotyledons and become unfolded—the plant is no longer in the "Initial growth" phenophase (for a more detailed explanation, see the section "An overview of unfolded leaves").

Nature's Notebook
PHENOPHASE DEFINITION

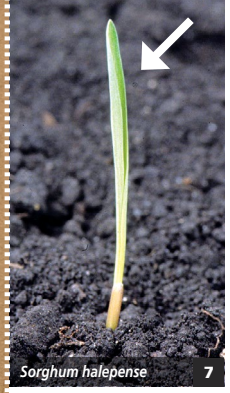
Initial growth

Grass or Sedge

New growth of the plant is visible after a period of no growth (winter or drought), either as new green shoots sprouting from nodes on existing stems, new green shoots breaking through the soil surface, or re-greening of dried stems or leaves. For each shoot, growth is considered "initial" until the first leaf has unfolded or has fully re-greened.

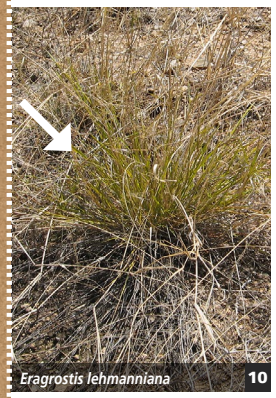
Rush

New growth of the plant is visible after a period of no growth (winter or drought) as new green shoots breaking through the soil surface. For each shoot, growth is considered "initial" until the exposed, green portion of the shoot has reached approximately 2 inches (5 cm) in length.


Sorghum halepense 7


Summer annual Poaceae sprout 8


Summer annual Poaceae sprout 9


Eragrostis lehmanniana 10


Digitaria californica 11


Setaria macrostachya 12


Carex sp. 13


Juncus gerardii 14


Juncus balticus 15

Grasses

In Image 7, the grass seedling's first leaf has emerged but has not yet unfolded so it is still considered in the "Initial growth" phase. However, an annual grass seedling often emerges as an unfolded leaf and its single cotyledon is usually left hidden underground. In this case, an observer may not see "Initial growth" because the leaf very quickly unfolds (Images 8-9). For a detailed explanation, see the section "An overview of unfolded leaves".

Perennial grasses show bits of green when renewed growth initiates. Check plants early and often—by the time green is obvious at a distance, the plant may be past the "Initial growth" phase. New growth can appear on last year's stems at the base of the plant, or at the stem nodes, or in some species it can initiate in odd places on the plant from intercalary meristems at the base of dry stems or leaf sheaths and blades (Images 10-12). It is considered "Initial growth" until the first new leaf has unfolded.

Sedges and rushes

New growth emerges as a sprout from underground rhizomes in both sedges (Image 13) and rushes (Images 14 and 15, white oval). It is considered "Initial growth" in sedges until the first leaf unfolds, and in rushes until the sprout reaches about 2 inches (5 cm) tall.

An overview of dormant and swelling leaf buds

What do they look like?

On these two pages we take a look at dormant and swelling leaf buds—buds that are resting or those beginning to swell just before buds break open. We will take a look at species that have bud scales to protect the embryonic leaves and those that do not have bud scales. Just for botanical reference—bud scales are also called cataphylls.

Those species whose buds have no bud scales—called naked buds—fall into two categories: those that tightly cover their embryonic leaves with tiny immature leaves (often in warm climates) and those that cover their embryonic leaves with immature leaves having dense hairs, parts of the plant stem or other leaf tissues (often in cold climates).

Although dormant or swelling leaf buds are not phases for which a *Nature's Notebook* participant would record observations, becoming familiar with the leaf buds of your observed species—and their subtle characteristics and activities—will enable you to make accurate observations when the buds become active after a dormant phase.

Buds with bud scales

Buds with scales that are overlapping (imbricate):

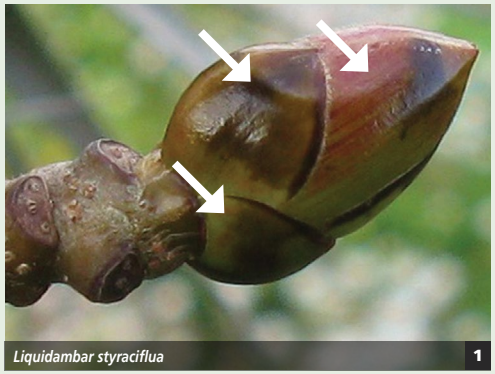
Images 1-7 show examples of species for which the dormant leaf bud has bud scales that have an imbricate structure—the scales overlap each other like the shingles on a roof. Image 1 shows a bud that is beginning to swell—with bud scales that have begun to shift and loosen around the enclosed embryonic tip.

Buds with a single scale:

Some species (like willows) only have a single bud scale that covers the embryonic leaves (Images 8-10). The buds in Image 10 have broken and have unfolded leaves—this image is included here so that one can see the position of the bud scales on the twig.

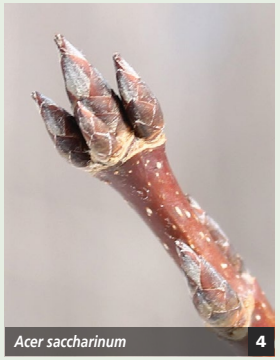
Buds with two scales that meet but do not overlap (valvate):

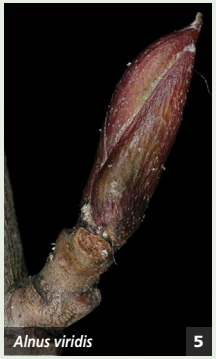
Some species have valvate buds (Images 11-12), where two bud scales meet tightly together and do not overlap each other.

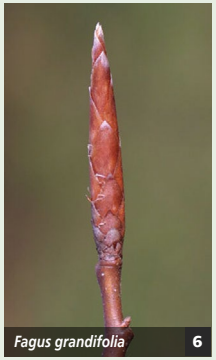

Liquidambar styraciflua 1


Acer pseudoplatanus 2

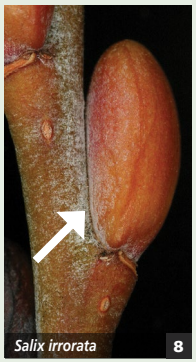

Quercus alba 3

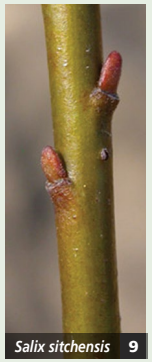

Acer saccharinum 4


Alnus viridis 5


Fagus grandifolia 6

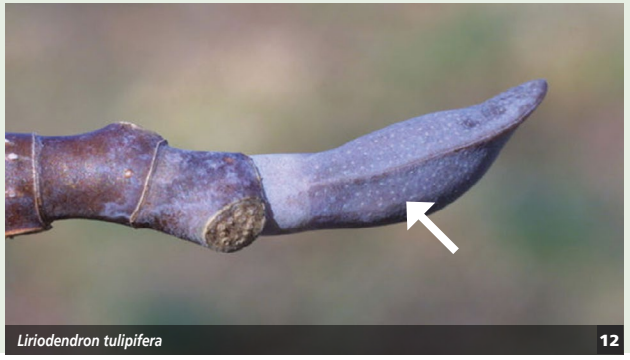

Amelanchier utahensis 7


Salix irrorata 8


Salix sitchensis 9


Salix sp. 10


Viburnum lentago 11


Liriodendron tulipifera 12

Naked buds (no bud scales) in cold-climate plants

There are several cold-loving plant species that have naked buds, that is, buds that are not covered and protected with bud scales during the cold weather months, but instead covered by tiny immature leaves tightly enclosing tinier embryonic leaves at the tip of the twig. These protective leaves are often covered with dense or woolly hairs (Images 13-17).

Naked buds (no bud scales) in warm-climate plants

Often in the warmer temperate-climate regions, perennial plant species—especially evergreen species—can have resting embryonic tips at the end of twigs that are hidden and covered tightly by many tiny immature leaves. These half-developed leaves are the only protective covering at the ends of branches and twigs, and leaf axils. These "buds" wait until the conditions are right for seasonal leaf growth to begin (Images 18-19).

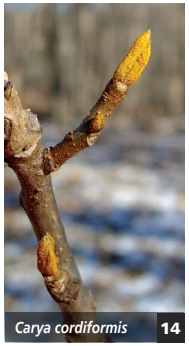
Other bud types

Other variations of bud architecture that occur in flowering plants (the angiosperms) include buds covered and protected by the leaf stipules—that is, tiny leaf-like appendages situated on both sides of the leaf's petiole at the petiole base (Images 20-22; Image 22 shows leaves emerging through the protective covering of stipules). Or leaf buds that are covered by the base of the leaf's petiole—subpetiolar (Image 23)—which may still have protective scales once the old leaf falls off and they are exposed (Image 24). Or leaf buds that are partially hidden or fully-imbedded within the stem tissue and located above a leaf scar in the axil of the leaf node (Image 25).

A note about bud set

Buds are usually formed or "set" when twig growth ceases at the end of the growing season. In cold climates, this occurs in late summer or fall and the newly formed bud can be soft and green before the bud scales toughen up. This process of bud formation should not be mistaken for the breaking of the bud after a period of dormancy.


Fraxinus nigra 13


Carya cordiformis 14

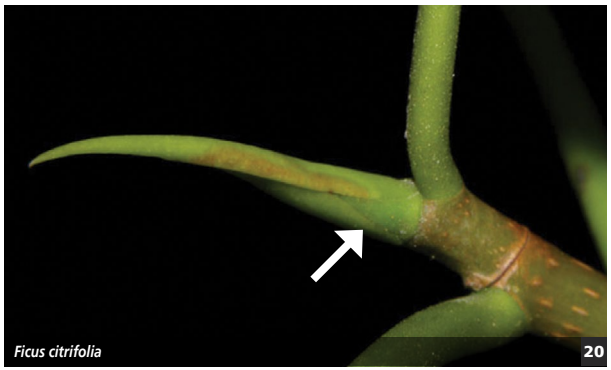

Viburnum lantanoides 15


Callicarpa americana 16


Hamamelis virginiana 17


Leucophyllum frutescens 18


Buddleja marrubiifolia 19


Ficus citrifolia 20


Ficus carica 21


Ficus carica 22


Platanus racemosa 23


Platanus wrightii 24


Ailanthus altissima 25

Nature's Notebook
PHENOPHASE DEFINITION

Breaking leaf buds

Tree/Shrub

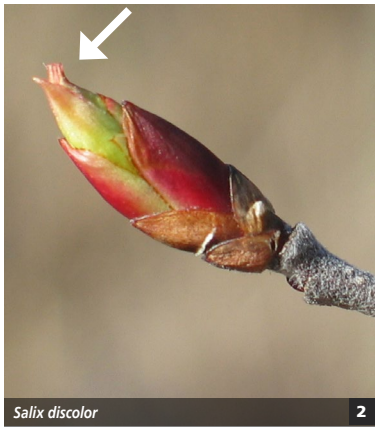
One or more breaking leaf buds are visible on the plant. A leaf bud is considered "breaking" once a green leaf tip is visible at the end of the bud, but before the first leaf from the bud has unfolded to expose the leaf base at its point of attachment to the leaf stalk (petiole) or stem.

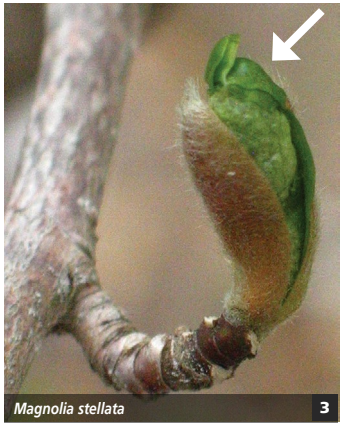
The phenophase "Breaking leaf buds" captures the first emergence of leaves on a dormant plant at the beginning of a plant's active seasons. When all the buds on a plant have at least one unfolded leaf, this phenophase ends for the observed plant (for a more detailed explanation, see the section "An overview of unfolded leaves").

Deciduous trees and shrubs with scaled buds

Deciduous species whose buds have protective scales that cover the embryonic leaves of growing (meristematic) areas during a resting (dormant) phase, will "swell", signalling the plant's renewed activity. That is, the tight covering of bud scales over the embryonic leaves will loosen and expand—the bud appears to be swelling—gradually separating open so that the newly green and growing leaves can be seen at the bud's tip (some species' new leaves will appear yellow or reddish instead of green). At the point an observer sees newly growing leaves exposed between the scales of the bud, they should report "yes" for "Breaking leaf buds" (arrows in rows 1-2).


Amelanchier arborea 1


Salix discolor 2


Magnolia stellata 3


Quercus rubra 4


Alnus incana 5


Vaccinium corymbosum 6


Acer saccharum 7


Rhododendron sp. 8

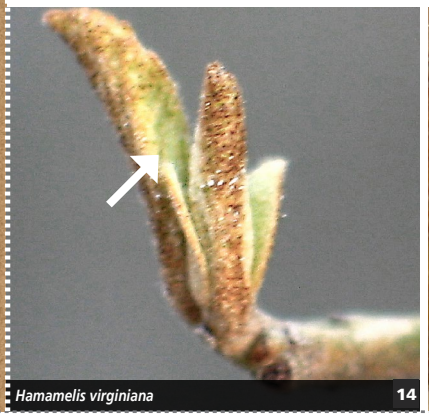

Arctostaphylos sp. 9


Kalmia latifolia 10


Toxicodendron radicans 11


Asimina triloba 12


Rhus glabra 13


Hamamelis virginiana 14


Rhus typhina 15

Evergreen trees and shrubs with scaled buds

Although evergreen trees and shrubs will retain leaves all year, their scaled buds will behave identically to those of deciduous species after a period of no leaf growth. The buds will begin to swell following a resting or dormant phase, and the scales will gradually separate and open so the newly growing leaves can be seen at the bud's tip (row 1).

Deciduous trees and shrubs with naked buds (no bud scales)

Images 11-15 illustrate species that lack bud scales, where protective leaves (of naked buds) are sometimes brown and remain that way during the dormant period. When the bud becomes active and begins to swell, the brown leaves begin to grow and get larger, yet remain their dormant color brown. The bud is considered "breaking" when the first green can be seen on the leaf's surface (arrows in Images 11, 12, 14). In some cases this first hint of leaf color could be red and not green (arrows in Images 13, 15). Once the first leaf's base becomes visible or, if it was apparent while in its dormant stage, once the leaf unfolds or unrolls enough to appear more or less a small version of the adult leaf, that bud is no longer in the "breaking" stage.

In tall trees, it may be very difficult to discern "Breaking leaf buds" and the observer may not be certain whether this phenophase has occurred until fully unfolded leaves are visible. If this is the case, the observer could report "?" for this phenophase if they suspect it is occurring but are not certain.

In rare cases a plant may undergo a second round of "Breaking leaf buds" if most of its leaves are killed by a late frost, severe drought, or an insect defoliation.

An overview of unfolded leaves

When is a leaf considered "unfolded"?

At the point when a leaf has "unfolded", *Nature's Notebook* considers the bud or shoot as transitioning from "Initial growth" or "Breaking leaf buds" into the next vegetative phenophase, either the "Leaves" phenophase or the "Young leaves" phenophase, depending on the type of plant it is. The definition for "unfolded" differs slightly depending on whether your plant species is a forb, grass, sedge, rush, or tree or shrub. Getting familiar with your plant species—in this case the characteristics and behaviors of its leaves—and its definition for an "unfolded" leaf will help you to determine the transition into the new phenophase, and enable you to record consistent, quality observations.

Note that each bud or shoot on a plant may transition to the "Leaves" or "Young leaves" stage at a different time. Therefore, an observer will often see "Initial growth" or "Breaking leaf buds" on their plant at the same time they see "Leaves" or "Young leaves", and when that is the case they should report "yes" for both.

Forbs

On this page are several series of images illustrating both annual and perennial forb species moving through "Initial growth" up to the point of the first "unfolded" leaf or leaves—arrows point out the unfolded leaf. Annual and perennial species differ slightly in their presentation of the first unfolded leaf, which is usually a small version of the mature leaf. Each species will have their own characteristic "look".

Annual forbs

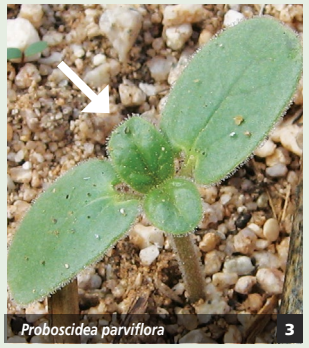
Annual forb shoots (row 1) begin as a germinating seed, pushing or pulling two cotyledons (seed leaves) above the soil surface. Between the two cotyledons one or two "true" leaves will emerge—generally miniatures of the species' characteristic mature leaf shape. When an observer can first see an expanded true leaf blade, although it may still be tiny, the first leaf is considered to have "unfolded" (Image 3).

Perennial forbs

Perennial forbs (rows 2-4) begin their new seasonal growth as a new sprout pushing through the soil or from an above-ground stem node. When an observer first sees an expanded leaf blade, although it may not yet be full size, the first leaf is considered to have "unfolded" (Images 7, 9, 12, 16).


Proboscidea parviflora 1

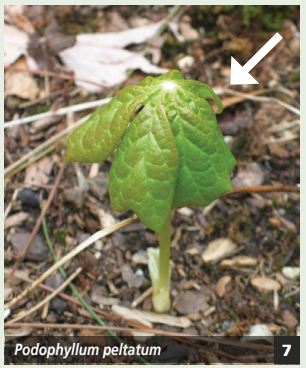

Proboscidea parviflora 2

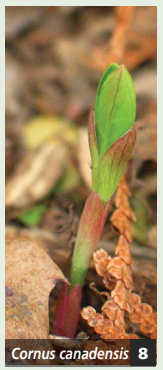

Proboscidea parviflora 3


Podophyllum peltatum 4

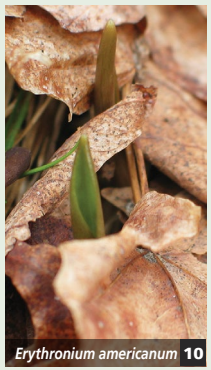

Podophyllum peltatum 5

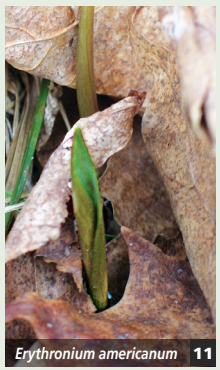

Podophyllum peltatum 6


Podophyllum peltatum 7


Cornus canadensis 8


Cornus canadensis 9


Erythronium americanum 10

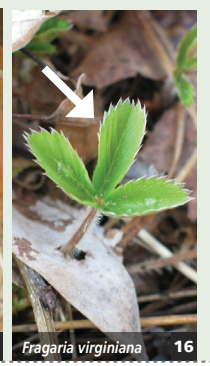

Erythronium americanum 11


E. americanum 12


Fragaria virginiana 13


Fragaria virginiana 14


Fragaria virginiana 15


Fragaria virginiana 16

Evergreen forbs

Although evergreen forbs are generally not assigned the "Initial growth" phenophase, there may be a period of growth before the first new leaf has "unfolded" after a period of no leaf growth (row 1). Some forb species also have scaled leaf buds that break open (circles in Images 17-18). The definition for the first unfolded leaf in evergreen forb shoots is similar to that for perennial forbs—when you can see the first expanded leaf blade emerging from a bud or shoot, even though it may not yet be full size (arrows in Image 19).

Graminoids

Despite the fact that each of the graminoid plants seems to have very similar leaves, they have different characteristics of leaf development. For each, being "unfolded" is slightly different.

Grasses

The first leaf of a shoot, initially tightly rolled, is considered unfolded once it unrolls and the blade begins to fall away at an angle (the leaf's sheath remains clasping the hidden stem and new leaves). Row 2 illustrates the sequence with the arrow indicating the first unfolded leaf.

Sedges

The first leaf of a shoot, initially folded tightly in half, is considered unfolded once it has grown long enough that the two halves of the leaf blade have begun to spread apart like the opening of a book. Row 3 illustrates this with the arrow indicating the unfolded leaf.

Rushes

A new leaf blade is cylindrical, or occasionally flat—dependent on the species—and does not really unfold in any way, it simply continues to grow taller. Therefore, to distinguish the transition between the "Initial growth" and the "Leaves" phenophases, we define "unfolding" as having occurred once the leaf blade has grown to 2 inches (5 cm) in height. Row 4 illustrates this transition to the unfolded leaf. Image 28 shows leaf blades in "Initial growth" (less than 2 inches tall) and Image 29 shows a few in the "Leaves" phenophase (over 2 inches tall).

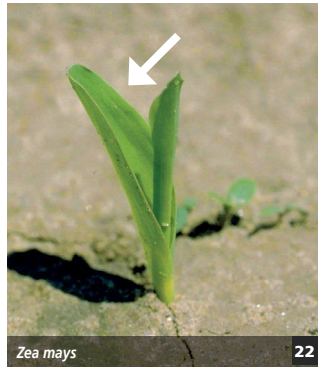

Chimaphila umbellata 17


Chimaphila umbellata 18


Chimaphila umbellata 19


Chimaphila umbellata 20


Zea mays 21


Zea mays 22


Zea mays 23


Carex pilosa 24


Carex pilosa 25


Carex pensylvanica 26


Carex pensylvanica 27


Juncus gerardii 28


Juncus gerardii 29

An overview of unfolded leaves *(continued)*

When is a leaf considered "unfolded"?

Generally, for deciduous or evergreen trees and shrubs, the *Nature's Notebook* definition identifies the first "unfolded" leaf as the point at which the leaf base of the first new leaf from each bud or shoot can be seen where it attaches to the leaf stalk (petiole) or stem (if there is no petiole). Often this means the leaf base becomes unhidden from between bud scales or other plant parts that protect and hide the tiny, new leaves. The type of leaf buds that are characteristic for any given plant species will influence how the definition is interpreted—as leaf buds having bud scales have a more clear-cut signal than those without bud scales.

Again, remember that each bud on a plant may transition to the "Leaves" or "Young leaves" stage at a different time. Therefore, an observer will often see "Breaking leaf buds" on their plant at the same time they see "Leaves" or "Young leaves" and when that is the case they should report "yes" for both.

Deciduous trees and shrubs

To the right are several image series of deciduous species shown from dormant, swelling or breaking leaf buds to the first unfolded leaf. The arrow indicates the unfolded leaf—where an observer can see the leaf base attached to the petiole or stem.

Deciduous trees or shrubs with scaled buds

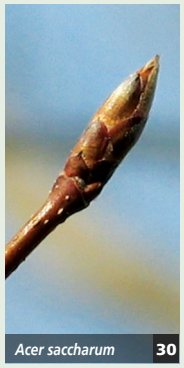
Buds scales loosen and separate as the bud comes out of dormancy, and the leaves emerge, expand and unfold (rows 1 and 2).

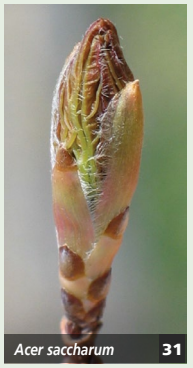
Deciduous trees or shrubs with naked buds (no bud scales)

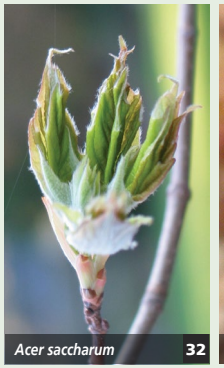
Protective leaves loosen and separate as the plant comes out of dormancy and begin to turn green (row 3). Once the first leaf's point of attachment to the petiole is visible or, if it was visible while dormant, once the leaf unfolds or unrolls enough to appear more or less a small version of the adult leaf, the first leaf of that bud has unfolded.

Deciduous trees or shrubs with scaled buds and sessile leaves (no petioles)

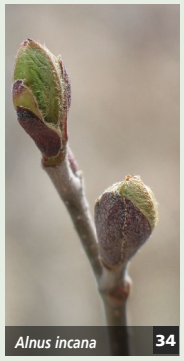
Bud scales loosen and separate, then the sessile leaves emerge, expand and unfold. An observer will watch for the leaf base attachment to the stem, not a petiole (row 4).


Acer saccharum 30

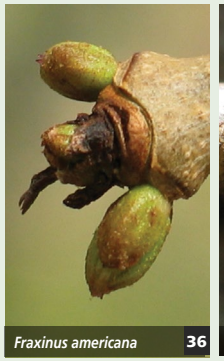

Acer saccharum 31


Acer saccharum 32

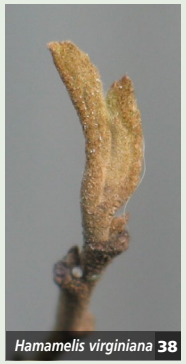

Acer saccharum 33


Alnus incana 34


Alnus incana 35


Fraxinus americana 36


Fraxinus americana 37


Hamamelis virginiana 38

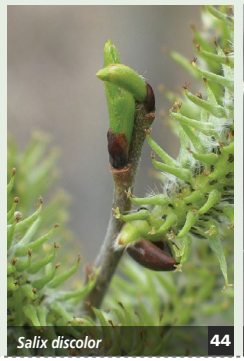

Hamamelis virginiana 39


Hamamelis virginiana 40


Hamamelis virginiana 41


Vaccinium corymbosum 42


Vaccinium corymbosum 43


Salix discolor 44


Salix discolor 45

Evergreen trees and shrubs

Evergreen trees and shrubs retain leaves at all times—since each leaf will live one to several years, there is an overlap of older leaves and new leaves so that the plant remains green year-round. However, evergreen species often experience periods of no growth, followed by the initiation of new leaf growth. To the right are several series of evergreen species images shown from dormant, swelling or breaking leaf buds to the unfolding of the first new leaf. The arrow indicates the unfolded leaf—where an observer can see the leaf base.

Evergreen trees or shrubs with bud scales

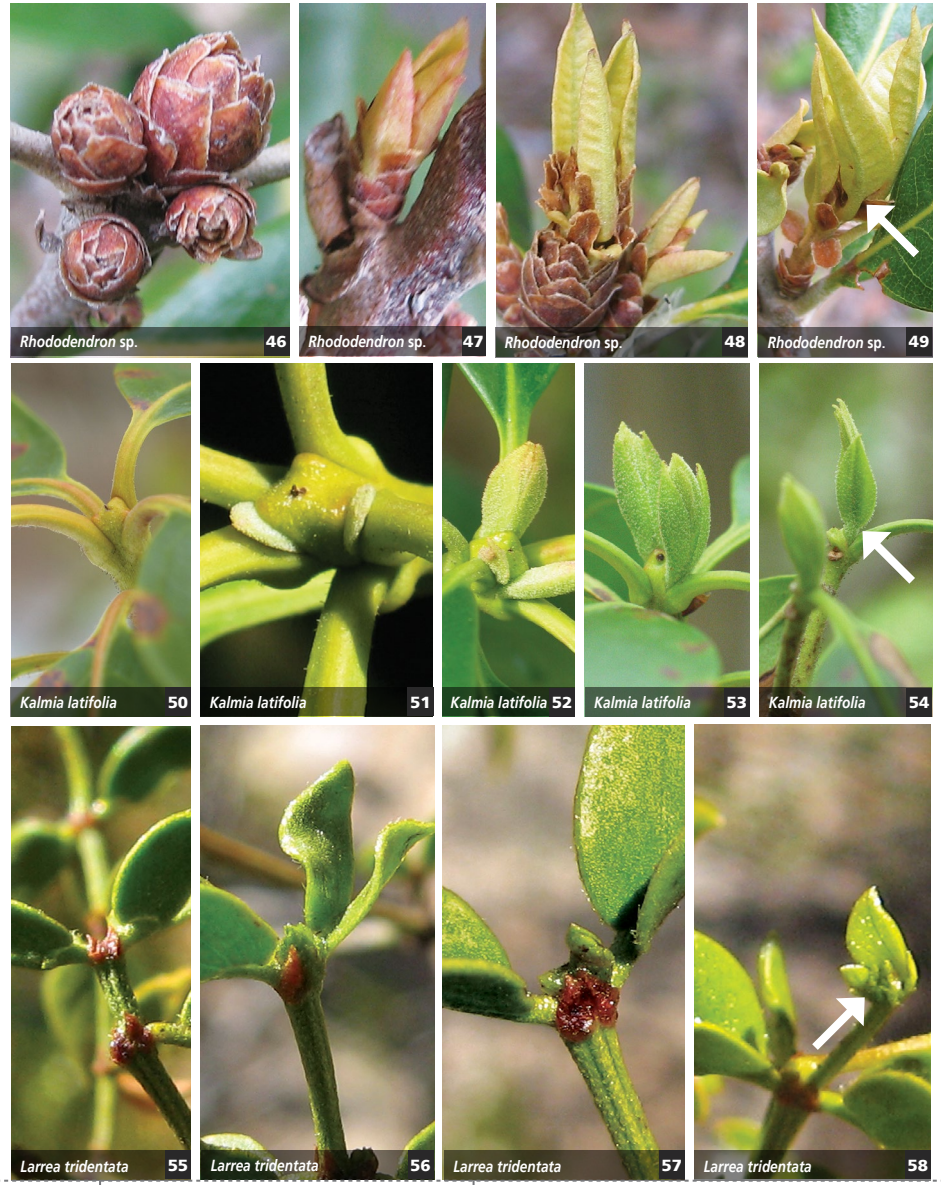
Buds swell and the bud scales loosen and separate as the plant's buds come out of dormancy and the new leaves emerge, expand and unfold (row 1).

In some species, the anatomy can differ enough to be visually confusing—such as the mountain laurel's sunken and hidden leaf buds (row 2) which emerge from the base of the petioles of the top whorl of leaves. These valvate buds (buds having two scales in which their edges meet mid-bud) first appear as little flat tongues around the terminal end of the stem and slowly develop. Eventually the two bud scales separate to expose the tiny leaves (Image 54).

Evergreen trees or shrubs with no obvious bud scales

In some cases, evergreen trees and shrubs have non-typical branch and stem termini that are also called naked buds—when protective leaves tightly surround the embryonic leaves at the end of twigs and branches; these plants are often from warmer, dry habitats. Small, tightly enfolding leaves gradually loosen and separate, and enlarge, as the plant comes out of a rest period or dormancy. Other plant species in this category do not have protective leaves, although may have other protection by other plant tissues (row 3). Tiny leaves begin emerging from the end of a branch or twig at embryonic stem nodes.

Once the tiny leaf's base becomes apparent or, if it was apparent while dormant, once the leaf emerges or unrolls enough to appear more or less a small version of the adult leaf, or the nubs of leaflets are visible, the leaf has unfolded.



An overview of unfolded leaves *(continued)*

When is a leaf considered "unfolded"?

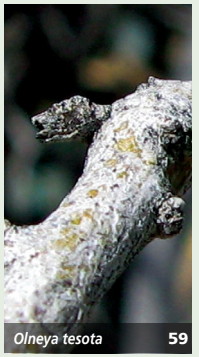
Some tree and shrub species seemingly have no leaf buds. Often, these plants fall in a category called drought deciduous plants. Very tiny buds, then leaves, emerge from the stem nodes (the meristems) often located on stem tissue called a short shoot (tiny woody nobs having highly compacted stem nodes with very little or no stem internode between each node). After a period of plant stress or rest, the new leaves emerge quickly from the plant's stem nodes. Some species do this extremely quickly and just as quickly drop their leaves again, thereby minimizing water loss but maximizing their net photosynthetic activity. And as you might guess, what an observer would cue into for an "unfolded" leaf is slightly different for these species.

On these two pages we provide some images and accompanying explanations to guide an observer through these challenging observations.

Drought deciduous trees and shrubs

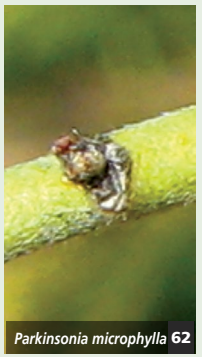
Drought deciduous trees and shrubs—which grow in desert and other dryland environments—drop leaves when the environment is stressful, and leaf out again when their resource needs are met. They often drop their leaves unpredictably during stressful episodes or predictably during a dormant period to become water efficient. Many have no discernible leaf buds—scaled or naked—but are quickly able to develop leaves from the meristem tissue at their stem nodes in response to sufficient resources, such as after a good rain storm. Often short shoot tissue is present at a stem node, with new leaves (and flower buds) emerging from the densely compressed nodes within this tissue. Watching closely, an observer will see new growth emerging from the nodes or short shoot, but only with experience will an observer be able to determine early if it is new leaf tissue or flower buds, as both can emerge from the same node. In some species the new leaves seemingly appear to emerge fully unfolded overnight and are tiny versions of a mature leaf. There may be no visible period of growth before the unfolded leaves appear.

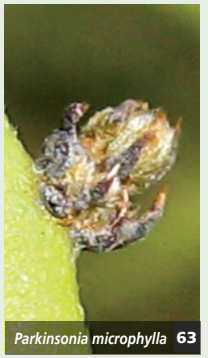
On this page are four rows of image series to help with visually understanding the "unfolded" leaf stage and some variations within drought deciduous species—each row showing a different species. The first image in each series shows dormant short shoot tissue present at a stem node. The arrow in each image series indicates an unfolded leaf for the species. Once a leaf has unfolded, an observer can distinguish the leaf's base and, for species with compound leaves, the new leaf's leaflets. These plant parts are tiny—often just a quarter of an inch long—so, an observer will need to carefully observe their plant. In Image 67, the node has three separate short shoots, each one in a differing phase—the bottom right short shoot is dormant while the short shoot on the left is beginning activity with new plant tissue emerging at the tip, and the upper right short shoot in this image has new leaf tissue emerging. In Image 66 a short shoot has two areas of leaf tissue emerging—the upper activity is newly emerging leaf tissue while the lower area has a newly unfolded leaf.


Olneya tesota 59


Olneya tesota 60


Olneya tesota 61


Parkinsonia microphylla 62

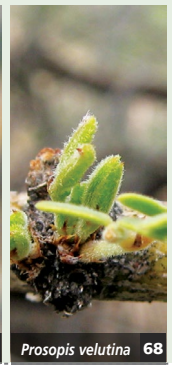

Parkinsonia microphylla 63


Parkinsonia microphylla 64


Acacia greggii 65


Acacia greggii 66


Prosopis velutina 67


Prosopis velutina 68


Prosopis velutina 69

Drought deciduous plants with unusual leaf characteristics

Ocotillo (*Fouquieria splendens*)

Ocotillo is a drought deciduous plant which displays two types of leaf growth: one type on the older part of the stems similar to plants discussed on the previous page where leaves emerge from axillary areas on short shoots, and another leaf type on the newly extending branches, at the end of each plant stem.

The first type of leaf growth occurs at the stem nodes on the long, stiff, spiny and often leafless stems that radiate from ground level (row 1). New sessile leaves will emerge at stem nodes, in a spine's axil along the stem following a rain event (arrows in Image 77). As soon as a discernible leaf base is observed, the leaf is considered unfolded. These leaves will be dropped from the plant, sometimes very quickly, as the environment dries. This can occur several times in a year.

The second type of leaf growth occurs once a year as new elongating branches grow at the tip of the spiny stems (row 2). As the new branch initiates growth (Image 80) and begins to elongate, a spiral of spine-like growths (the leaf petioles) with a tiny leaf blade angled upwards at its end (Image 81) will alternate along the new stem. As soon as the tiny leaf blade is recognizable as a leaf, it is considered unfolded (arrows in Image 81). The leaf blade will drop off early as the branch develops, leaving a petiole that will stiffen into a new spine at a stem node with a leaf bud in its axil (Image 82). New leaves will develop in the axils of the new spines as described in the last paragraph. Stem elongation usually occurs only once a year; further leaf initiation during the year will occur in the spine axils.

Desert ceanothus *(Ceanothus greggii)*

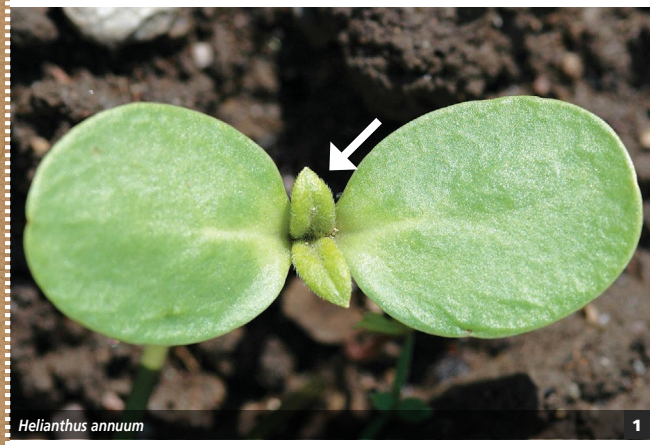
Desert ceanothus (row 3) is an evergreen desert plant having no leaf buds although leaf stipules protect the meristematic regions at the stem nodes. The leaves slowly emerge from ends of the branches at meristems or at existing stem nodes, looking very much like miniature mature leaves early in their development. As soon as a discernible leaf base is observed, the leaf is considered unfolded (arrow in Image 86). In early spring, do not confuse the scaled, hairy flower buds for leaf buds.

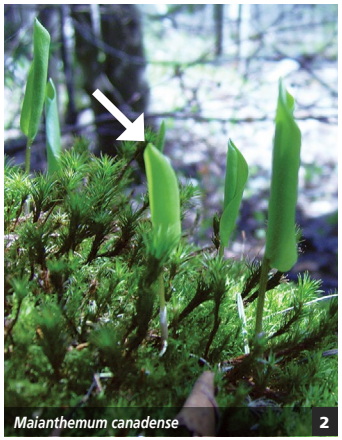
Nature's Notebook
PHENOPHASE DEFINITION

Leaves

Forb

One or more live, fully unfolded leaves are visible on the plant. For seedlings, consider only true leaves and do not count the one or two small, round or elongated leaves (cotyledons) that are found on the stem almost immediately after the seedling germinates. Do not include fully dried or dead leaves.

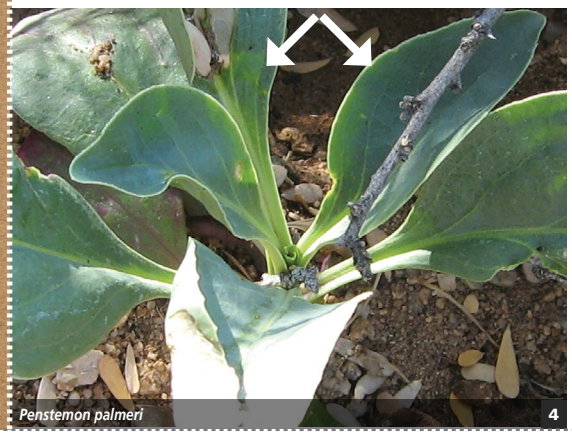

Helianthus annuum 1


Maianthemum canadense 2

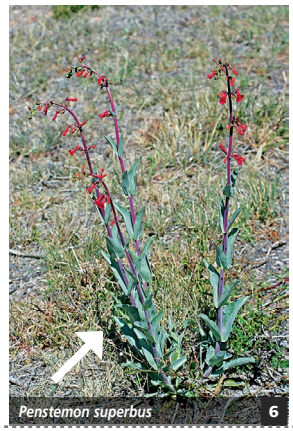

Penstemon sp. 3

Forbs

The "Leaves" phenophase encompasses the entire period during which live unfolded leaves are present on an annual or perennial forb. This begins with the first unfolded leaf (see the previous section "An overview of unfolded leaves") and ends when the last leaf on the plant has withered and died. Note that evergreen forbs are not assigned the "Leaves" phenophase because by definition they have leaves year-round.


Penstemon palmeri 4


Penstemon sp. 5


Penstemon superbus 6

Nature's Notebook
PHENOPHASE DEFINITION

Leaves

Grass
One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once it unrolls slightly from around the stem and begins to fall away at an angle from the stem. Do not include fully dried or dead leaves.

Sedge
One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once it has grown long enough that the two halves of the leaf blade have begun to spread apart like an open book. Do not include fully dried or dead leaves.

Rush
One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once the exposed, green portion of the leaf (or shoot) has reached approximately 2 inches (5 cm) in length. Do not include fully dried or dead leaves.


Paspalum dilatatum 7

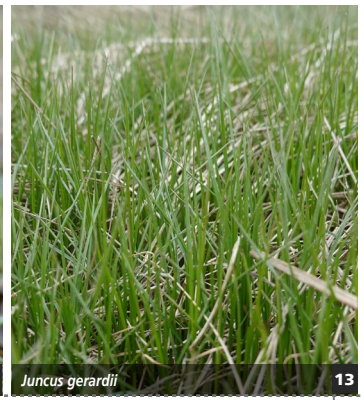

Setaria macrostachya 8


Carex obnupta 9


Morse
Carex leptopoda 10


Carex pensylvanica 11

Juncus gerardii 12


Juncus gerardii 13


Juncus gerardii 14

Grasses and sedges

The "Leaves" phenophase encompasses the entire period during which green, unfolded leaves are present on the grass (row 1) or sedge (row 2) plant. This begins with the first unfolded leaf (see the previous section "An overview of unfolded leaves") and ends when the last leaf on the plant dries up and turns brown at the end of the growing season. Some species will retain a few green leaves and remain in the "Leaves" phenophase all year (Image 11).

Rushes

The "Leaves" phenophase encompasses the entire period during which green, unfolded leaves are present on the rush plant (row 3). This begins when the first new shoot reaches 2 inches in height (see the previous section "An overview of unfolded leaves") and ends when the last stem of the plant dries up and turns brown at the end of the growing season.

Nature's Notebook
PHENOPHASE DEFINITION

Leaves

Tree/Shrub

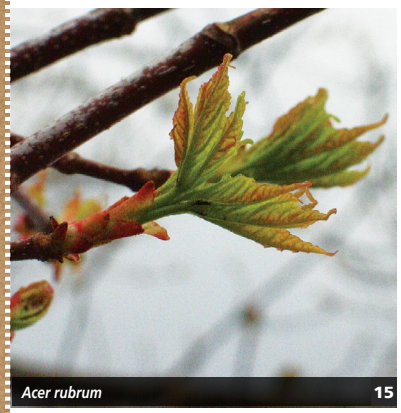
One or more live, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once its entire length has emerged from a breaking bud, stem node or growing stem tip, so that the leaf base is visible at its point of attachment to the leaf stalk (petiole) or stem. Do not include fully dried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

Trees and shrubs

The "Leaves" phenophase encompasses the entire period during which live, unfolded leaves are present on a tree or shrub. This begins with the first unfolded leaf (see the previous section "An overview of unfolded leaves"), includes the periods while leaves are increasing in size and while changing in color, and ends when the last leaf has fallen from the tree or shrub, or has dried up and died in place on a plant. The following image series include trees and shrubs that are deciduous, drought deciduous, and semi-evergreen. Note that evergreen trees and shrubs are not assigned the "Leaves" phenophase because by definition they have leaves year-round.

Deciduous trees and shrubs

Deciduous trees and shrubs are woody plants having flat leaves during the plant's growing season but drop their leaves during dormant periods, namely winter. And, they have leaf buds that are large enough to observe when the plant is dormant.

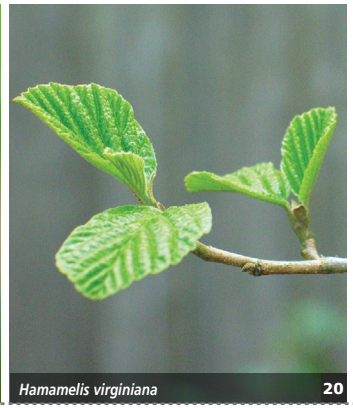

Acer rubrum 15


Acer rubrum 16

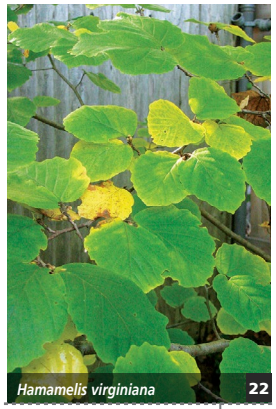

Acer rubrum 17


Acer rubrum 18


Hamamelis virginiana 19


Hamamelis virginiana 20


Hamamelis virginiana 21


Hamamelis virginiana 22


Hamamelis virginiana 23


Prosopis velutina 24


Prosopis velutina 25


Prosopis velutina 26


Prosopis velutina 27


Olneya tesota 28


Olneya tesota 29


Olneya tesota 30


Olneya tesota 31

Drought deciduous and semi-evergreen trees and shrubs

Drought deciduous trees and shrubs (rows 1-2) are dryland-adapted woody plants with flat leaves that may be evergreen, yet also may regularly drop off during stress, namely the dry periods. They have leaf buds that are too small to observe and leaves that develop sporadically, starting and stopping as needed, so that full-size leaves are difficult to identify. Semi-evergreen trees and shrubs (row 3) are woody plants with flat leaves that may be evergreen in mild climates, but may drop off in more extreme climates or with stress. They have leaf buds that are large enough to observe when the plant is dormant.


Quercus laurifolia 32


Quercus laurifolia 33


Quercus laurifolia 34


Quercus laurifolia 35

Nature's Notebook
PHENOPHASE DEFINITION

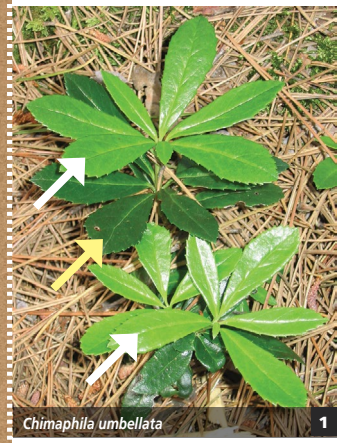
Young leaves

Forb

One or more young leaves are visible on the plant. A leaf is considered "young" before it has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

Forbs

This phenophase is included for forb species that usually, or occasionally, have last season's old leaves and newly growing leaves occurring on the plant at the same time. It captures the distinct seasonal periods when new leaf growth occurs. The observer can distinguish young leaves from older leaves on the plant by differences in size, color and/or texture. In these images, the white arrow indicates a young leaf that is smaller or a lighter green color than the mature leaves in the image (yellow arrows). Evergreen forbs (row 1) retain live leaves year-round. Semi-evergreen forbs (row 2) may regularly retain a few live leaves all year round, or may be evergreen in warmer areas and dieback to the ground in colder areas. This phenophase ends when the size, color and/or texture of all of the newer leaves are no longer distinguishable from the older leaves retained on the plant.

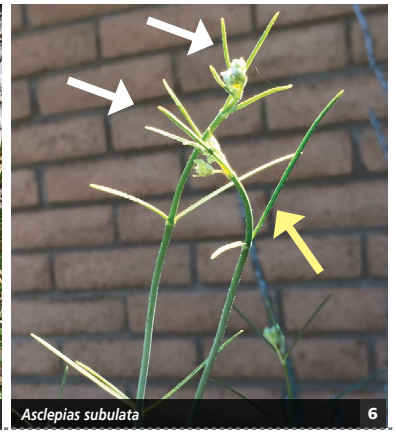

Chimaphila umbellata 1


Goodyera oblongifolia 2


Sarracenia purpurea 3


Croton argyranthemus 4


Fragaria virginiana 5

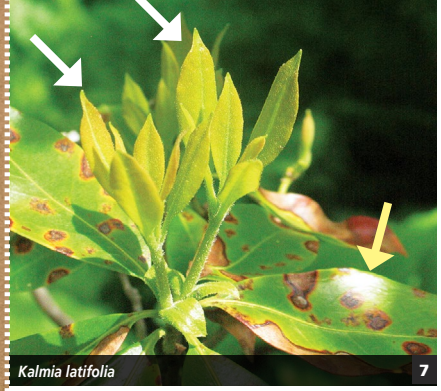

Asclepias subulata 6

Nature's Notebook
PHENOPHASE DEFINITION

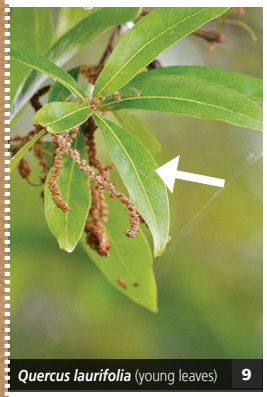
Young leaves

Tree/Shrub

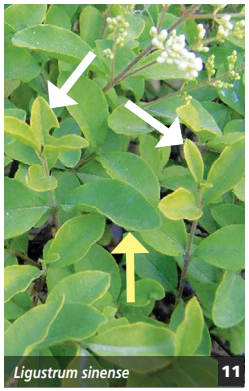
One or more young, unfolded leaves are visible on the plant. A leaf is considered "young" and "unfolded" once its entire length has emerged from the breaking bud, stem node or growing stem tip, so that the leaf base is visible at its point of attachment to the leaf stalk (petiole) or stem, but before the leaf has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

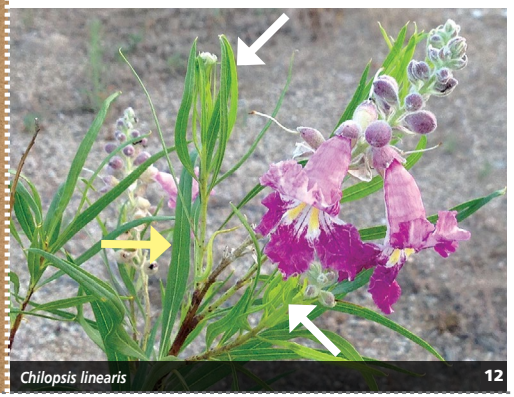

Kalmia latifolia 7

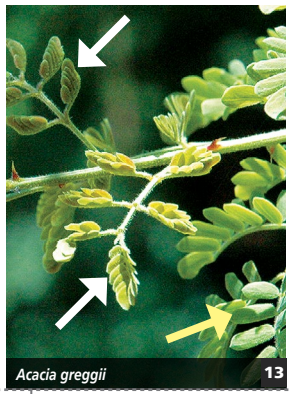

Larrea tridentata 8


Quercus laurifolia (young leaves) 9


Quercus laurifolia (mature leaves) 10


Ligustrum sinense 11


Chilopsis linearis 12


Acacia greggii 13

Trees and shrubs

Tree and shrub species that usually, or occasionally, retain old leaves on the plant, but also have newly growing leaves on the plant at the same time are assigned this phenophase. During active leaf growth, young leaves can be distinguished from older leaves by differences in size, color and/or texture. In these images, the arrow indicates a young leaf that is smaller or a lighter green color than the mature leaves in the image (yellow arrows). This phenophase ends when the new leaves can no longer be distinguished from the older retained leaves.

Evergreen

These species have leaves present year-round, with distinct seasonal periods when new leaf growth occurs (row 1).

Semi-evergreen

These species often behave deciduously in colder areas (drop all their leaves in autumn or winter) and evergreen in warmer areas. The "Young leaves" phenophase is important to record in the warmer areas to identify the seasonal growth period (row 2).

Drought deciduous

These species may or may not have old and young leaves present on the plant at the same time. It varies from year to year and month to month depending on rain and frost events (row 3).

Nature's Notebook
PHENOPHASE DEFINITION

Increasing leaf size

Tree/Shrub

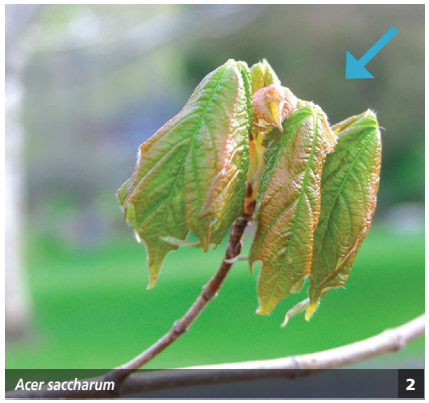
A majority of leaves on the plant have not yet reached their full size and are still growing larger. Do not include new leaves that continue to emerge at the ends of elongating stems throughout the growing season.

For deciduous tree and shrub species that have a single large flush of leaves at the beginning of the growing season, we observe "Increasing leaf size". This phenophase starts with the first unfolded leaf and ends when the majority of leaves from that flush have expanded to their full mature size. It represents "green-up"—the period of time it takes the plant to produce a full canopy of leaf tissue and build its photosynthetic capacity.

As they expand, leaves will often gradually change color from a lighter to a darker green and also might change from a soft, thin texture to a tougher mature texture. The following series highlights sugar maple leaf development, from newly "unfolded" leaves (Image 1) to full-size, mature leaves (Image 5). Images 1-4 all exhibit the "Increasing leaf size" phenophase (blue arrows).

Note that leaves on the same plant may grow to different sizes and textures (Image 6). For example, leaves growing in the shade on lower branches are larger and thinner than leaves growing in the sun of the treetop. Be aware that "full-size" for these "sun leaves" (white arrow) will be smaller than the full mature size of "shade leaves" (yellow arrow) on the same plant.

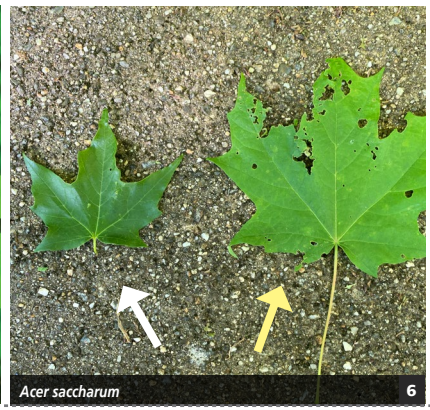

Acer saccharum 1


Acer saccharum 2


Acer saccharum 3


Acer saccharum 4

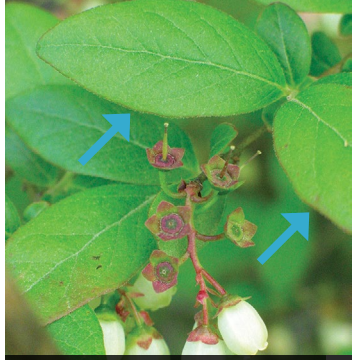

Acer saccharum 5


Acer saccharum 6

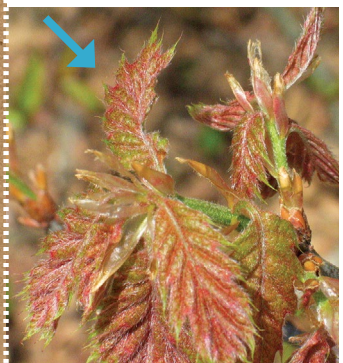
Increasing leaf size


Vaccinium corymbosum 7


Vaccinium corymbosum 8


Vaccinium corymbosum 9


Vaccinium corymbosum 10


Quercus rubra 11


Quercus rubra 12


Quercus rubra 13


Quercus rubra 14


Quercus rubra 15

Rows 1 and 2 above highlight additional tree and shrub species as they progress through the "Increasing leaf size" phenophase (blue arrows). The last image in each row shows full-size, mature leaves of the species.

After a plant has completed "green-up" to produce a full canopy of leaf tissue and most of the leaves are full size, new leaves may continue to appear at branch tips all season long (Image 16-17). This ongoing leaf growth and branch extension is common for many deciduous tree and shrub species. However, capturing the increasing size of these new leaves throughout the growing season is not the intention of this phenophase, and an observer should report "no" for "Increasing leaf size".


Hydrangea paniculata 16


Quercus rubra 17

Nature's Notebook
PHENOPHASE DEFINITION

Colored leaves

Tree/Shrub

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.

This phenophase is also covered in detail in the *Nature's Notebook* Nugget: Colored Leaves, which can be found on the USA-NPN website (usanpn.org).

The "Colored leaves" phenophase captures the period when leaves of deciduous trees and shrubs begin to deteriorate and lose their green color, in some species turning brilliant shades of yellow, orange or red. Often it represents the period of time when the deciduous plant is ramping down photosynthetic capacity towards the end of the growing season. However, this phenophase may also occur during times of extreme drought or insect infestations. Occurrence of this phenophase generally ends when either all the leaves have dropped off the plant, or if some remain on the plant, when they have dried up and become brittle.

Image 1 captures magnolia leaves just starting to change color, and Image 2 shows a more advanced state of color change. Images 5-7 show a progression of color change in oak leaves. Image 8 captures the leaf color of desert ironwood, a drought deciduous species, occurring while flower buds are developing in the spring.

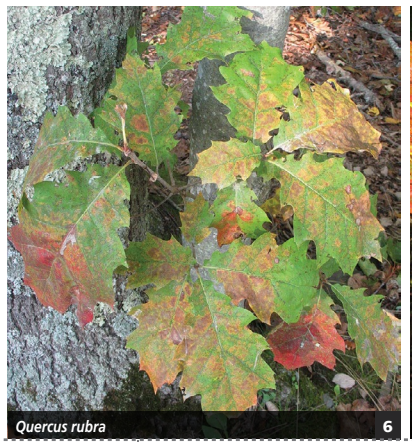

Magnolia stellata 1


Magnolia stellata 2


Prunus serotina 3


Rubus sp. 4


Quercus rubra 5


Quercus rubra 6


Quercus rubra 7


Olneya tesota 8

Colored leaves


Acer saccharum 9


Acer saccharum 10


Acer saccharum 11


Acer saccharum 12


Acer saccharum 13

Row 1 shows a progression of end-of-season leaf color on a sugar maple. In some species the "Colored leaves" phenophase can come and go during the senescent season if all colored leaves drop off the plant, such as in a storm, yet green ones remain and subsequently turn color.

For some species, it is characteristic for dead, brittle leaves to remain on the plant for an extended period into the winter season. These "marcescent" leaves are no longer alive and not included as "Leaves" or "Colored leaves". When all remaining leaves on a plant have reached this dried and brittle stage, the leaf phenophases have ended for the plant and an observer should report "no" for both "Leaves" and "Colored leaves" (Images 14-15).


Quercus rubra 14


Fagus grandifolia 15


Acer rubrum 16

In some situations, red or pink coloring appears in new, developing leaves or mature, healthy-looking leaves early in the year (Image 16). The development of this red pigment helps to protect tender leaves from intense sunlight. This type of coloring should be ignored for this phenophase. Observers should only report “yes” for "Colored leaves" when they see non-green color that is a result of drought or leaf aging towards the end of the growing season.

Nature's Notebook
PHENOPHASE DEFINITION

Falling leaves

Tree/Shrub

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.


Magnolia stellata 1


Acer saccharum 2


Alnus incana 3

For deciduous, drought deciduous and semi-evergreen tree and shrub species observers watch for "Falling leaves" toward the end of the growing season when dying (senescing) leaves begin to drop from the plant. An observer might actually see leaves drop at the time of their observation, but more likely they will notice that leaves have dropped since the last time they visited, in which cases they should report "yes" for "Falling leaves". They should report "no" for "Falling leaves" if it does not appear that anything dropped since their last observation.

Images 1-6 show leaves that have recently fallen from the plant and are resting on the ground below.


Cornus alternifolia 4

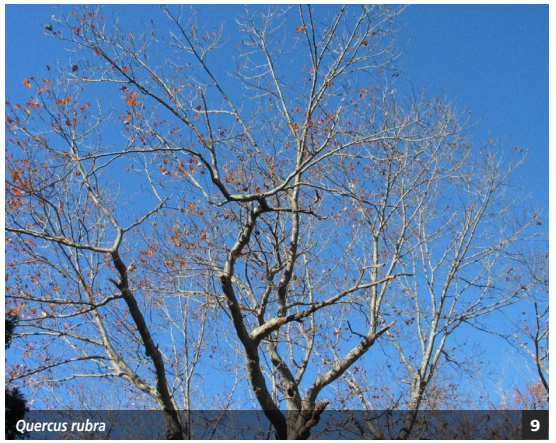

Hamamelis virginiana 5


Quercus rubra 6

Falling leaves


Quercus rubra 7


Quercus rubra 8


Quercus rubra 9

Row 1 shows a progression of leaf fall from a northern red oak. An increasing number of leaves are missing from the canopy as they fall from the tree. This phenophase ends for the season when no live leaves are left on the plant (although dried, dead leaves might still be attached). The occurrence of “Falling leaves” might not be continuous from observation to observation. For instance, it might cease during a spell of mild weather but start up again with cold or windy weather. If this is the case, the observer should report "no" for “Falling leaves” if none appear to have fallen since their last observation.

Occasionally, several handfuls of healthy green leaves will fall during a strong spring or summer wind storm (Images 10-11). The observer should ignore these and not report them as "Falling leaves".


Quercus rubra 10


Acer saccharum 11

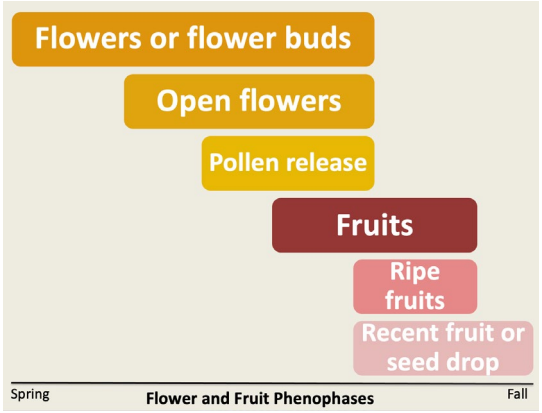

Quercus rubra 12

As explained in the previous section for "Colored leaves", dry and brittle marcescent leaves that remain on the plant are no longer considered live leaves (Image 12). When they finally fall off the plant, these leaves should be ignored and not reported as "Falling leaves".

An overview of reproductive (flower and fruit) phenophases

How are they related to one another?

1



2

The reproductive phenophases for *Nature's Notebook* plant species are organized into two distinct categories

1. Flowering. These phenophases characterize the period when a plant has active flower buds and, subsequently, when it opens its flowers to expose reproductive organs to facilitate pollination and fertilization.

2. Fruiting. These phenophases characterize the period when the flower's ovaries have been fertilized, through fruit development and ripening, and finally, the dispersal of fruits and seeds.

Fruiting usually follows flowering in the annual cycle (see Diagram 2 for example overlap of reproductive phenophases), but there are some species that delay fruit development from the fertilized ovary until the following year. In these cases, fruiting phenophases may occur before flowering phenophases during the annual cycle.

Flowering—includes the *Nature's Notebook* phenophases:

- "**Flowers or flower buds**" (or "**Flower heads**" for grasses and sedges) is a phenophase that observers will watch for in all species (with a few unusual exceptions). It captures the entire period of time that developing flower buds and/or fresh, open flowers are present on the plant, from the emergence or swelling of the first flower bud (Image 1) or flower head, to the wilting or drying of the last flower. For plant species that require an observer to follow specific cues, those cues will be described within the "Flowers and flower buds" or "Flower heads" phenophase definition found on the species' profile page or datasheet in *Nature's Notebook*.

  Note that some species will develop (or "set") next year's flower buds in late summer or fall, and the buds will remain tightly closed and dormant over the winter. These flower buds should be ignored for this phenophase until they begin to swell and develop after their dormancy has broken in late winter or spring.

- "**Open flowers**" is a phenophase that observers will watch for in all species except those where the plant would need to be torn open and damaged to view hidden flowers. It captures the period of time when the male and/or female flower parts are ready (or will soon be ready) to shed or receive pollen, and are accessible by pollinators (Image 3). Occurrence of this phenophase ends when all the flowers on the plant are "spent" (wilted or dried). For plant species that require an observer to follow specific cues, those cues will be described within the "Open flowers" phenophase definition found on the species' profile page or datasheet in *Nature's Notebook*.

- "**Pollen release**" is a phenophase that observers will watch for in species that are considered allergenic, including grasses and many wind-pollinated trees. It captures the period of time when flowers are open and pollen is visibly being shed. Occurrence of this phenophase ends when release of fresh pollen grains from the plant is no longer detectable.

  Note that it is nearly impossible to evaluate this phenophase in tall trees where flowers are out of reach.

Flowering phenophases are nested such that an observer reporting "yes" for "Pollen release" should also be reporting "yes" for "Open flowers", and if reporting "yes" for "Open flowers" should also be reporting yes for "Flowers or flower buds" (or "Flower heads" for grasses and sedges) (Diagram 2 illustrates how flowering phenophases overlap).

Fruiting—includes the *Nature's Notebook* phenophases:

- "**Fruits**" is a phenophase that observers will watch for in all species. It captures the entire period of time when developing and mature, ripe fruits are present on the plant, from the detection of the first newly initiated fruit (Image 4) until the last ripened fruit either drops from the plant or opens and releases all its seeds. Within the "Fruits" phenophase definition for each *Nature's Notebook* species, there is a species-specific description of fruit development cues to guide observers in what to look for.

  Note that many species' fruits are capsules or pods that split open when they become ripe and release seeds (referred to as "dehiscent" fruit), after which the empty capsule or pod remains on the plant. These empty fruits that have released all their seeds should be ignored for this phenophase.

- "**Ripe fruits**" is a phenophase that observers will watch for in all species. It captures the period of time when ripe fruits are present on the plant (Image 5). Within the "Ripe fruits" phenophase definition for each *Nature's Notebook* species, there is a species-specific description of the cues that indicate a fruit has become ripe. Occurrence of this phenophase ends for the season when the last mature fruit or seed drops or is removed from the plant.

  As explained above for the "Fruits" phenophase, empty fruits that have released all their seeds should be ignored for this phenophase.

- "**Recent fruit or seed drop**" is a phenophase that observers will watch for in all species. It captures the period of time when the present season's fruits display their ripeness cues, and mature fruits or seeds are dropping from the plant as they disperse. It is especially useful to report on this phenophase for species where ripeness is defined by fruit drop or splitting to release seeds, in which case the observer might never see ripe fruits present on the plant. Occurrence of this phenophase ends for the season when no mature fruits or seeds are left on the plant (although for some species, empty capsules or pods may persist).

  Note that immature fruits sometimes drop before they become ripe, either in heavy rain or wind storms, or because they were aborted by the plant. The dropping of these immature fruits should be ignored for this phenophase.

Fruiting phenophases are nested such that an observer reporting "yes" for "Ripe fruits" should also be reporting "yes" for "Fruits" (Diagram 2 illustrates how fruiting phenophases overlap). "Recent fruit or seed drop" often occurs while ripe fruits are still present, but the last observation will most likely occur alone. That is, no fruits are left on the plant ("Fruits" and "Ripe fruits" are not occurring), but the ripe fruits that were present at the last observation have now dropped ("Recent fruit or seed drop" did occur).


3


4


5

An overview of dormant flower buds

What do they look like?

Let's take a look at dormant flower buds versus newly swelling buds—that is, buds that begin expanding in size and loosening bud scales just before they break open to expose flower buds (yes, buds within buds—often flower buds are protected under bud scales).

First... how does an observer identify a vegetative (leaf) versus a reproductive (floral) bud? Often a plant's species description identifies bud types based on the position on the plant, or its shape or size relative to the other buds on the plant. For some plant species, the flower and leaf buds differ so greatly there will be no difficulties in deciphering the different bud types. Yet, these generalizations don't hold true 100% of the time. What to do?

Try to learn as much as you can about the plant species you have chosen to observe. Read tips and descriptions. Ask experts. Look at photos of the species in all seasons. Then, get familiar with your chosen plant by watching carefully as buds first open—can you see a colored flower petal or is it a leaf tip? If it helps, spend a season studying your plant so that understanding the phenophase definitions for your species makes taking observations effortless and accurate.

Coming out of dormancy

Many species in our cooler regions develop (or "set") next year's floral buds in the late summer months into early winter. These buds remain dormant, resting until specific conditions are met for activity to renew. The observer should report "no" for "Flowers or flower buds" until these buds break dormancy and begin swelling in the spring. However, since the first signs can be subtle, the observer should not worry about catching the very beginning of the "Flowers or flower buds" phenophase and just report "yes" once they are sure a flower is developing.

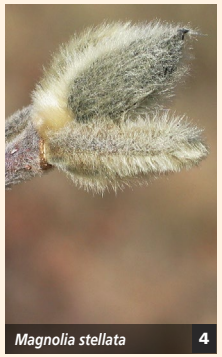
On this page, image series for four species highlight dormant floral buds and the subsequent, newly active, swelling floral or mixed buds. The first image in each row shows a dormant floral bud. The subsequent images are those in the initial stages of swelling, just before floral parts peek out. The final image shows petals or reproductive parts becoming visible (white arrows).

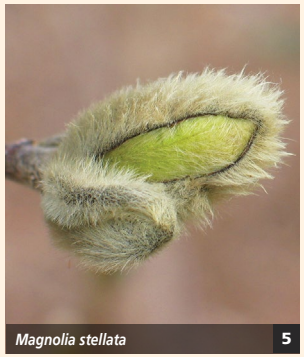
These four species also highlight how buds can vary across species. For forsythia (row 1), two types of buds are found on the plant—floral (Image 3) and leaf. For star magnolia (row 2), three types of buds might occur—floral, mixed (Image 7) and leaf. For red maple (row 3), there are three types of very similar buds—female floral, male floral (Image 12) and leaf. Gray alder (row 4), also has female floral (Image 16), male floral (Image 17) and leaf buds, but each looks very different, making observations much easier.

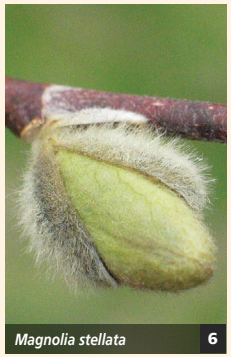

Forsythia x intermedia 1

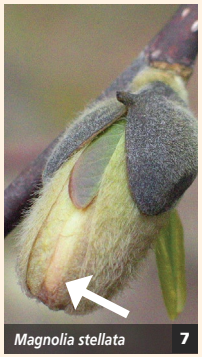

Forsythia x intermedia 2


Forsythia x intermedia 3


Magnolia stellata 4


Magnolia stellata 5


Magnolia stellata 6


Magnolia stellata 7

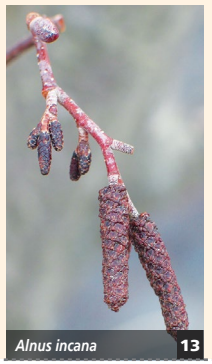

Acer rubrum 8


Acer rubrum 9


Acer rubrum 10


Acer rubrum 11

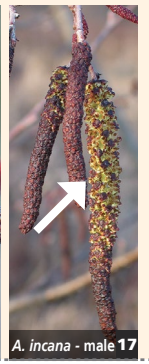

Acer rubrum 12


Alnus incana 13


Alnus incana - female 14


Alnus incana - male 15


Alnus incana - female 16


A. incana - male 17

An overview of mixed buds

What do they look like?

Some plant species have mixed buds, where both embryonic leaves and flower buds develop within the same protective bud scales. Sometimes the new leaves and flowers will emerge from the bud at the same time, and sometimes one will precede the other. This means the observer must look closely to know when to begin reporting "yes" for "Breaking leaf buds" and "Flowers or flower buds". They should not report "yes" for "Breaking leaf buds" until they see the tip of a leaf emerging from the broken bud or the first green of leaf growing from a naked bud.

For many species that develop mixed buds, not all the buds on the same plant will be of a mixed type. Most likely an observer will also see buds having only new leaves (vegetative bud) or only new flowers (reproductive bud).

Often in species having both mixed and single-type buds, the mixed buds are larger and plumper when compared to vegetative or reproductive buds. Also within mixed buds, developing flowers often can be contained within their own bud covering—a bud within a bud.

Image 1 shows a mixed bud—look carefully to see the bud scales below the recently emerged leaves and flowers. You can see both the leaf petioles and the peduncle of the floral inflorescence emerge from between the same bud scales. For comparison, a careful look at Image 2 shows leaves emerging from within terminal bud scales and the flowers emerging from within two lateral buds' scales; the leaves and flowers are in separate—not mixed—buds!

Mixed buds with bud scales

Images 1, 3-5 show mixed buds with bud scales and their emerging leaves (yellow arrows) and flower buds or flowers (white arrows). The observer should report "yes" for both "Breaking leaf buds" and "Flowers or flower buds" because expanding flower buds and leaf tips (but not yet petioles) are visible.

Mixed buds without bud scales

Image 6 shows a species which has naked buds (no bud scales) and has flower buds emerging from between tiny new leaves. The observer should report "yes" for "Flowers or flower buds", but "no" for "Breaking leaf buds" because the leaves have not yet begun to open and show green (see "An overview of unfolded leaves").

Some other variations

Species having leaves without leaf buds can have reproductive (floral) buds that do have bud scales—occurring at the same node! See page 29, Images 83-85 for an example. Get to know your species so observations are easier and accurate.


Oemleria cerasiformis 1


Acer rubrum 2


Sambucus racemosa 3


Magnolia stellata 4


Acer negundo 5


Viburnum lantanoides 6

An overview of flowers and inflorescences

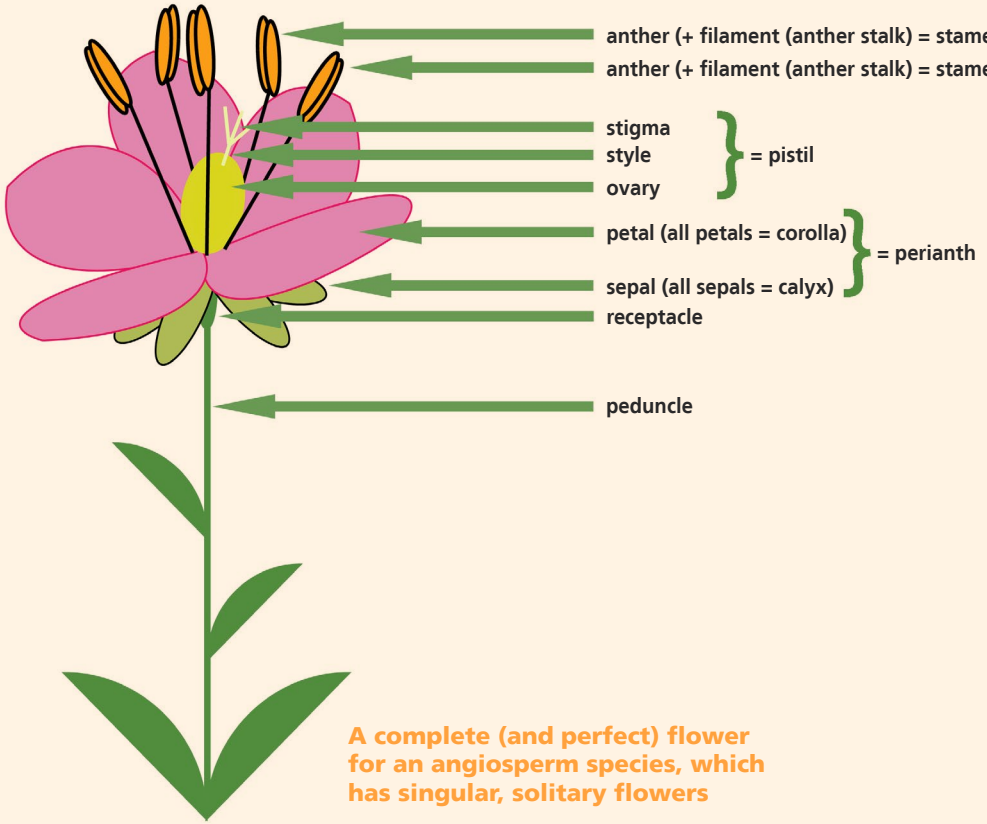
A flower is a highly evolved structure within the angiosperms (flowering plants) that supports an angiosperm species' ability to reproduce, and sustain and promote that species. Over the spectrum of angiosperm species there is enormous variation in floral structures (and reproductive strategies). On these pages we cover only the basics, just enough to familiarize the observer so they can begin to understand what they are seeing on their plant.

This subject is also covered in more detail in the USA National Phenology Network's *Botany Primer* in the section "Flowers and Inflorescences". Look for the chapter titles "About Flowers", "About Basic Flower Variation", and "About Inflorescences or Clustered Flowers". The *Botany Primer* can be found on the USA-NPN website (usanpn.org).

The organization of flowers and their parts

The diagram below offers a glimpse at the basic structure of a *complete* flower, that is, a flower having all of its possible parts. Complete flowers are also *perfect*, meaning they have both male and female reproductive parts. A typical and common flower type has four whorls of floral parts: the sepals (collectively in one flower called the calyx), the petals (collectively in one flower called the corolla), the male stamens (collectively in one flower called the androecium), and the female pistil(s) (collectively in one flower called the gynoecium). The sepals and petals in one flower, collectively, are called the perianth. They are attached below, and surround, the reproductive flower parts—the stamens and pistils. These floral parts are attached in various ways atop the receptacle, which sits atop the flower stalk (a peduncle if the flower is solitary, or a pedicel if the flower is contained within an inflorescence). Each plant species has its own floral design and alterations, sometimes with parts missing, or combined, or so similar as to not be easily distinguished (as in flowers with identical sepals and petals—then called tepals).

The observer should keep in mind that their species' flowers may be organized differently than in the basic diagrams provided on these pages.

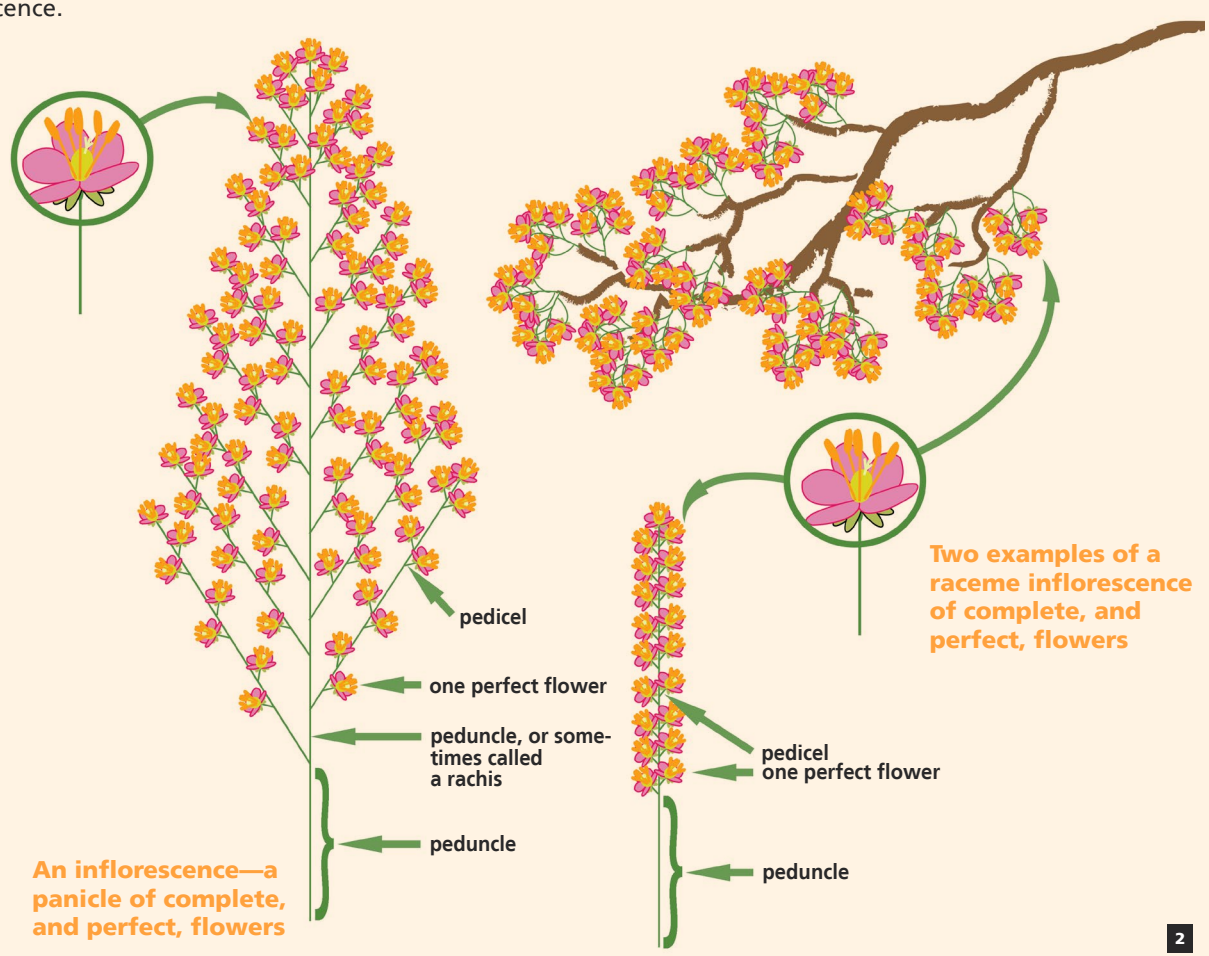


A complete (and perfect) flower for an angiosperm species, which has singular, solitary flowers

1

The inflorescence—patterns of clustered flowers

Many species cluster their flowers into simple, or very complex, patterned arrangements—an inflorescence. The intent of these designs and configurations is primarily to create a floral display that increases visibility and appeal for the necessary pollinators, or, in wind-pollinated species, to efficiently release and receive pollen. The diagrams below highlight two different types of inflorescences (there are many basic types, and in addition, many complex combinations of the basic types). To the right are a few examples: Image 3 shows a forb species with one solitary flower; 4, a tree species with many solitary flowers; 5, a spike-like panicle of racemes; 6, a raceme; 7, a catkin; 8, a succulent species with a single panicle; 9, a tree species with many panicles; 10, a capitulum; 11, a corymb of capitula. Once all the ovaries have been fertilized and fruit begins developing, an inflorescence is called an infructescence.



2


Kallstroemia grandiflora 3


Magnolia x soulangiana 4

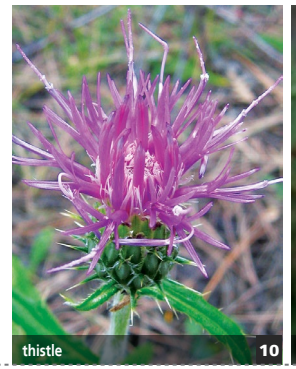

Verbascum thapsis 5


Lupinus sp. 6


Prosopis velutina 7


Yucca baccata 8


Sambucus racemosa 9


thistle 10


Achillea millefolium 11

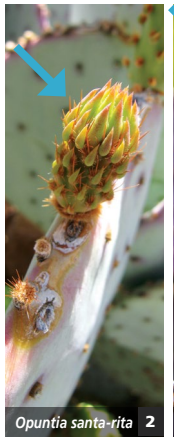
Nature's Notebook
PHENOPHASE DEFINITION

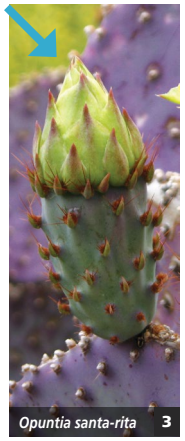
Flowers or flower buds

Cactus, Forb, Tree/Shrub

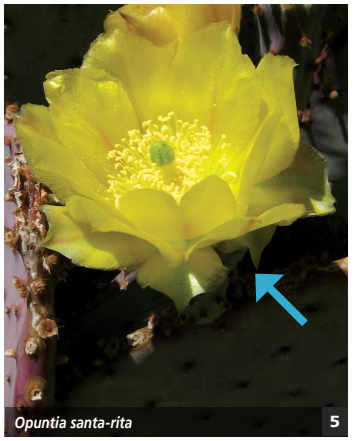
One or more fresh open or unopened flowers or flower buds are visible on the plant. Include flower buds or inflorescences that are swelling or expanding, but do not include those that are tightly closed and not actively growing (dormant). Also do not include wilted or dried flowers.


Opuntia santa-rita 1


Opuntia santa-rita 2

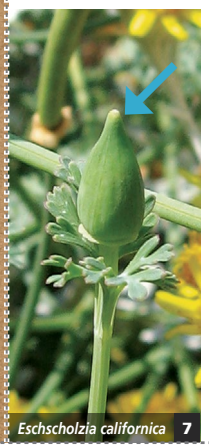

Opuntia santa-rita 3


Opuntia santa-rita 4


Opuntia santa-rita 5


Opuntia santa-rita 6

For the "Flowers or flower buds" phenophase, an observer should report "yes" as soon as previously-formed flower buds have become active after dormancy or newly-formed flower buds are actively growing on the plant. An observer should continue reporting "yes" for this phenophase until the last flower on the plant completes its floral activities, and the plant's reproductive effort shifts exclusively to fruit development. The image series on these pages—a cactus above and a forb below, and shrubs and trees on the following pages—show examples of flower development with arrows identifying "Flowers or flower buds". The last image of each series shows a "spent" flower—a wilted or dried flower that should not be included in this phenophase. Each species has characteristic signs of the end of active flowering. Becoming familiar with the characteristics of your species will help you to identify and more accurately report the status of flower buds and flowers on your plant.


Eschscholzia californica 7


E. californica 8


E. californica 9

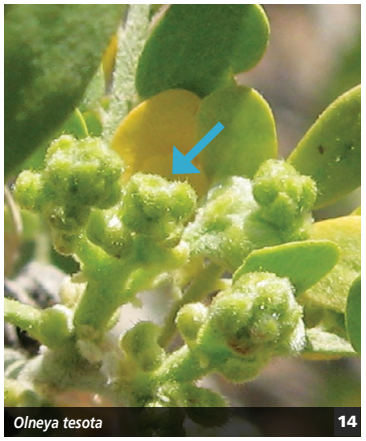

Eschscholzia californica 10


Eschscholzia californica 11


Eschscholzia californica 12

Flowers or flower buds


Olneya tesota 13


Olneya tesota 14


Olneya tesota 15


Olneya tesota 16


Olneya tesota 17


Olneya tesota 18

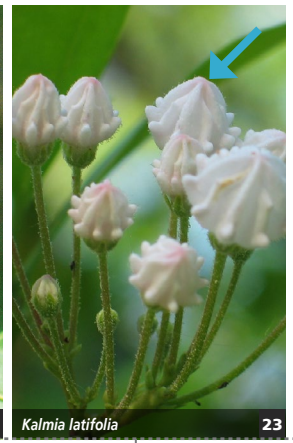
The two image series on this page sequence the "Flowers or flower buds" phenophase of a representative drought deciduous tree (above) and an evergreen shrub (below). Both of these species have complex floral displays of grouped flowers—in inflorescences. The arrows identify the period of activity for this phenophase: from the initial development of newly-formed flower buds (Image 13) or the swelling of previously-formed flower buds after dormancy (Image 20) through open flowers with active reproductive flower parts (Images 17 and 24), an observer should report "yes" for "Flowers or flower buds". Each of these species signal the completion of floral activity with wilting and drying flower petals—the last image of each series shows "spent", wilted or dried flowers that should not be included in this phenophase. For some species, as in the example below, flower buds are formed in late summer (Image 19) and remain dormant on the plant until spring. The late season development of flower buds meant to open the following season will appear to be active growth, but generally should not be included in this phenophase. However, sometimes unusally warm temperatures in fall can cause these flower buds to break dormancy and open prematurely. If this type of activity occurs, an observer should report "yes" for "Flowers or flower buds" as well as "Open flowers".


Kalmia latifolia 19


Kalmia latifolia 20

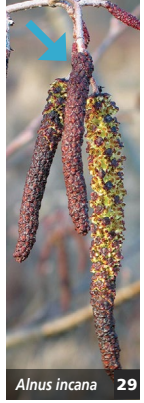

Kalmia latifolia 21


Kalmia latifolia 22


Kalmia latifolia 23


Kalmia latifolia 24

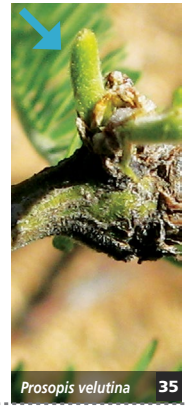

Kalmia latifolia 25

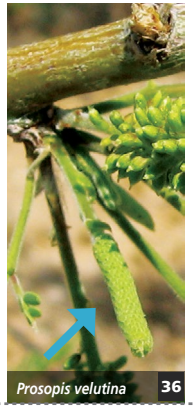


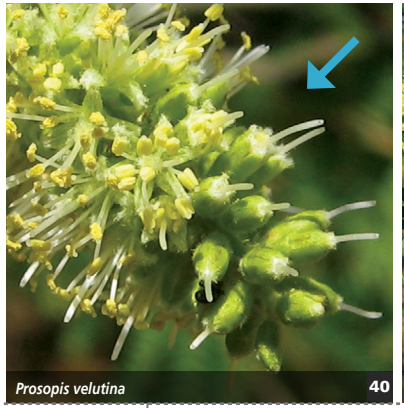
Tiny flowers tightly clustered into a crowded inflorescence

Plant species with very tiny flowers can have their flowers arranged into dense inflorescences that appear to be a single unit, such as a catkin (in pussy willows and other willows, maples, birch, mesquite), a capitulum (daisies) or a spadix (cattails, jack-in-the-pulpit). This page highlights one of these inflorescence types—the catkin. Row 1 displays a monoecious species with separate male and female flowers in separate catkins, and whose catkins have a dormant, resting phase during winter (Image 26 shows dormant catkins). Row 2 shows a species that has flowers with both male and female parts in its catkins (perfect flowers) which are fresh, active and ready to develop when they first appear.

For many species with catkins, a special species-specific description of what to look for is added to the "Flowers and flower buds" phenophase definition in *Nature's Notebook*. For gray alder (row 1), this additional floral description states: "For *Alnus incana*, the male inflorescence is a catkin which is initially compact and stiff, but eventually unfolds to become longer and hang loosely from the branch. The female inflorescence is also a catkin which is very small, reddish, and has leafy scales. Once the female flowers wilt, the catkin turns green and grows thicker as the fruits develop." An observer should start reporting "yes" as the catkins become active after dormancy (male catkins in Images 27-30; female in Images 32-33) and then report "no" for the plant when all the male flowers on the plant have opened, released their pollen, and are showing signs of wilting and/or drying (Image 31), *and* the all female flowers (or exposed parts such as stigmas) have wilted and/or dried *or* fruits have begun to develop (Image 34). For images in row 2, an observer should start reporting "yes" when the catkin first appears (Image 35) and continue reporting "yes" throughout the series until all the flowers are wilted (not shown).







Unusual or difficult floral characteristics

Flowers can be inconspicuous by their size, color, or position on the plant. Non-typical flowers can be confusing, such as those missing floral parts or with unusual reproductive arrangements. This page offers a few examples of plant species with unusual and/or difficult-to-observe flowers.

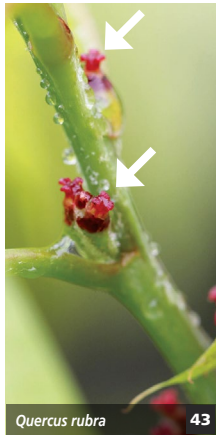
In oak species, female oak flowers are very tiny and hide in the axils of new leaves. They can occur as a single flower or in a small cluster of flowers which still, collectively, are inconspicuous, tucked deep in the leaves, and—to add to the complexity—up high in the canopy of large trees. In some species, they are brightly colored, yet still difficult to see. Their male counterparts are long, dangly catkins and, despite each of the catkin's flowers being tiny, their arrangement in a large group makes them visible when they are active. See row 1 for a sample of the flower's location on the tree, and a look at several female oak flowers of different species (arrows).

Jack-in-the-pulpit also hides its tiny flowers (row 2). Its species-specific phenophase definition reads "For *Arisaema triphyllum*, watch for the presence of the brown-striped pulpit (spathe), which contains and hides the flowers. Please do not tear open the pulpit to look for the individual flowers." Therefore, if an observer sees the floral structure shown in Image 45, they should report "yes" for "Flowers or flower buds" without trying to look inside—the cut-away glimpse of the female flowers in Images 46-47 is offered solely for your information (the male flowers occur on a separate plant for this species).

Desert hackberry (row 3) also has flowers that are easy to miss; tiny green, non-showy, unisexual flowers (described as inconspicuous) that are missing floral parts and hidden amongst the leaves (arrows in Image 48). Image 49 shows the teeny male flowers, and Image 50, the tiny female flowers. Look carefully at your plants to get to know their flowers!

This topic is also covered in detail in the *Nature's Notebook* Nugget: Teeny Tiny Flowers, which can be found on the USA-NPN website (usanpn.org).


Quercus pacifica 42

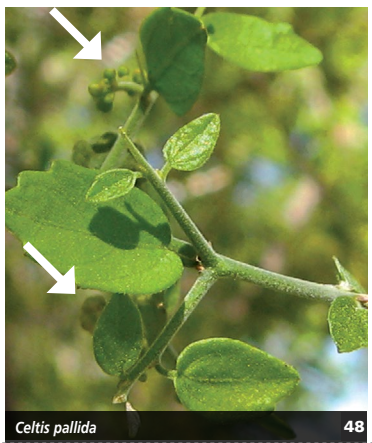

Quercus rubra 43


Quercus imbricaria 44


Arisaema triphyllum 45


Arisaema triphyllum 46


Arisaema triphyllum 47


Celtis pallida 48


Celtis pallida 49


Celtis pallida 50

An overview of grass flowers and flower heads

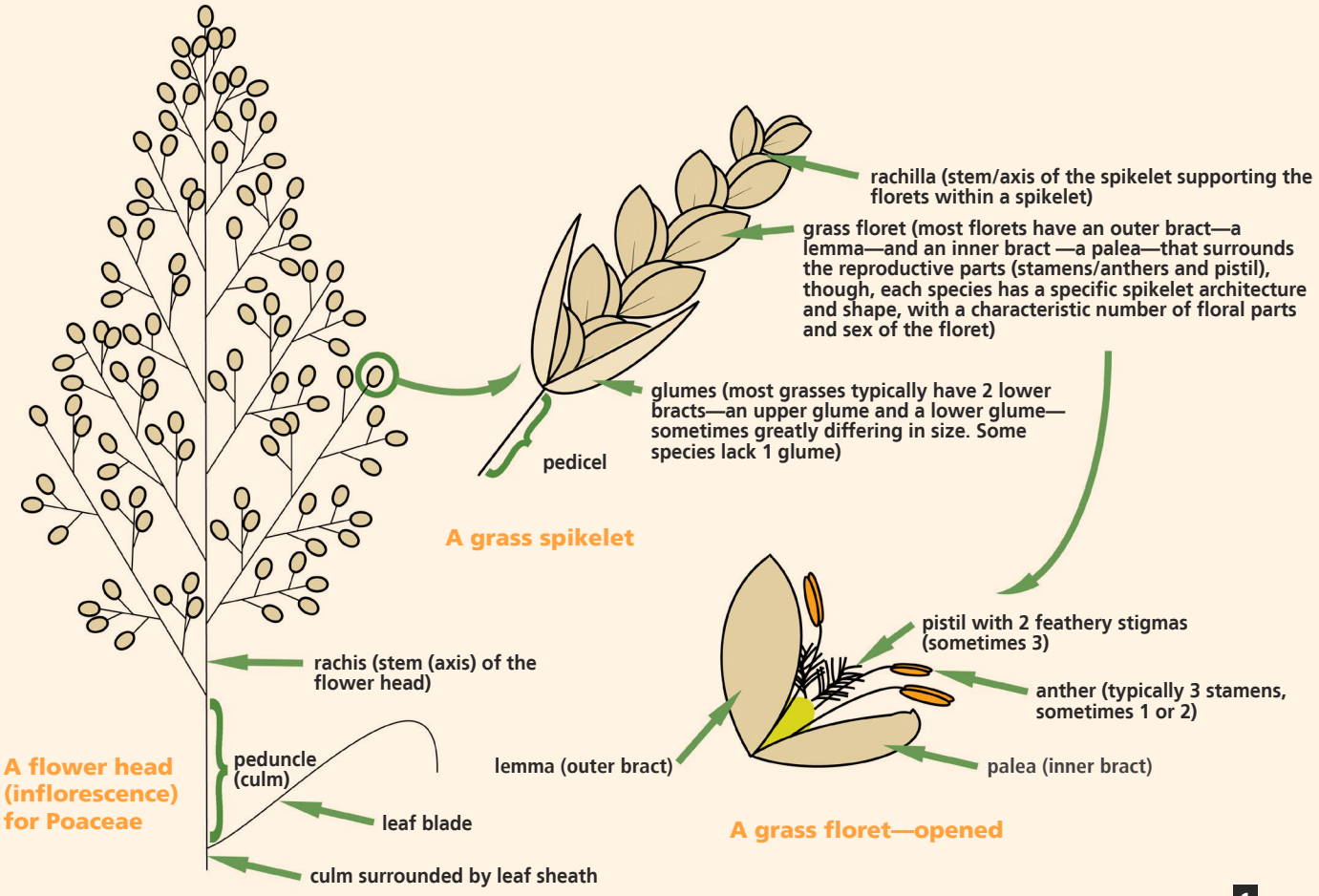
These pages provide a glimpse at graminoid (grass-like) flowers and flower heads (inflorescences). Grasses, sedges, and rushes all belong to the angiosperm (flowering plants) group of plants, yet their flowers are highly modified and sometimes difficult to interpret. These tiny, inconspicuous flowers are often wind-pollinated, foregoing showiness for efficiency in their reproductive effort.

Becoming familiar with the anatomy for these types of plants will enable you to determine when your plant becomes reproductively active, and make accurate phenophase observations for the grasses' flowers.

Grass flowers—called florets—are very tiny and inconspicuous, and grouped into a uniquely basic and compact characteristic structure—a spikelet—that has bracts attached below the one to many tiny florets. These spikelets are again clustered into a larger group—the flower head or inflorescence—which holds one to hundreds of spikelets in a unique and characteristic arrangement diagnostic for each species in the grass family, Poaceae.

The organization of grass flower parts in the family Poaceae

The diagram below very generally illustrates a grass inflorescence and the floral parts that comprise it; each species has its own unique architecture and size—and some have floral variations not depicted here. The spikelet and floret diagrams are only a very general example for all grasses—to familiarize observers with the basic floral structure of grasses.



1

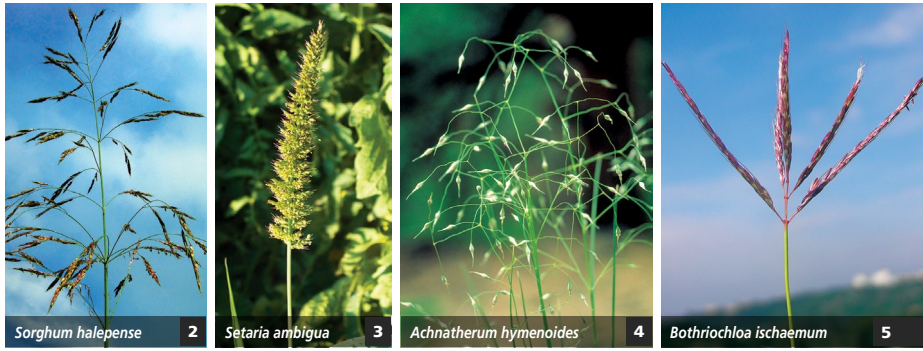
The variety of grass flower heads (inflorescences) in the Poaceae plant family

There are a wide array of arrangements in grass inflorescences (flower heads) in the grass plant family—rows 1 and 2 are a small sampling of the variety (Image 2, a panicle; 3, a spike-like panicle; 4, a panicle with flexuous branches; 5, a panicle of sub-digitate racemes; 6, a spicate raceme; 7, a pendulous panicle; 8, a panicle of spike-like branches that are one-sided and double-rowed racemes). As the diagram on the previous page shows, the basic floral unit is the spikelet and many spikelets are clustered in various patterns and grouped within an inflorescence. The number of glumes contained in one tiny spikelet along with the number of florets—and their sex and how they are arranged—is unique and characteristic for each species. In addition, a number of species are monoecious—that is, male and female flowers occur in different areas within a single inflorescence. There also are dioecious species (unisex plants), and often the separate plants and their inflorescences can be dimorphic—that is, they have a distinctly different appearance from one another despite being the same species.

The florets and spikelets

As described, a grass spikelet is the most basic unit of the clustered florets found within a grass inflorescence and found on its pedicels and branches. The spikelets may occur singly along a branch or may also be clustered in various arrangements along the stem or branch. Spikelets have a great variety of forms—yet there is a basic structure of the spikelet for all grasses. That is: two glumes (an upper and lower) at the base of the spikelet attached just below the florets (Image 11), and each floret having one lemma (lower floral bract) and one palea (upper floral bract) and reproductive parts (pistils and stamens). Depending on species, spikelets may be missing parts—usually due to evolutionary developments. For grass florets, bracts replace petals and sepals—grasses have two floral bracts, the lemma and the palea which surround and protect the reproductive parts. When bracts are present but have no functional reproductive parts to protect, the floret is referred to as "sterile" or "reduced" (see sterile lemma and palea in Images 10, 12).

See Image 9 for a look at florets with extended feathery stigmas (orange arrow) and yellow anthers (red arrow). When the reproductive parts are extended like this, an observer should report "yes" for the "Open flowers" phenophase. If florets are sterile, they will never have "Open flowers".


Sorghum halepense 2

Setaria ambigua 3

Achnatherum hymenoides 4

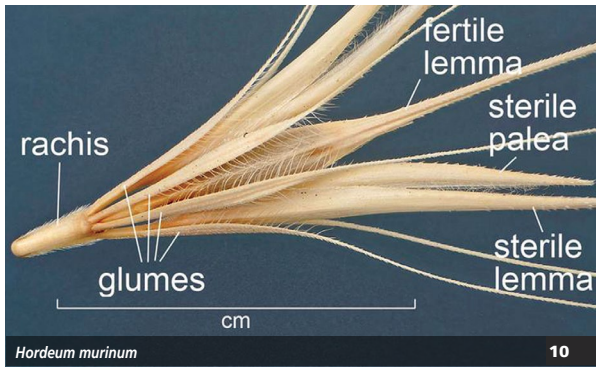
Bothriochloa ischaemum 5


Hordeum sp. 6

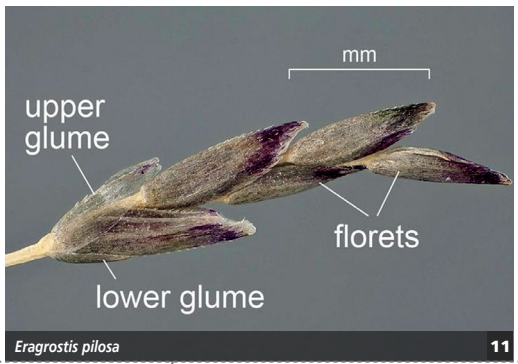

Bromus tectorum 7


Bouteloua gracilis 8

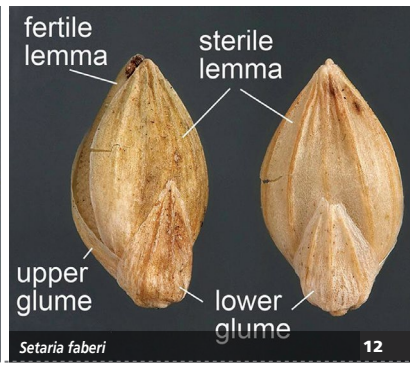

Setaria neglecta 9



Hordeum murinum 10



Eragrostis pilosa 11



Setaria faberi 12

An overview of sedge flowers and flower heads

Sedge florets are similar to grass florets—their flowers are highly modified and sometimes difficult to interpret. Sedges, like grasses, are referred to as "graminoids". Their tiny, inconspicuous flowers are often wind-pollinated, foregoing showiness in their reproductive effort.

Despite their similarities to grasses, the anatomy of sedges is slightly different. Becoming familiar with these plants will enable you to make accurate observations when your plant's flowers do open or become reproductively active.

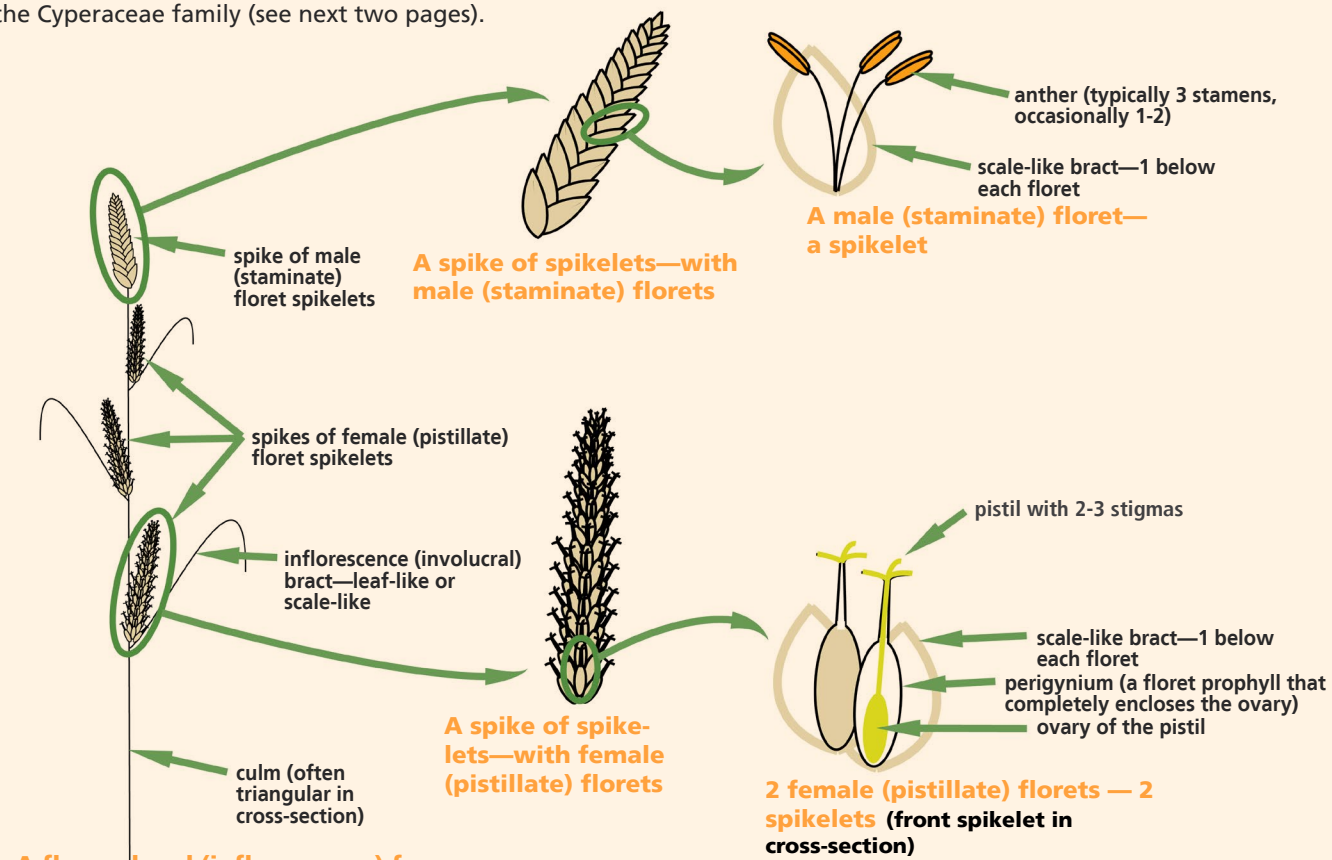
Sedge florets are very tiny and inconspicuous, and grouped into a unique, characteristic structure having one to many florets. Each floret often has a scale leaf attached at the base of each flower, and may have bristles or a scale-like bract attached beneath the reproductive parts (depending on species)—the scale-like bract replaces, or bristles are, the perianth (petals and sepals) of the flower.

There are several different floral patterns for the sedge family, Cyperaceae. The diagrams over the next four pages provide a glimpse at some generalized structures of different types an observer might come across.

The organization of sedge flower parts in the genus *Carex*

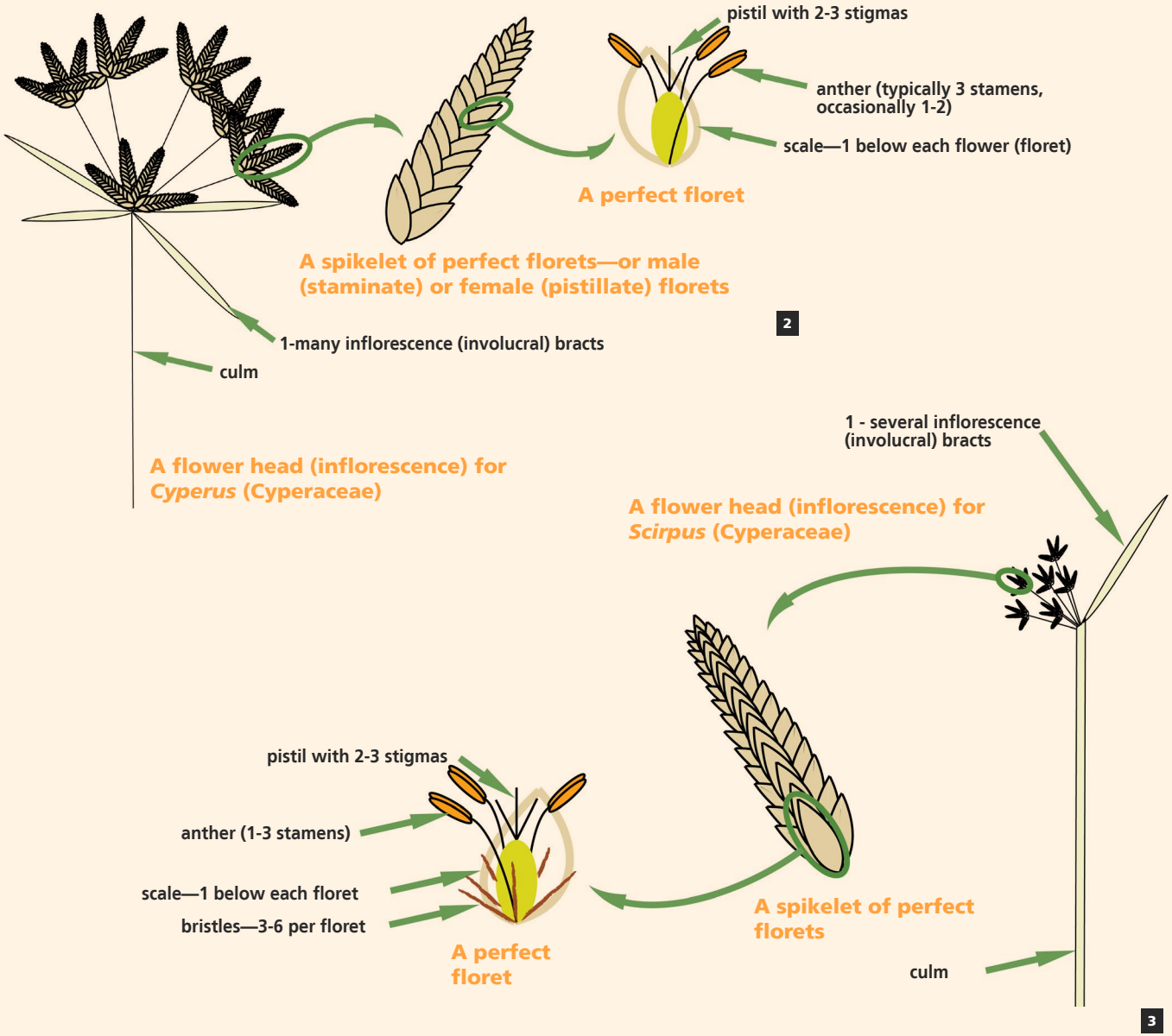
The diagram below illustrates a generalized sedge inflorescence specifically for the genus *Carex*, and the floral parts that comprise it. Keep in mind each species has its own unique architecture and size and floral variations; the spike, spikelet, and floret diagrams shown here are a very general example. The common characteristic, though, is the monoecious (male or female) flowers arranged in various patterns within a spike. Also, for female flowers of *Carex*, a modified, bottle-like or bag-like bract (perigynium), occasionally flattened, completely surrounds the pistil with stigmas protruding from an opening at a top. The male and female spikes are then arranged into a larger grouping—the flower head or inflorescence—which is comprised of one to several spikes in a characteristic arrangement diagnostic for each species.

This characteristic grouping of florets and their specific terminology differs in the genus *Carex* from the other genera in the Cyperaceae family (see next two pages).



1

The organization of sedge flower parts in the genera *Cyperus* and *Scirpus*



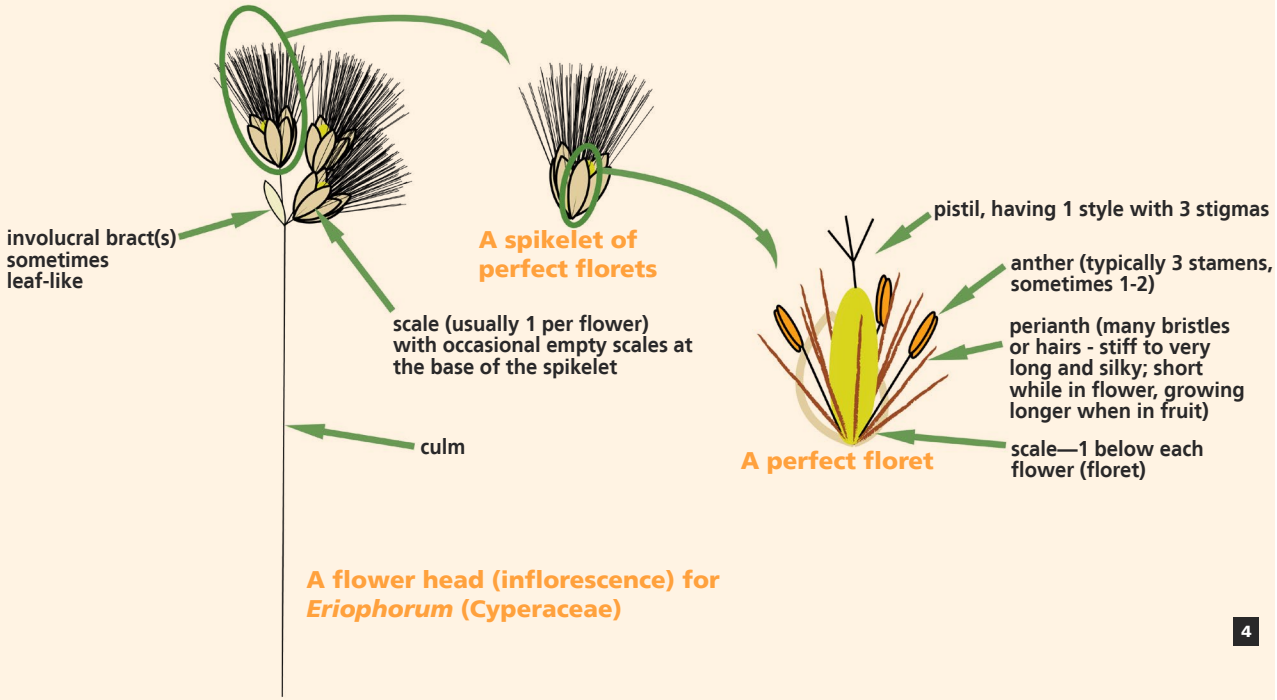
Most other genera in the Cyperaceae plant family do not have a perigynium that surrounds or partially encloses the pistil, as the genus *Carex* does. Nor do they have separate male and female florets. For most genera in this very large plant family the florets are perfect—that is, they have both male and female reproductive parts within each floret. The two illustrations on this page highlight genera that have inconspicuous, highly modified flowers or florets, yet are perfect. Genera and species like Diagram 2 have no perianth (petals, sepals, tepals, bristles), yet genera and species similar to Diagram 3 do have a perianth typically comprised of various types of bristles.

Although most sedge species' florets other than *Carex* are perfect (bisexual), there are a few exceptions in every genera. Occasional species within a genera having perfect florets may be monoecious or dioecious—and when monoecious, their spikelets may contain only one sex of florets, or may have other combinations. Generally, male (staminate) florets occupy the top tier of the spikelet and female (pistillate) florets are below them.

Getting to know the species you have chosen will be helpful with your phenophase observations.

The organization of sedge flower parts in the genus *Eriophorum*

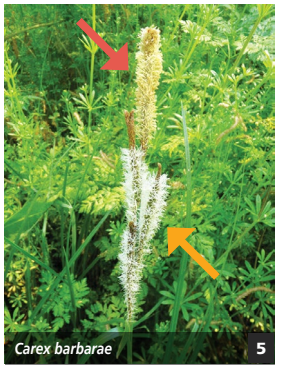
The sedge species having florets with bristles (for a perianth) differ tremendously. The bristles are typically short during the "Open flowers" phenophase, and in many species remain short, or they slightly elongate or fall off as the fruit develops (such as those in Diagram 3). Conversely, for many species in the genus *Eriophorum*, once the fruit begins developing, the bristles often elongate into silky, cottony strands that catch the wind and obscure the floral scales and fruits (see Diagram 4 below and Image 31 on the next page). So pretty!

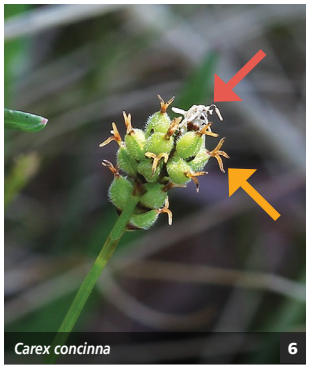


4

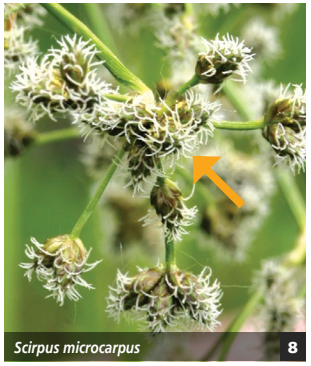
Open flowers in a sedge

The images on the right offer glimpses of "Open flowers" of various types in the family Cyperaceae. Row 1 of images includes species in the genus *Carex*; row 2, *Scirpus*; row 3, *Cladium* and *Cyperus*; and row 4, *Eriophorum* (red arrows indicate male reproductive parts, orange arrows indicate female reproductive parts). It is not unusual for the male and female flower parts to be active at separate times. As long as one sex is active in a flower, the flowers are considered "open". This separation of activity encourages cross-pollination and supports recombination of genetic material. An observer should report "yes" for the "Open flowers" phenophase if they see fresh and active male or female reproductive parts.


Carex barbarae 5


Carex concinna 6


Scirpus pendulus 7


Scirpus microcarpus 8


Cladium mariscoides 9


Cyperus esculentus 10


Eriophorum virginicum 11


Eriophorum crinigerum 12

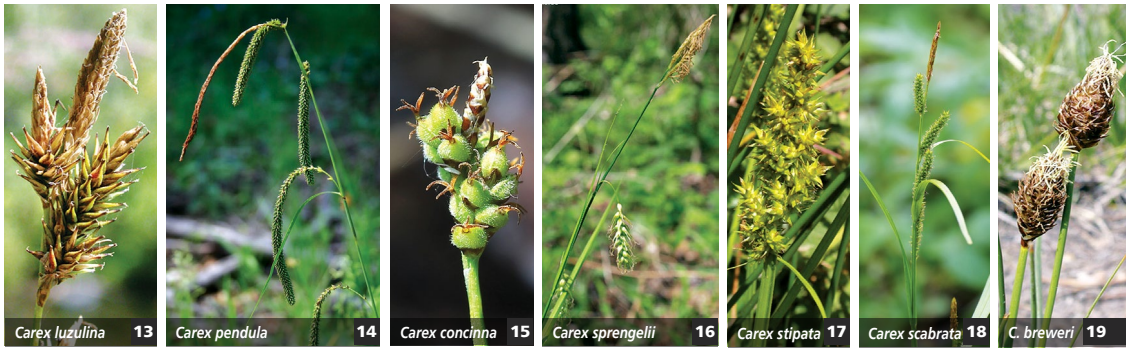
The variety of flower heads (inflorescences) of various genera in the Cyperaceae plant family

There are numerous inflorescence arrangements for sedge, bulrushes, and the grass-like sedge species—to the right is a very small sampling of the wide variety of architectures of inflorescences found in Cyperaceae.

Row 1 shows some of the variations of *Carex* species (commonly called "sedge") inflorescences. The floret is always monoecious (only male or female), but each spike may have only male or female florets—or may have both types—depending on a species' unique characteristics. Often each of the florets has a tiny leafy scale beneath it. And, each of the female florets has a modified scale called an perigynium (also called a "utricle") that completely surrounds the pistil of the flower; they have a bottle-like shape, although occasionally are flattened (see Diagram 1 at the beginning of this section for details). They have no perianth (petals or sepals).

Row 2 highlights *Scirpus* and *Schoenoplectus* ("bulrush") inflorescences. Each of the tiny flowers in a spikelet may have a scale leaf under each floret, and each floret is perfect having both male and female reproductive parts. Each floret has 0 to 6 bristles, depending on species, that surround the pistil and stamens of the flower (see Diagram 3). The bristles replace the petals and sepals of the flower, and are of various types depending on species.
Row 3 highlights species in the genuses *Cladium* ("sawgrass") and *Cyperus* ("flatsedge"). These florets may each have a scale below and are bisexual, but differ from the bulrushes by not having bristles surrounding the pistils and stamens (see Diagram 2). There is no perianth.

Row 4 highlights an *Eriophorum* ("cottongrass") inflorescence. Each of the florets in a spikelet are perfect. And, below each of the florets is a scale leaf. Also, the florets have bristles that surround their pistil and stamens (see Diagram 4). The bristles are typically short while the flower is open, but grow longer, often very long, silky and/or fluffy when the fruit develops—thus, "cottony".


Carex luzulina 13

Carex pendula 14

Carex concinna 15

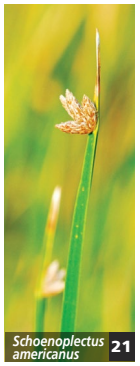
Carex sprengelii 16

Carex stipata 17

Carex scabrata 18

C. breweri 19

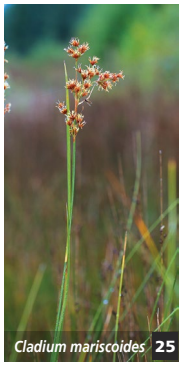

Schoenoplectus lacustris 20


Schoenoplectus americanus 21


Schoenoplectus pungens 22


Schoenoplectus acutus 23


Scirpus pendulus 24


Cladium mariscoides 25


Cladium californicum 26


Cyperus esculentus 27


Cyperus eragrostis 28


Eriophorum vaginatum 29


E. vaginatum in flower 30


E. vaginatum in fruit 31

An overview of rush flowers and flower heads

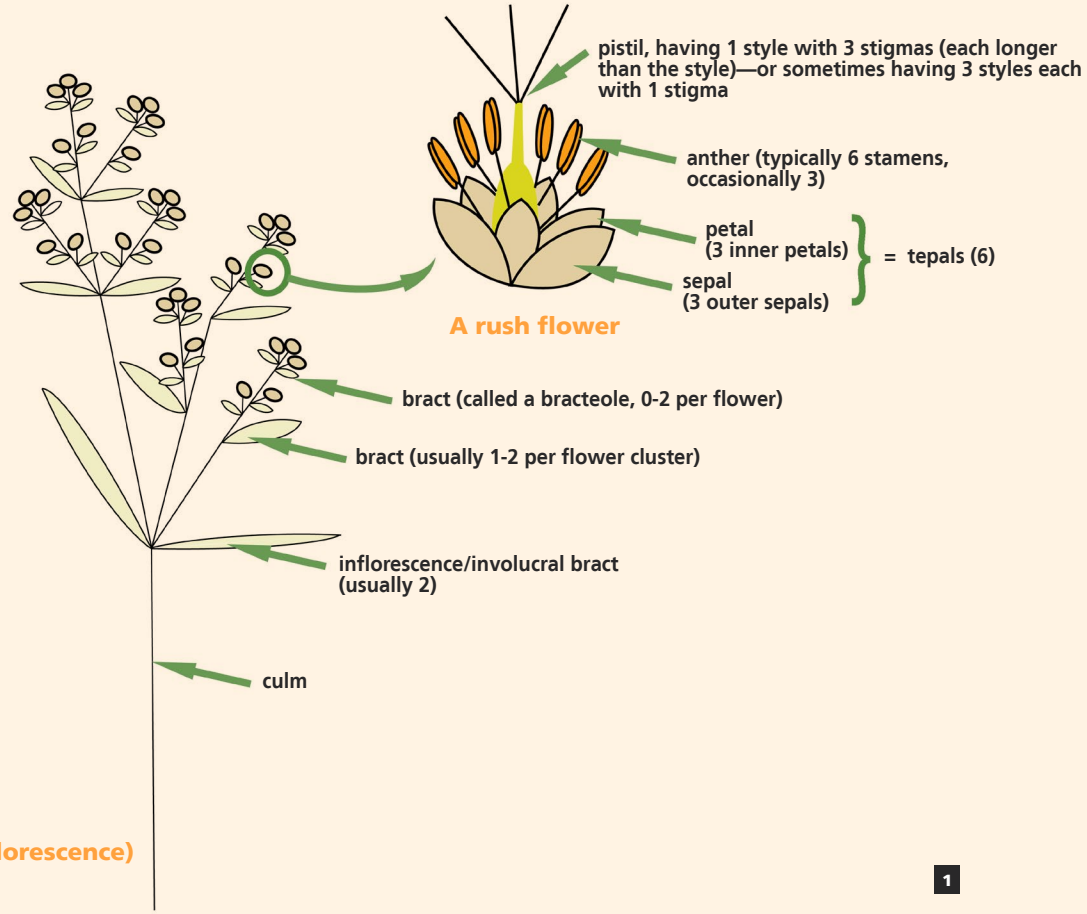
Rushes are another graminoid of the angiosperms (flowering plants) and in the plant family Juncaceae. As with grasses and sedges, their flowers are tiny and modified and sometimes difficult to interpret, although these inconspicuous flowers resemble many large flowers with which we are familiar when looked at closely. They are often wind-pollinated, foregoing showiness while flowering.

Becoming familiar with the anatomy of these species will enable an observer to make accurate observations as the plant's flowers become reproductively active.

Rush flowers are very tiny and inconspicuous, and clustered into a uniquely characteristic structure that has leafy bracts attached below both the individual flowers and also the clusters of many tiny flowers. The flowers resemble many other familiar flowers, except that they are tiny and hard to see. Unlike the grasses and sedges, they have petals (3) and sepals (3), and as other familiar plant species (like magnolias and tulips), the petals and sepals look alike, so are called "tepals". The tiny flowers are organized into larger groups—the flower head or inflorescence—which has one to hundreds of flowers organized within a unique arrangement, characteristic to species.

The organization of rush flower parts in the family Juncaceae

The diagram below illustrates a rush inflorescence, although each species would have its own architecture and size. The inflorescence and flower diagrams are only a very general example for all rushes. Most of the species in this plant family have flowers that are bisexual (having male and female reproductive parts).



1

The variety of rush flower heads (inflorescences) in the Juncaceae plant family

As with the other graminoids, rushes have a diversity of arrangements of inflorescences (flower head or seed head)—Images 2-9 include a very small sampling of the wide variety of architectures and forms of rush flower heads to be found.

The flowers

A rush inflorescence is an organized unit of clustered flowers. Most rush species have bisexual flowers within an inflorescence, although a few species are dioecious and have male and female flowers located on separate plants (ensuring cross-pollination).

Images 10-16 are close-ups of the tiny flowers of various rush species with open flowers. An observer would look for the male or female reproductive parts showing between the outer flower parts—in rushes, the tepals. Orange arrows indicate the often pinkish stigmas of the pistil, and red arrows indicate the yellowish anthers of the stamens in the flower.

Most rush species have timed the female and male activity in their flowers to occur at the same time, but a number of species have coordinated their activities differently. The female reproductive parts of some species become active before the male parts. This activity causes a display similar to Image 16 where the tepals have not fully opened but have begun to open just enough so that the stigmas can protrude from between the tepals to collect pollen, and potentially be fertilized. This activity and strategy is called protogyny and supports cross-pollination, postponing the flower's own pollen from pollinating and fertilizing its own ovules. Shortly, the tepals will fully open and the stamens will become active, the anthers opening and releasing pollen. If the stigmas of the pistil are still active at the time of stamen activity, it may be that they have not received pollen earlier or the ovules have not been fertilized. In this case, the stigma may then receive the flower's own pollen—if the species has the capacity to accept its own pollen (called self-compatibility)—and may self-fertilize. Some plant species utilize this strategy as bet-hedging during the reproductive effort.

An observer should report "yes" for the "Open flowers" phenophase even if they see only female reproductive parts (Image 16). A comment could be included to note that only the female flower parts are active for this flower.


Juncus xiphioides 2

Juncus laccatus 3

Juncus ensifolius 4

Juncus dubius 5


Juncus bufonius 6

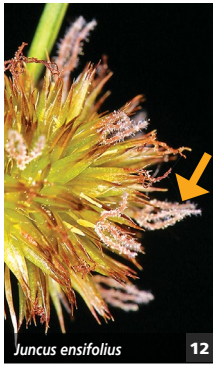

Juncus bolanderi 7


Juncus longistylis 8

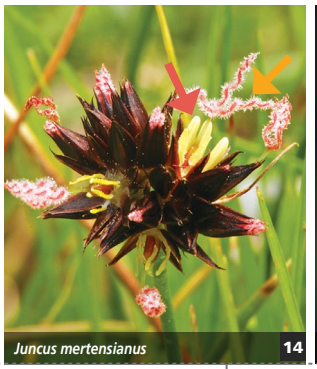

Juncus chlorocephalus 9


Juncus balticus 10


Juncus chlorocephalus 11


Juncus ensifolius 12


Juncus howellii 13


Juncus mertensianus 14


Juncus nevadensis 15


Juncus orthophyllus 16

Nature's Notebook
PHENOPHASE DEFINITION

Flower heads

Grass, Sedge

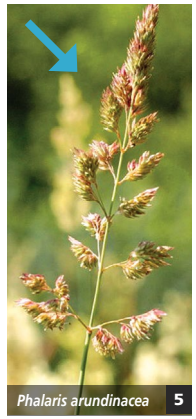
One or more fresh flower heads (inflorescences) are visible on the plant. Flower heads, which include many small flowers arranged in spikelets, emerge from inside the stem and gradually grow taller. Include flower heads with unopened or open flowers, but do not include heads whose flowers have all wilted or dried or begun to develop into fruits (grains).


Phalaris arundinacea 1


Phalaris arundinacea 2


Phalaris arundinacea 3


Phalaris arundinacea 4


Phalaris arundinacea 5


Phalaris arundinacea 6

For the "Flower heads" phenophase, an observer would report "yes" as soon as an inflorescence is initiated and visible on their plant. An observer would continue reporting "yes" for this phenophase until the last flower on the plant wilts and/or dries, and its reproductive effort turns exclusively to fruit development. Row 1 of images shows flower head development for a grass species and row 2, for a sedge species. In both series, the flower heads in the last image have only wilted and dried reproductive parts, in which case an observer should report "no" for "Flower heads".


Carex pensylvanica 7


Carex pensylvanica 8


Carex pensylvanica 9


Carex pensylvanica 10


Carex pensylvanica 11

Nature's Notebook
PHENOPHASE DEFINITION

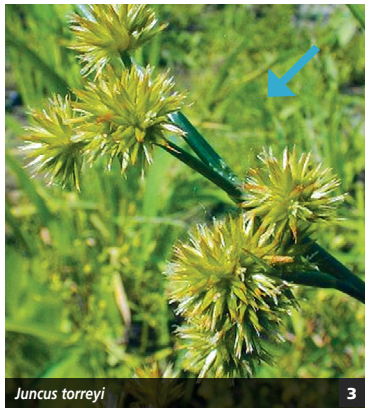
Flowers or flower buds

Rush

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.


Juncus interior 1


Juncus confusus 2


Juncus torreyi 3


Juncus chlorocephalus 4


Juncus pallidus 5

Rushes

Although rushes are graminoids, the flowers are more similar to non-graminoid flowers, therefore it has the "Flowers or flower buds" phenophase instead of the "Flower heads" phenophase used for grasses and sedges. Similar to grasses and sedges, an observer should report "yes" as soon as an inflorescence is initiated and visible on their plant. An observer should continue reporting "yes" for this phenophase until the last flower on the plant turns its reproductive effort to fruit development. The image series on this page presents an example of what an observer may see.


Juncus torreyi 6


Juncus tenuis 7

Row 1 of images is a composite of several rush species. The images flow from inflorescence initiation and flower bud formation (Image 1) to the point where the floral clusters still have some open flowers but also some flowers that have transitioned into fruit development (Image 5).

The transitioning of the flowers from the "Open flowers" phenophase into fruit development is subtle. Drying stigmas and anthers can be one clue, but each species has their individual characteristics. Image 6 highlights an inflorescence showing signs of this shift for one species, and Image 7 shows fruits developing.

Nature's Notebook
PHENOPHASE DEFINITION

Open flowers

Cactus, Forb, Tree/Shrub

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.

The "Open flowers" phenophase would seem self-explanatory. As the definition states, an observer would simply look for the male and female reproductive parts between fresh flower petals and sepals, and then, its done! That is true for most species and flowers, and generally, observing for "Open flowers" is quite straightforward. Yet some species have other characteristics to consider. We cover some of those details on these next few pages.

The images below highlight some of the easier flowers that an observer might come across on the pages of *Nature's Notebook*. These flowers are often larger, but when tiny, they have floral parts that are easy to recognize. For these images, the red arrows point to the male reproductive parts and the orange arrows point to the female reproductive parts. An observer would not necessarily see both at one time, but should report "yes" for "Open flowers" when seeing activity from either male or female, or both floral reproductive parts.


Carnegiea gigantea 1


Opuntia santa-rita 2


Penstemon superbus 3


Ceanothus greggii 4


Kalmia latifolia 5


Sambucus racemosa 6


Yucca baccata 7


Magnolia x soulangiana 8


Parkinsonia microphylla 9

Observing challenging flowers

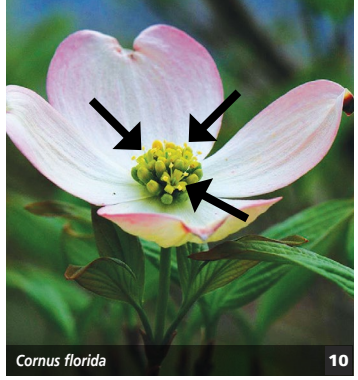
As an observer develops a good technique for observing a typical "open" flower, it may become easier to understand challenging flowers. This page highlights a sampling of "difficult" flowers; those having an unusual structure, or are tiny, crowded, inconspicuous, or have hidden or missing parts (such as petals or sepals or both).

Some flowers can be perplexing. It helps to know where the flowers are located on the plant that you are observing. Are they separate and complete like those on the previous page? Or are they hidden within an inflorescence that mimics a flower, such as the tiny, crowded flowers in the center of showy bracts as in some dogwoods? Or are they very tiny—often looking like petals—and very crowded with many others into an inflorescence that mimics one big flower—like a sunflower? Or, are they very tiny, petal-less, unisexual, and crowded into dangly catkins?

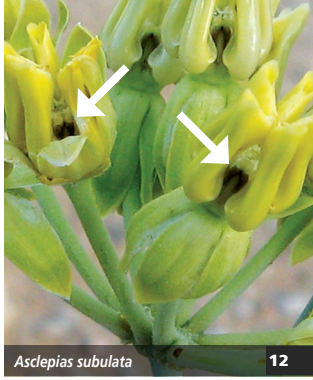
When it gets down to it—despite how atypical a flower may be—an observer is specifically looking for the flower's reproductive parts for the "Open flowers" phenophase: the stamens and/or the pistil(s)—or stigma—if the ovary of the pistil is hidden. For the images to the right, red arrows indicate "open" male parts; orange arrows, "open" female parts; and white or black arrows, both parts crowded together. If your plant species has challenging flowers, get the specifics of their flowers. Find reliable sources and get your questions answered!

For some of these difficult flowers, a species-specific description is added to the species' "Open flowers" phenophase definition. For flowering dogwood (Image 10) this description reads: "For *Cornus florida*, ignore the four large, white bracts and watch for the opening of the small flowers in the center of the bracts."

In tall trees, it may be impossible to determine whether reproductive structures are visible. In this case the observer might have to report "?" for "Open flowers".

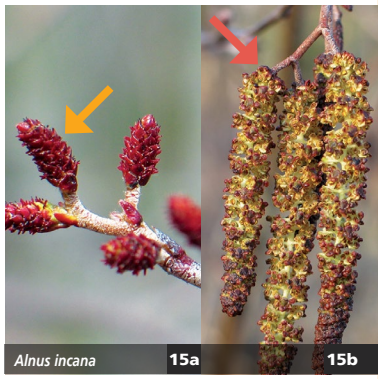

Cornus florida 10

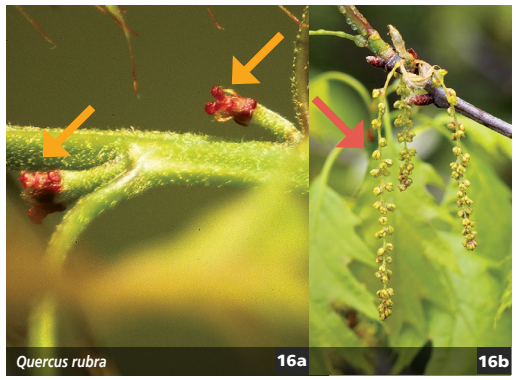

Passiflora sp. 11

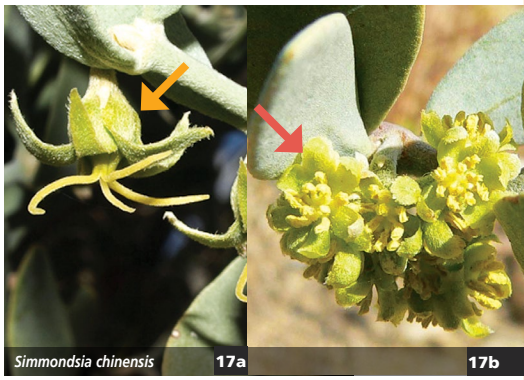

Asclepias subulata 12

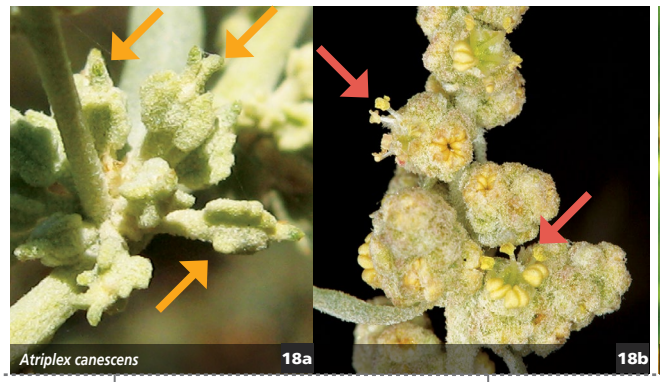

Plantago sp. 13a 13b

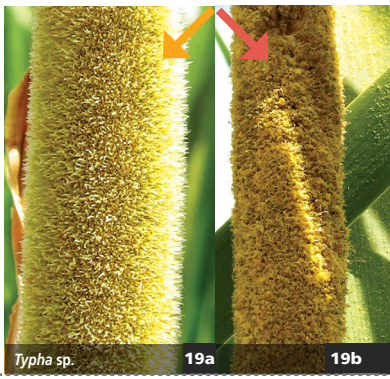

Platanus racemosa 14

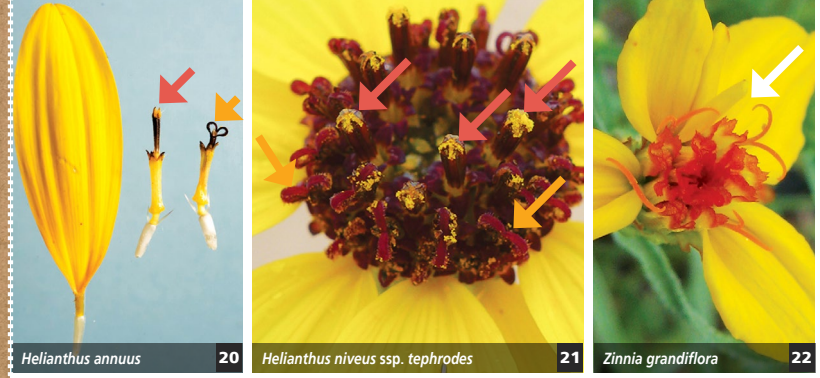

Alnus incana 15a 15b


Quercus rubra 16a 16b


Simmondsia chinensis 17a 17b


Atriplex canescens 18a 18b


Typha sp. 19a 19b


Helianthus annuus 20

Helianthus niveus ssp. tephrodes 21

Zinnia grandiflora 22

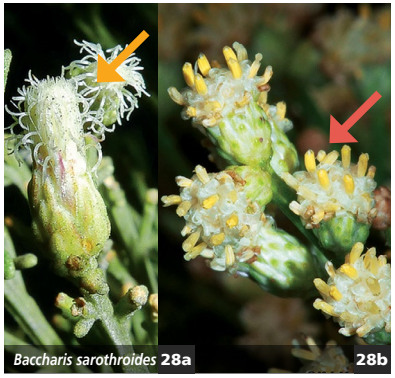

Liatris punctata 23


Taraxacum offincinale 24


Cirsium occidentale var. californicum 25

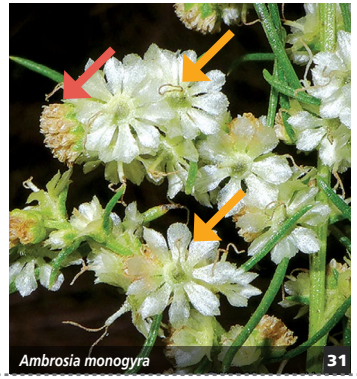

Pseudognaphalium sp. 26


Ericameria nauseosus 27


Baccharis sarothroides 28a 28b


Artemisia californica 29


Ambrosia psilostachya 30


Ambrosia monogyra 31

Open flowers in the sunflower family

In the plant family Asteraceae—which include daisies, sunflowers and the like; dandelions, lettuce and the like; gayflowers, cocklebur, ragweed, sagebrush, burrobrush; thistles and the like; goldenrods, rabbitbrush and the like—the flowers require a closer look to decide whether they are "open". What may look to be a single flower is an inflorescence—called a capitulum. Very simply, a capitulum is comprised of a few to lots of teeny flowers supported on the capitulum's receptacle, and surrounded by one to several rows of involucral bracts (phyllaries)—collectively called the involucre. In this type of inflorescence, some of the tiny flowers might resemble a flower's petals and the phyllaries resemble a flower's sepals.

The two basic types of flowers found in capitula are disc florets and "petalled" ray florets. Image 20 shows a ray floret on the left, and disc florets—in male and female phases—on the right side of the image. Disc and ray-type florets generally have a corolla (petals) and a modified calyx, and vary in having male and female reproductive parts. Their modified calyx (called a pappus) is a ring of hairs, bristles, awns, scales (used to disperse the fruits) or it may be absent. The corolla is either a fused tube of five tiny petals for the disc florets or strap-shaped petal or petals for the ray florets. The calyx and corolla are attached at the top of the ovary—an inferior ovary—and surround the stamens and style. In most species, the five stamens are a fused tube that surround the style, which has two stigmatic branches at the top. The anthers become active first (protandry), releasing pollen before the style extends up between the stamens. The stigma becomes active as the style pushes up between the stamens. See Images 20-21 for a look at examples of what each reproductive phase might look like (red arrows are male phase, orange arrows, female phase). As described by the "Open flowers" phenophase definition, it is the stamens' and stigma's activity an observer will look for to determine "open" flowers; report "yes" if either phase is active.

In the Asteraceae family there are many floral tribes, each have a specific combination of floret types that comprise a capitulum. Some species have many capitula further arranged within a complex inflorescence (Images 23, 26-31), the arrangement specific for the species. In Images 22-31, white arrows indicate male or female activity; red arrows, florets in male phase; orange arrows, florets in female phase.

Nature's Notebook
PHENOPHASE DEFINITION

Open flowers

Grass, Sedge

One or more open, fresh flowers are visible on the plant. A flower is considered "open" when reproductive parts (male anthers or female stigmata) can be seen protruding from the spikelet. Do not include flowers with wilted or dried reproductive parts.

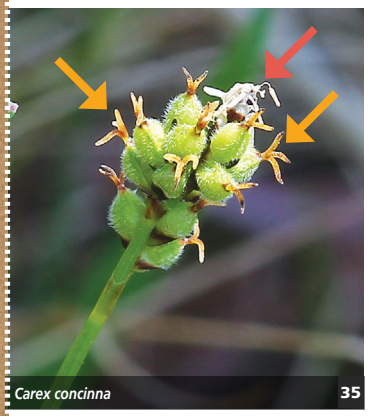
Rush

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.


Bromus inermis 32


Pennisetum setaceum 33


Tripsacum sp. 34


Carex concinna 35


Carex aurea 36


Scirpus microcarpus 37


Juncus balticus 38


Juncus howellii 39


Luzula hitchcockii 40

Row 1 shows open florets in grasses, row 2 shows sedges, and row 3 shows rushes. Arrows point to the reproductive parts in each image with red arrows for the male reproductive parts and orange arrows for the female reproductive parts.

If the tiny graminoid flowers are confusing to you, take a look back at the informational pages provided for grasses, sedges, and rushes. Diagrams focus on the florets and flowers in order to get a more solid understanding of what to look for when observing the flowers of these species.

Also, get to know your species well enough to know if the flowers are perfect, or monoecious or dioecious. In Images 34-36 male and female flower parts occur in separate florets. Images 33, 37 and 40 show flowering strategies in which mostly only one sex is active at a time (protandry, protogyny).

Nature's Notebook
PHENOPHASE DEFINITION

Pollen release

Forb, Grass, Sedge, Rush, Tree/Shrub

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

The "Pollen release" phenophase is included for those plant species that have been reported to cause allergies in a large number of people in our population, such as maple, oak, mesquite and privet, ragweeds, and grasses.

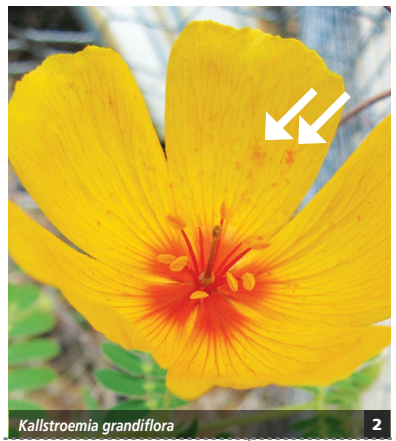
Several methods may work for an observer to detect pollen release. The best method to use will depend on each species' characteristics and its pollination strategy, although allergen species commonly have abundant and easily detected pollination events. That said, some species may offer a challenge when detecting pollen; it can sometimes be tricky.

To start, an observer simply might look carefully and closely at the plant for evidence of pollen residues within flowers or dusted onto leaves, such as in Images 1-3. If they choose this method, they must make sure the plant's anthers are fresh. If they are long-dried and withered with only small amounts of pollen present, the pollen might have come from other sources. But, as the definition suggests, an observer might gently shake the plant to see if pollen grains are released, such as in Image 4 where clouds of pollen are evident. For plants that have very tiny flowers an observer might be able to gently shake or tap the plant over a dark surface, such as in Image 5.

For tall trees an observer might find that flowers are too far above them to detect pollen release. If this is the case, they will have to report "?" for this phenophase unless they see clouds of pollen being blown by the wind.

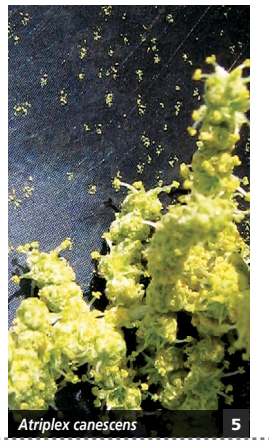
Grasses are generally tricky plants on which to make observations. The next page offers some insights to grass pollen release and detecting activity or senescence of anthers. Also, some images are offered to show the surprising variation of pollen colors and packaging. Not all pollen gets released as loose grains!

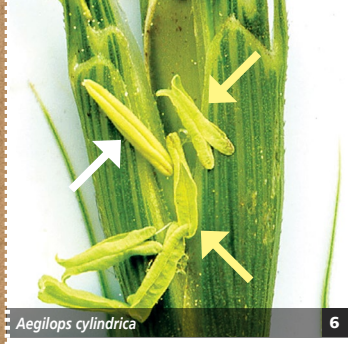

Opuntia versicolor 1

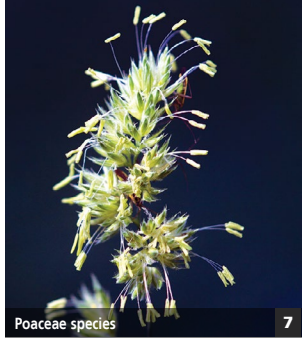

Kallstroemia grandiflora 2


Typha sp. 3


Pinus sp. 4


Atriplex canescens 5


Aegilops cylindrica 6


Poaceae species 7


Saccharum spontaneum 8


Paspalum quadrifarium 9


Tripsacum dactyloides 10

Pollen release in grasses

Row 1 of images illustrates several grass species in the process of releasing pollen. In Image 6 several grass flowers have extended anthers indicating pollen is being released. Yet, if you look more closely, you might notice that several of the anthers have split open, having previously released their pollen but not yet withered and dried (yellow arrows). At least one of the anthers is still closed and is extended out from the flower (white arrow)—so it will not be too long before it also splits open to release the pollen grains (each species has their own anther-opening mechanisms). Some grasses can be tricky if an observer does not look closely. At a distance the anthers, dangling from their flowers, could be withered and dried having released all of their pollen grains some days ago. Just to be sure, the observer should take a closer look at their plant to make sure pollen release is in fact occurring in at least a few of the flowers or florets within the inflorescence when reporting "yes" for this phenophase.

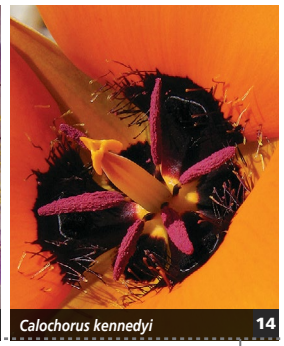
Unusual pollen colors and packages

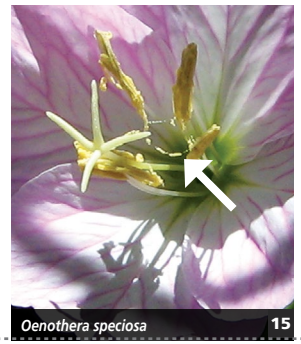
Although we do not usually ask for this phenophase for these kinds of flowers, here are some examples of other types of pollen. Each species has differently shaped anthers, dispersal methods, and timing strategies that supports the species' reproductive success. Some of the less common physical differences an observer may come across include vibrant anther and pollen colors (Images 11-14) and unique pollen packaging (Images 15-16) compared to the loose pollen grains in various shades of yellow that we commonly see. Several plant families have unique ways to disperse their pollen, mostly these methods involve pollen packaging that attaches to insect pollinators and is efficiently relocated. Image 15 highlights a pollen string where pollen grains are strung together by viscin threads into chains of pollen, and Image 16 shows pollinia (white arrows)—tiny masses of pollen—from a milkweed flower (orchids also) clinging to a bee's leg. Yellow arrows point to the anthers that surround the stigmatic disc of the flower.

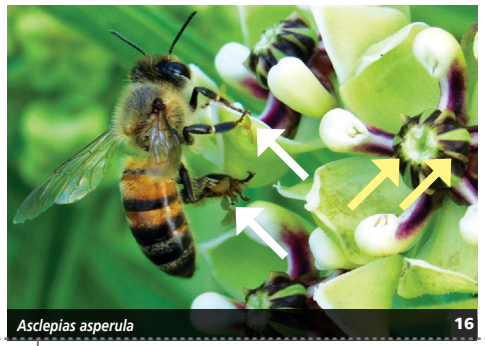

Anthoxanthum odoratum 11


Gilia tricolor 12


Calochorus sp. 13


Calochorus kennedyi 14


Oenothera speciosa 15


Asclepias asperula 16

An overview of "spent" flowers

When is a flower "spent"?

For the "Open flowers" phenophase, the definition directs the observer to look at the fresh flowers on the plant, eliminating from an observer's assessments any flowers with wilted or dried reproductive parts that are no longer active. This is straightforward and easy to understand. For the most part, as anthers complete pollen release and ovaries are fertilized, the petals and sepals, anthers, stigma and style dries and often falls off (often described as being "deciduous" in floral descriptions). There are some exceptions—as usual!

The sequence of activity of a flower's effort

A flower's sequence of activity, and cues for the end of its effort, differs from species to species, but generally within a species the sequence will be consistent. As a flower's activity wanes and freshness diminishes, pollination ends, fertilization is complete or, in most species, nearing completion; the flower is "spent". Depending on the species, this can happen within hours, days, or over months. The sepals and petals may change color, close up, wilt and/or dry, fall off or remain on the plant. The anthers often dry quickly after releasing their pollen. A subtle color change will cue an observer to the drying (such as a fresh intense yellow when full of pollen to a dull, dry, whitish-yellow once the pollen is released and the anthers are empty). In some species the stamens or anthers quickly fall off.

A flower's female reproductive parts display a greater diversity of patterns across species. The stigma and style may dry and fall off, they may dry but remain attached to the developing fruit until it is ripe, or they may stay fresh and well developed, either remaining green or changing in color, while the fruit develops.

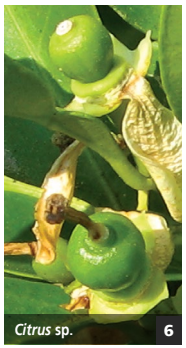

Citrus sp. 1


Citrus sp. 2


Citrus sp. 3


Citrus sp. 4


Citrus sp. 5


Citrus sp. 6

For the species in the image series above, as the flower petals open (Image 1)—and before they are completely open—the anthers open and release pollen (Image 2). The stigma may, or may not, be receptive at this point as it slowly extends upward. Then, all floral parts are completely exposed and seemingly active (Image 3); the anthers still look fresh although a closer look shows that most of the pollen has been released. Next (Image 4), the stamens begin to wilt and dry, as the petals, still mostly fresh, also begin to show signs of drying—and yet the style and stigma remain fresh and seemingly receptive. As the flower deteriorates, the petals fall off and the stamens are empty and dry (Image 5); the flower is "spent". Next, the stigma and style dries and falls off the developing fertilized ovary—the fruit (Image 6).

An observer should report "yes" for the "Open flowers" phenophase, by definition, for Images 2-4. Image 5 (with orange border) is a "spent" flower, no longer "fresh" or active—having withered and dried floral parts and petals dropped off.

Variation is the norm; cues of a "spent" flower differs by species

As freshness fades for a flower—after pollen has been released and stigmas are no longer receptive to pollen (although unseen pollen tubes may still be growing down through the style into the ovary of the pistil)—a sequence of floral activities occurs. Typically these hardly-noticed events involve the drying and/or dropping off of floral parts that are no longer of use. Otherwise, sustaining freshness in these floral parts would take energy away from the plant, or would get in the way of potential fruit development. Rows 1-3 offer some of the different cues that might be seen by an observer.

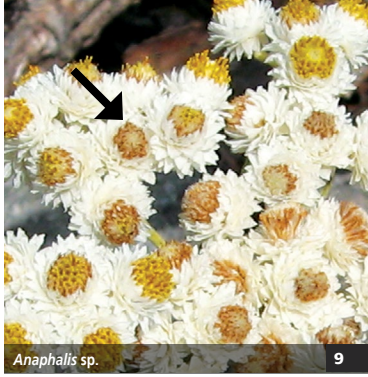
A species' flower may signal the end of its effort with petals that change color indicating the flower is spent (Images 7-9); or petals wilt, some close up, then dry but stay attached for a while (Image 10, 14, 15); or petals fall off immediately before wilting (Images 11-13); or flower heads may close their bracts (phyllaries) up over the spent florets (Image 16), or not, and the ray flowers dry up as the individual spent disc florets begin drying (Image 17).

Plants which may need a closer look

Row 4 of images highlights several instances where an observer might need to look more closely at their plant. This is especially relevant when the plant has dense inflorescences of tiny flowers. It may seem that the group of flowers is "spent", but a closer look could uncover a few fresh flowers that remain reproductively active and even an unopened flower bud or two (arrows indicate still open and active flowers amongst the spent flowers).


Opuntia engelmannii 7


Eriogonum fasciculatum 8


Anaphalis sp. 9


Ferocactus wislizeni 10


Eschscholzia californica 11


Fouquieria splendens 12

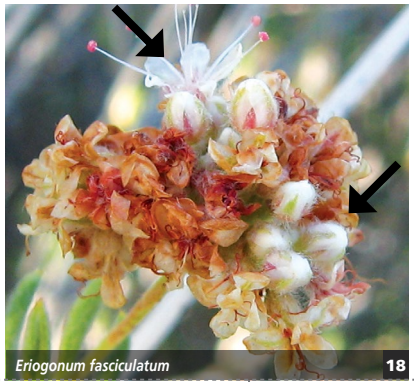

Penstemon superbus 13


Punica granatum 14


Acacia berlandieri 15


Grindellia sp. 16


unknown Asteraceae 17


Eriogonum fasciculatum 18


Chrysothamnus sp. 19


Schoenoplectus americanus 20

An overview of new fruits

When has a fruit initiated from a flower?

As with all other plant activity discussed earlier in this document, fruit initiation is species' specific—its characteristics unique to a species—and yet, also dependent on the conditions at the time of pollination and fertilization. Some species are very quick at fertilizing and starting fruit development after receiving pollen, and others have evolved unique delayed strategies that best serve the success of the species.

Pinpointing the beginning of fruit development is often very difficult. This section highlights what an observer might consider when trying to determine the start of the "Fruits" phenophase.

This topic is also covered in detail in the *Nature's Notebook* Nugget: Flowers Turning to Fruit, which can be found on the USA-NPN website (usanpn.org).

We offer cues that indicate fertilization has taken place and the flower has successfully transitioned into fruit development; yet, since each species' fruit development is unique, your acquired knowledge of your plant will be your best tool. Experience gained by careful observation of your plant, over time, will be your surest source of information.

What are some early signals an observer might watch for?

Begin by understanding where the flower's ovaries are located within the flower for the plant species. Close inspection of the plant's flowers, or searching out good information sources, should reveal an ovary's position. Knowing the position of the ovaries will help with fruit onset observations; is the ovary "superior" (petals and sepals attached below the ovary(s)), "inferior" (petals and sepals attached at the top of the ovary(s)), or are the petals and sepals attached to a floral cup (hypanthium) that surrounds the ovary—often hiding the lower part of the ovary but leaving the upper part in view? And remember, a superior ovary can also be deeply hidden between its enclosing petals.

Read the species' fruit development descriptions that follow the "Fruits" phenophase definition provided on the species' profile page in *Nature's Notebook*. Further, consider some of the cues offered here that might help to catch fruit onset a bit earlier. Primarily, an observer would be watching for ovaries that remain a green color and enlarge as the flower changes. Some ovaries do not get fertilized—they dry, shrivel or fall off.

An observer should not over worry about catching the very beginning of the "Fruits" phenophase and only report "yes" once they are confident they are seeing a live ovary that has been fertilized and is developing into a fruit. They could also report "?" if fairly sure, but still need more evidence.

Ovaries that remain green

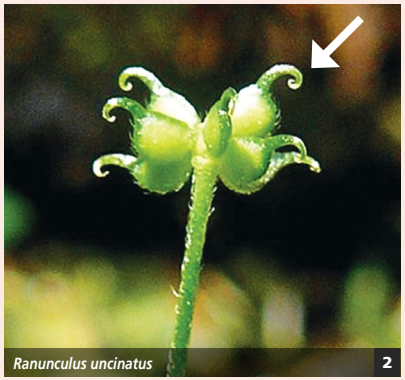
In Image 1, a green ovary (the fruit; inferior ovary) of a spent evening primrose flower is only days old and already showing distinct signs of developing (staying green and alive, and enlarging) while all other floral parts drying and dropping off.

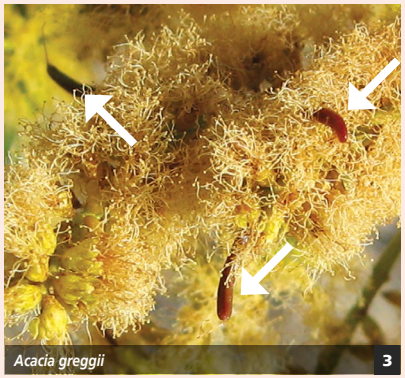
In some species, the stigma may remain attached for a prolonged period, with the style remaining and drying as the fruit ripens and dries (Image 2). Watch for the steady enlarging of the ovary (the fruit) over time, quick or slow—depending on the species.

Ovaries that are hidden between persistent alive or drying plant parts

For some species, it may take a bit longer to detect fruit development (Images 3-4). For Eastern Mojave buckwheat (Image 4), the "Fruits" definition states: "One or more fruits are visible on the plant. For *Eriogonum fasciculatum*, the fruit is tiny and capsule-like, partially enclosed in a spent flower base (calyx), with many such spent flower bases tightly clustered together. The spent flower base changes from green to light brown or rusty brown as it dries out." For this species with hidden fruits, this visual cue of flower base color change identifies the beginning of potential fruit development—the point when an observer should report "yes" for the "Fruits" phenophase.


Oenothera elata ssp. hirsutissima 1


Ranunculus uncinatus 2


Acacia greggii 3


Eriogonum fasciculatum 4

Some species are quick quick quick to initiate fruit

There are quite a few species in nature that "set" fruit very quickly. An observer would have to be watching their plant closely, and regularly, to catch this event (Images 5-10). The ovaries can be seen enlarging soon after the flower parts drop or dry—sometimes pushing through the barely dry flower parts (Image 10). On occasion in some species, the flower hardly seems spent when the ovaries show signs of developing further (Image 8).

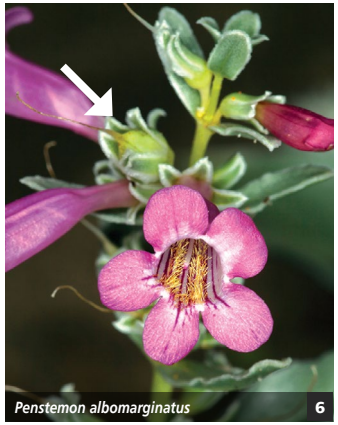
Some species delay fruit initiation for a while... sometimes quite a while

Some species delay fertilization as part of their strategy... some for a surprisingly long time. Fertilization can be suspended a few weeks following pollination (Images 11-12). Witchhazel is one of those species that is delayed for a longer time: pollination occurs at flowering in the late fall to early winter, yet fertilization is delayed and does not occur until the following late spring or early summer (Image 13). In this case, although small, unfertilized ovaries are visible on the plant throughout winter and spring, the observer should report "no" for "Fruits" until the ovaries begin to swell and enlarge later in the spring or summer. Once an observer understands the patterns of their species, it will be easier to estimate how to watch their plant to catch fruit initiation, and the "Fruits" phenophase, as early as possible.

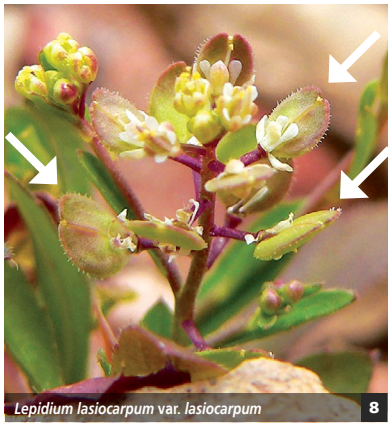
It bears repeating

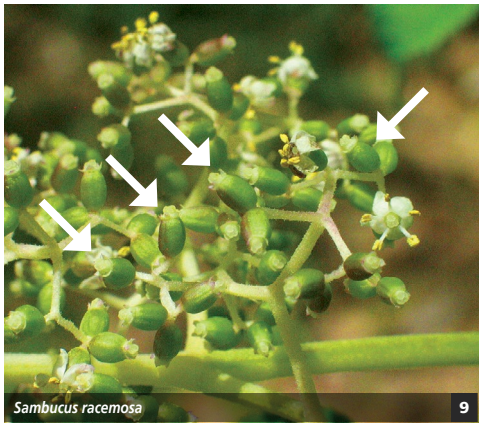
All of our observers are learning, even the most experienced. Take your time to learn the basics for your plant species so that your observations are as accurate as possible. Be comfortable, and confident, with what you report. It provides quality data.


Solanum lycopersicum 5


Penstemon albomarginatus 6

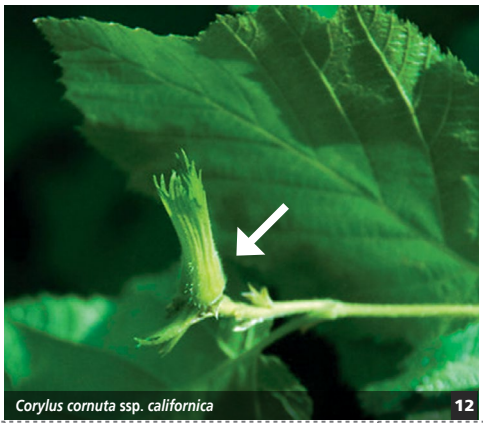

Cucumis melo 7

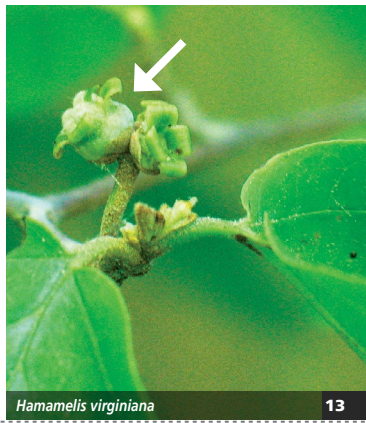

Lepidium lasiocarpum var. *lasiocarpum* 8


Sambucus racemosa 9


Olneya tesota 10


Quercus rubra 11


Corylus cornuta ssp. *californica* 12


Hamamelis virginiana 13

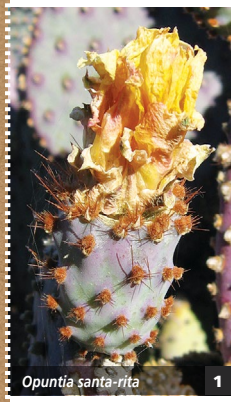
Nature's Notebook
PHENOPHASE DEFINITION

Fruits

Cactus, Forb, Grass, Sedge, Rush, Tree/Shrub

One or more fruits are visible on the plant.

See each Nature's Notebook *species profile for a species-specific description of fruit development.*


Opuntia santa-rita 1


Opuntia santa-rita 2


Opuntia santa-rita 3

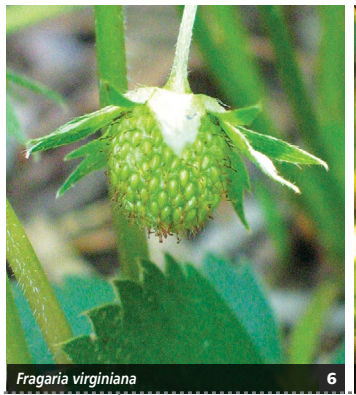

Opuntia santa-rita 4

The "Fruits" phenophase encompasses the entire period during which fruits are present on a plant. It begins with the first observation of the plant's first initiated fruit for the season (see the previous section "An overview of new fruits") and ends when the last fruit on the plant has ripened and released all its seeds, or has dropped off or been removed from the plant. In the case of "dehiscent" fruits that spilt open to release seeds, the empty capsule or pod that remains on the plant after all the seeds are gone should be ignored and no longer considered "Fruits" for the purpose of monitoring with *Nature's Notebook*.

Cacti and forbs

The first image in each row shows early fruit initiation and the last image shows a ripe fruit as defined in the species-specific description of fruit development and ripeness cues (row 1, a cactus; row 2, a perennial forb).


Fragaria virginiana 5


Fragaria virginiana 6

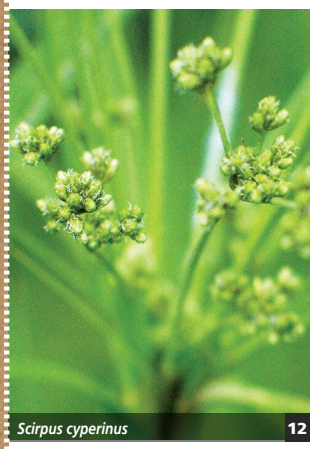

Fragaria virginiana 7

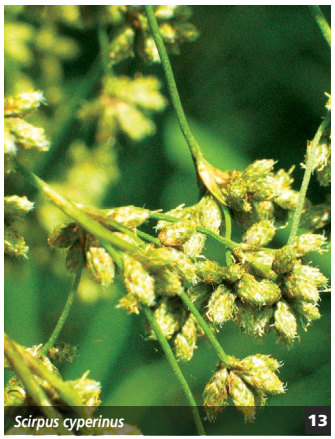

Fragaria virginiana 8


Spartina patens 9


Spartina patens 10


Spartina patens 11

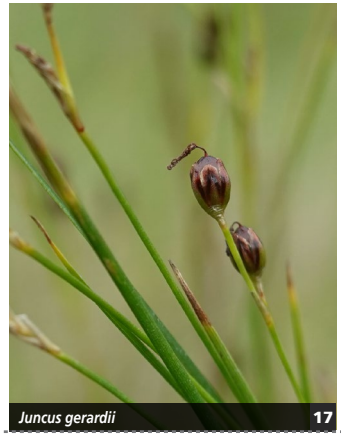

Scirpus cyperinus 12


Scirpus cyperinus 13


Scirpus cyperinus 14


Scirpus cyperinus 15


Juncus gerardii 16


Juncus gerardii 17


Juncus gerardii 18


Juncus gerardii 19

Graminoids

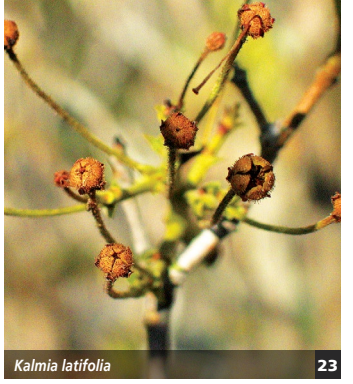
Three image series are offered as examples for the graminoid plant groups, that is, the grasses, sedges, and rushes. Row 1 highlights a grass; row 2, a sedge; row 3, a rush. The first image in each row shows fruit initiation and the last image shows a ripe fruit.

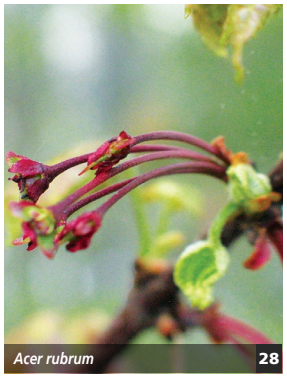
For graminoids, fruit development is mostly hidden within plant parts, and will take some experience to acquire an understanding of this phenological stage for these plants. Reading over the fruit definitions for these species will only offer a basic description for the observer; an inexperienced observer should take a season for careful observation before reporting on graminoid fruit phenophases. For example, the "Fruits" definition for the grass species in row 1 is: "For *Spartina patens*, the fruit is a tiny grain, hidden within tiny bracts and grouped into small clusters that are closely arranged along alternating branches on a large, open plume (or seed head), that changes texture from soft or watery to hard and drops from the plant. Do not include seed heads that have already dropped all of their grains." If you are not familiar with grass fruit development, take it slow, compare your observations to plant changes over time (take notes or photos for yourself), and ask questions.

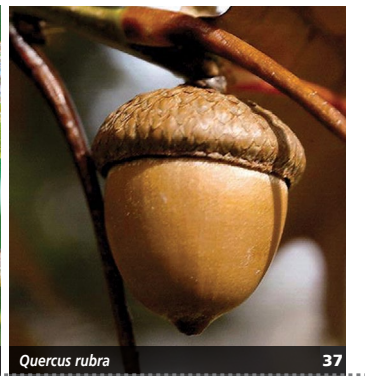
Trees and shrubs

This page offers a few image series of larger species—a shrub (row 1) and some tree species (rows 2-4). Despite being larger, the fruit types can be similar, if not identical, to forbs (such as berries, capsules, pods), cacti (fleshy fruits), and rushes (capsules). Several types of fruits are displayed in these images: capsules that split open and release their seeds (row 1), winged fruits that drop when ripe (rows 2 and 3), and nut-type fruits that change color and often drop from the tree when ripened (row 4).

As noted on previous pages, a description of fruit development for each species is included with the "Fruits" phenophase definition, and provides a simple overview for what an observer could expect for that species. The "Ripe fruits" phenophase definition will identify the cues an observer would watch for to determine fruit ripeness for each species. Each of these image series for the "Fruits" phenophase starts with newly initiated fruits (Images 20, 24, 28, 33) and ends with the ripe fruit phase (Images 23, 27, 32, 37). An observer should report "yes" for the "Fruits" phenophase from fruit initiation through ripe fruits on a plant, until all the ripe fruits have dropped off or lost all of their seeds. Row 1 is an example of a species with dehiscent capsules that will remain on the plant after all seeds are released. Once empty of seeds, the capsules should be ignored and not included as "Fruits".







An overview of aborted fruits

What does an aborted fruit look like?

Interruption and cessation of fruit development can occur as a result of a random episode in a plant's life cycle or as a species' reproductive strategy. It is not unusual to see one or two ovaries or immature fruits that have discontinued development, but some species mass eliminate—so as to settle into a balance of producing a crop of healthy fruits and insuring its own plant health.

How can an observer be sure the fruit has been aborted before ripening. Should an observer record what they see?

A few examples are offered here just to alert an observer to the potential of this event occurring. For most species, the cessation of a fruit's development is relatively rare, for others, it is a common strategy used to reduce the size of the fruit crop to maximize success of the remaining fruits during its fruiting effort.

Examples of aborted fruits

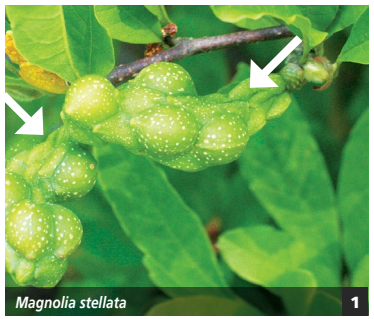
Not all ovules get fertilized after flower pollination, and not all fruits that are fertilized continue to develop into fully ripe fruits. Their development can be interrupted and the fruit dies before ripening. There are many potential reasons for this; competition within the plant for necessary resources, abnormalities, disease or injury, local weather, and competition from without that severely limits environmental resources needed to provide the energy it takes a plant to develop its fruit.

The events causing cessation of fruit development typically would involve just a few of a plant's fruits. When an observer catches this event—if they understand what they see—a note could be entered into the species' observation comments field reporting that some fruits have been aborted. On occasion, a mass abortion event could take place (some species do this regularly). An event of this sort might reduce an observer's count of fruits over time because fruits that have clearly been aborted should be ignored and no longer considered "Fruits".

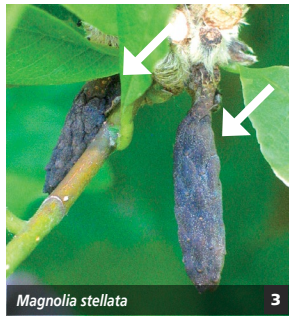
Just for comparison, row 1 provides examples of where not all pistils within a flower, or flowers within an inflorescence, were fertilized following pollination (white arrows). In species with multiple, accessory, or aggregate fruits, a distorted fruit may result when only some of the pistils that occur within a single flower are fertilized (Image 1). If not all flowers within an inflorescence are fertilized, the infructescence would have empty spaces between those flowers that were fertilized and initiated fruits (Image 2).

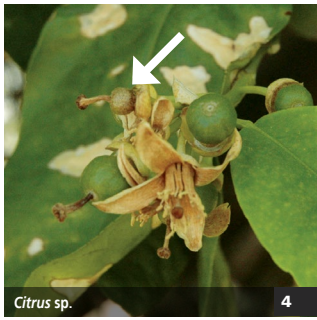
Rows 2-4 show aborted fruits; the arrows point to those aborted. Compare Image 3 to Image 1: they are the same species, yet the partially unfertilized fruit versus the aborted fruits look very different. In some instances, aborted fresh, underdeveloped, fruits drop and can be found lying underneath a plant (Image 7). In this case, the observer should report "no" for "Recent fruit or seed drop" because these dropped fruits are not mature.

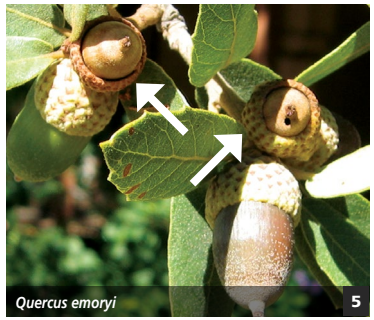
There is no way of knowing the cause of these events (unless you are knowledgeable about the species)—there can be many reasons. Yet, it is important that our observers be aware of aborted fruits, simply so they are disregarded when reporting on the plant's fruit.

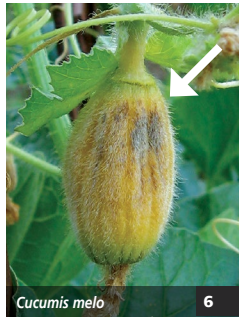

Magnolia stellata 1

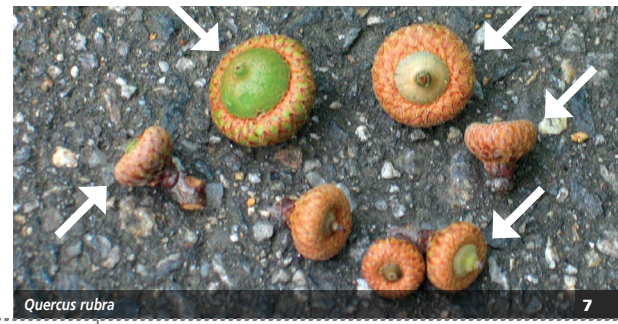

Salix discolor 2


Magnolia stellata 3


Citrus sp. 4


Quercus emoryi 5


Cucumis melo 6


Quercus rubra 7

Nature's Notebook
PHENOPHASE DEFINITION

Ripe fruits

Cactus, Forb, Grass, Sedge, Rush, Tree/Shrub

One or more ripe fruits are visible on the plant.

See each Nature's Notebook *species profile for a species-specific description of ripe fruits.*


Salix discolor 1


Salix discolor 2


Salix discolor 3

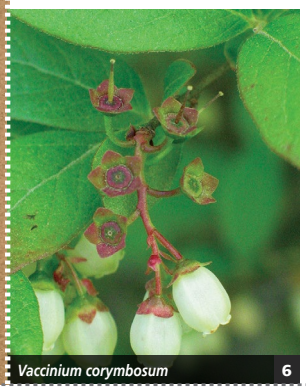

Salix discolor 4


Salix discolor 5

Each plant species can display a unique set of characteristics as the fruit develops and becomes ripe. There are many fruit types, such as capsules which change color and split open when ripe (referred to as "dehiscent" fruits), berries which become fleshy and change various colors before reaching their ripened color, pods which change color as they ripen but do not open, or nuts hidden in hulls in which the hull changes to a ripened color and drops from the plant. *Nature's Notebook* provides a description for each species of their developing fruit (included in the "Fruits" phenophase definition) and the cues that indicate when their fruit is ripe (included in the "Ripe fruits" definition). An observer need only read this species' specific description that will describe the fruit's typical sequence of development. As you watch your plant over time, you may discover it differs a bit from the description. Use this acquired knowledge for your future observations in subsequent years.

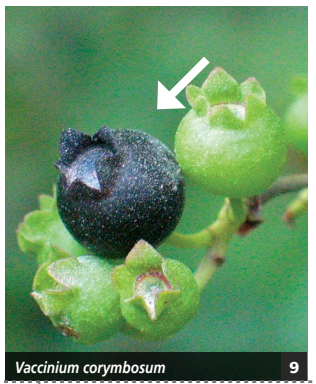
Row 1 shows a sequence for pussy willow, and an arrow points to the observation of the first ripe fruits according to it's "Ripe fruits" definition: "One or more ripe fruits are visible on the plant. For *Salix discolor*, a fruit is considered ripe when it has dried and split open to expose seeds with white fluff. Do not include empty capsules that have already dropped all of their seeds." Image 5 shows an infructescence of empty capsules that have dropped all of their seeds and should no longer be considered "Fruits" or "Ripe fruits".

Row 2 shows a sequence for highbush blueberry, and an arrow points to the observation of the first ripe fruit according to its "Ripe fruits" definition: "One or more ripe fruits are visible on the plant. For *Vaccinium corymbosum*, a fruit is considered ripe when it has turned blue or blue-black."


Vaccinium corymbosum 6


Vaccinium corymbosum 7


Vaccinium corymbosum 8


Vaccinium corymbosum 9


Vaccinium corymbosum 10

Ripe fruits

This page contains image pairs to offer some examples of different kinds of fruit an observer might come across. The left image of each pair is the unripe stage, the right image of each pair is at the "Ripe fruits" phase.

Some of the types of ripe fruit an observer might come across on various plant species are capsules (or capsule-like) that dry and split open with or without fluff attached to the seeds (Images 12, 14, 16, 30); capsules and seed-like fruits that dry or change color and do not split open (Images 18, 20); pods that dry and do not split open—the color change is their indicator of ripeness (Image 22); fleshy fruits that change color (Image 24); fleshy fruits with rinds that change color (Image 26); or dry fruits such as "nuts" that change color or grains that change texture and color (Image 28). The arrows identify the ripe fruit.

As with the examples on the previous page, each species' "Ripe fruits" phenophase definition will describe and alert an observer to the cues of its ripe fruit stage.

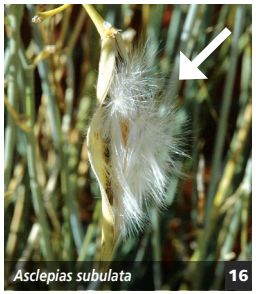

Ceanothus sp. 11


Ceanothus sp. 12


Penstemon superbus 13


Penstemon superbus 14


Asclepias subulata 15


Asclepias subulata 16


Xanthium strumarium 17


Xanthium strumarium 18


Baileya multiradiata 19


Baileya multiradiata 20


Prosopis velutina 21


Prosopis velutina 22


Cornus canadensis 23


Cornus canadensis 24


Cucumis melo 25


Cucumis melo 26


Setaria sp. 27


Setaria sp. 28


Juncus confusus 29


Juncus confusus 30

An overview of ripened, persistent fruits

When should an observer stop reporting on the current fruit crop?

It can be confusing for an observer to know when to stop reporting "yes" for those ripe fruits left on a plant—especially those that are lingering into, and persistent through, another season—months after having fully ripened. The information on this page should help clear up those observational dilemmas.

When to stop reporting "yes" for the "Ripe fruits" phenophase

The initial step would be to determine if the lingering fruits on the plant have dropped all their seeds or had their seeds removed—leaving empty hulls, capsules, pods, or skins and rinds of fleshy fruits (Images 1, 2, 5, 7, 8). If seeds are no longer present, the fruits are no longer viable and the observer should report "no" for "Fruits" and "Ripe fruits". For species such as those in rows 2 and 3, persistent, seedless, old fruit might be present along with fresh flowers and new fruit (Images 5 and 3, respectively), and sometimes remain on the plant well into the next season (Image 8). In tall plants, if fruits are too high to be inspected, the observer may have to report "?" for these phenophases if they are unsure whether the seeds have dropped or been removed from the fruits by wildlife.

But what of those persistent fruits still holding onto their seeds? For capsules and pods, the drier fruits, that retain seeds (Image 6), the observer should continue to report "yes" for the "Fruits" and "Ripe fruits" phenophases until all the seeds have been removed from the plant.

And what of fleshy fruits, such as berries and rose hips, that remain on the plant and begin deteriorating with no clear endpoint for reporting "yes"? It depends. An observer might think about it from an animal's or bird's perspective:

- Continue to report "yes" for "Fruits" and "Ripe fruits" as long as these fruits seem plump, edible and appealing to wildlife (Image 9).
- But—when the fruits begin to dry up and shrivel like a raisin, it becomes questionable whether to consider them as "Fruits" and "Ripe fruits". Once all remaining fruits on the plant seem extremely dry, inedible or unappealing to wildlife (Image 11), report "no" for these phenophases and place a note in the comments section that deteriorated fruit persists on the plant.

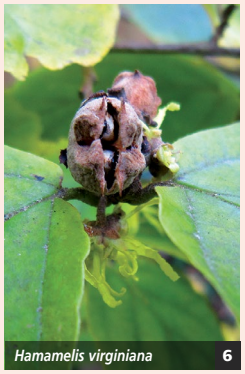

Ilex verticillata 1


Chimaphila umbellata 2

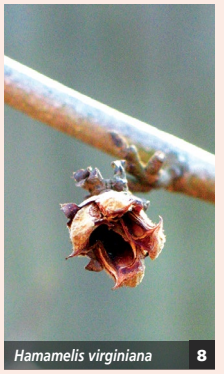

Chimaphila umbellata 3


Chimaphila umbellata 4


Chimaphila umbellata 5


Hamamelis virginiana 6


Hamamelis virginiana 7


Hamamelis virginiana 8


Ilex verticillata 9


Ilex verticillata 10

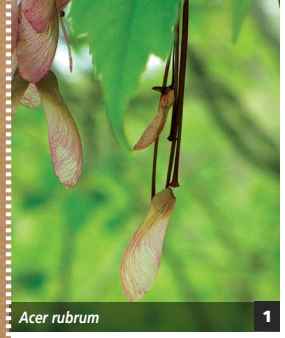

Ilex verticillata 11

Nature's Notebook
PHENOPHASE DEFINITION

Recent fruit or seed drop

Cactus, Forb, Grass, Sedge, Rush, Tree/Shrub

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.


Acer rubrum 1


Olneya tesota 2


Erythronium americanum 3


Salix discolor 4


Typha sp. 5


Asclepias subulata 6


Betula nigra 7


Ilex verticillata 8

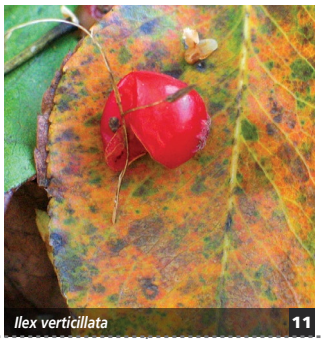
The fruits of some species drop from the plant as soon as they ripen, in which case an observer may easily miss the chance to report the presence of "Ripe fruits" on the plant. For this reason, the "Recent fruit or seed drop" phenophase was added to *Nature's Notebook*. If a plant's fruit obviously ripened and dropped since the last visit, the observer should report "yes" for this phenophase.

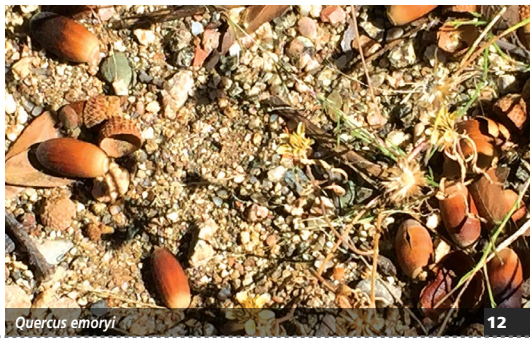
Carefully examine the plant and the fruits for evidence of fruit or seed drop. It may be that there are pedicels with no fruit, that previously held ripening fruit (Image 1). Or a few—or all—of the seeds missing from a capsule or pod that was full of seeds on the last visit (few, Image 2 and all, Images 3-4), or fruits that seem to be blowing away (Images 5-7), or even the skin of a fleshy fruit that is left after a bird or other animal snacked on the insides (Image 8). Or ripe fruits, or seeds, lying directly beneath the plant that were not there at the last visit (row 3).

Immature or aborted fruits that drop before ripening should not be included for this phenophase. Nor should empty fruits that are finally dropping from the plant after having long ago dropped all their seeds.


Betula papyrifera 9


Magnolia stellata 10


Ilex verticillata 11


Quercus emoryi 12

2

THE PLANT FUNCTIONAL GROUPS

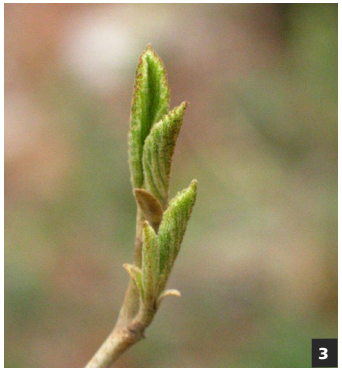
CONTENTS

Section 2: The Plant Functional Groups

SECTION TWO INTRODUCTION


1


2


3

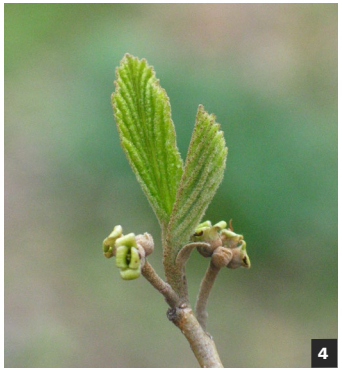
Section 2 of this *Primer* focuses on how the phenophases of an individual plant progress over the course of an annual cycle, and presents an overview of the sequence of phenological events observers should look out for when making their repeated observations. This section is organized by plant "functional 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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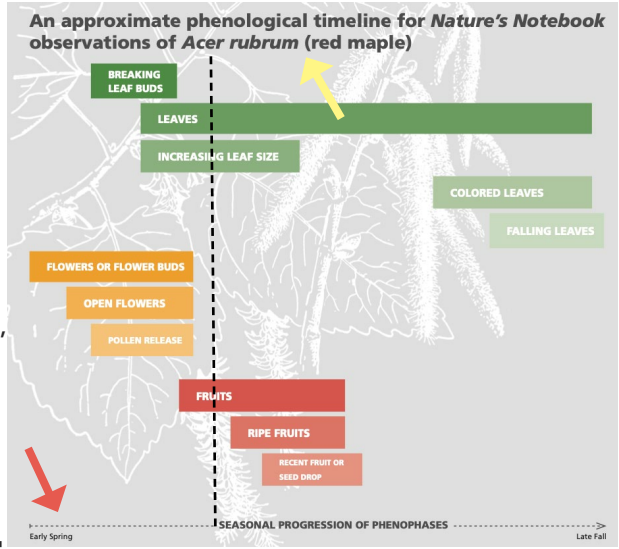
The "species page" timeline

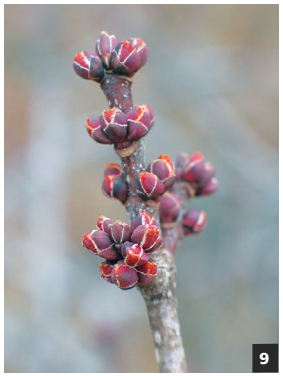
In the page heading, species is identified by scientific name and common name (yellow arrow). Seasonal extent of the timeline is indicated at the bottom (red arrow). Horizontal colored bars represent individual phenophases; green for leaf phenophases, orange for flower, red for fruit. Where bars overlap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

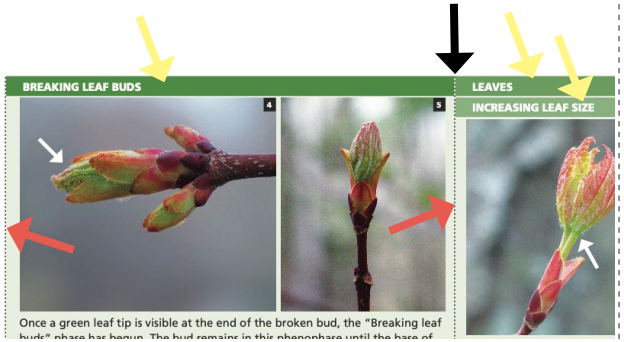
While individuals of the species often follow the pattern shown, it is important to note that these timelines are only an approximation of reality. Considering the genetic variation within a species, health of an individual plant, geographic location of the site, microclimates of a landscape, and quirks 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

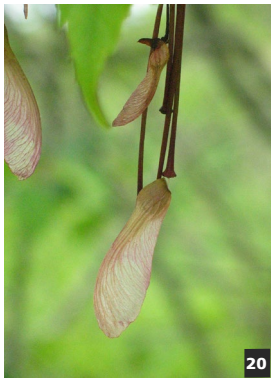
Colored bars represent individual phenophases (yellow arrows), with images underneath depicting plant structures in that phenophase. Often arrows or circles are used to point out what to look for in the image (white arrows in this example). Dashed lines indicate the start and end of phenophases (red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



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.

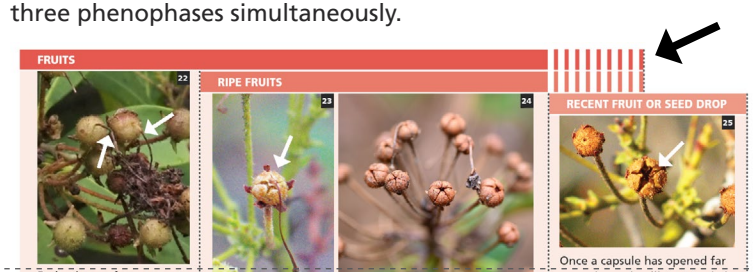
Transitions between phenophases are shown for an individual plant structure (a single bud, leaf, flower or fruit) rather than for the entire plant. When one phenophase bar ends where another begins, it indicates the individual structure will be in one phenophase or the other, but not in both at the same time. For example, a leaf bud remains in the "Breaking leaf buds" phenophase until its first leaf unfolds. After that, the individual bud is in the "Leaves" phenophase and no longer in the "Breaking leaf buds" phenophase. However, different buds on the same plant may still be in the "Breaking leaf buds" stage after others have shifted into the "Leaves" stage. This is indicated in the timeline by overlapping bars, indicating that both phenophases can occur at the same time over the entire plant.

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!

CACTUS

This functional group includes species that belong to the Cactaceae plant family. These plants typically have succulent stems and branches with scales and spines instead of leaves. Seasonal growth of the vegetative parts of the plant can be difficult to follow and thus is not included for monitoring with *Nature's Notebook*.

Representative species:

- *Opuntia santa-rita* (Santa Rita pricklypear)
- *Carnegiea gigantea* (saguaro)

Leaf phenophases

Leaf phenophases are not included for this functional group.

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; More than 1000

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

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.

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; More than 1000

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; More than 1000

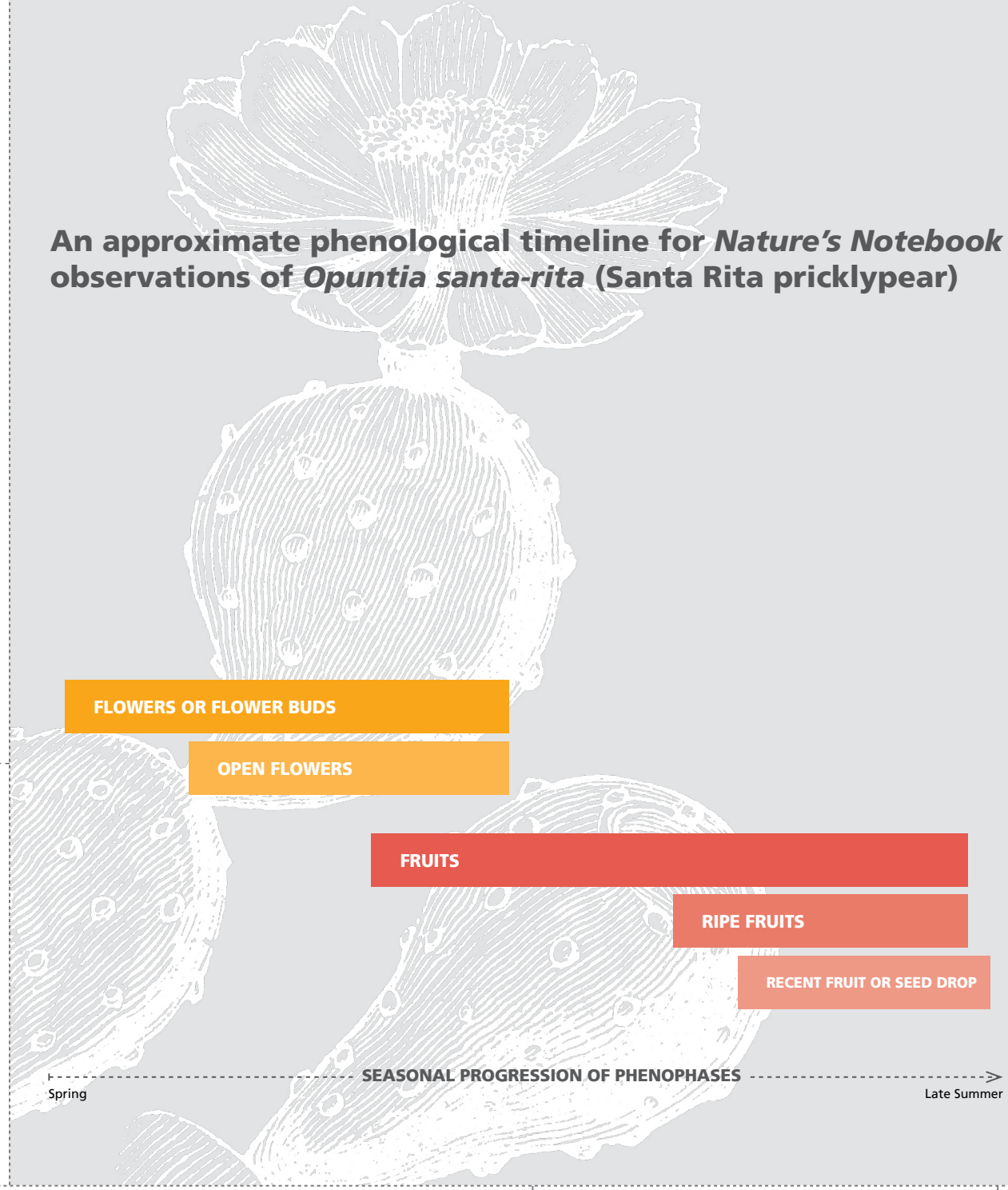
An approximate phenological timeline for *Nature's Notebook* observations of *Opuntia santa-rita* (Santa Rita pricklypear)

Santa Rita pricklypear is a colorful cactus of the Sonoran and Chihuahuan deserts. Its flat, disc-shaped pads—technically the stems of the plant—are bluish-green, blue, or reddish-violet depending on conditions. Tiny, succulent leaves appear very briefly, quickly drying and dropping from the plant.

Its bright yellow flowers are pollinated by insects and birds, and its bright red fruits are favored by many animals, including humans. The bright flowers and fruits set against the colorful stems make it a favorite plant for landscaping in southern Arizona.

Phenological characteristics of note:

- stem and flower buds appear at the same time from top edge of pads
- fruit ripeness indicated by color change



Opuntia santa-rita

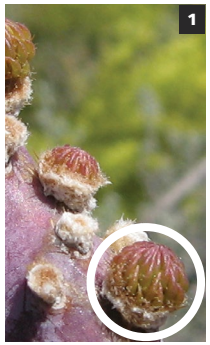
(Santa Rita pricklypear)

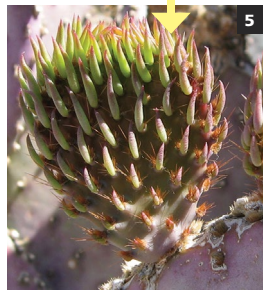
Activity begins in spring as stem and floral buds emerge from "areoles"—specialized growth areas dotted across the plant—on or near the top edge of a pad. Both bud types are covered with tiny, succulent, pointed leaves that typically dry up and fall off early in development. Stem and floral buds are distinguished by their different shapes (Images 1-5).

Flower phenophases

Santa Rita pricklypears usually produce several flower buds. Once you see a flower bud begin to emerge (Image 6, white arrow), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

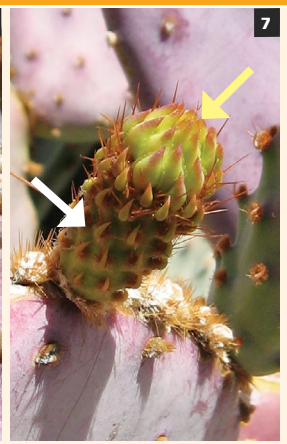
The "Open flowers" phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried.





Stem and floral buds. Floral buds are round when viewed from above (Image 1, white circle) and grow into a cylindrical shape (Image 4). Stem buds are oval when viewed from above (Image 2, yellow oval) and grow into a flat, round pad (Image 5). Both types are growing side by side in Image 3—a floral bud on the left (white arrow) and a stem bud on the right (yellow arrow).

FLOWERS OR FLOWER BUDS



Round flower buds (Image 6, white arrow) emerge from areoles on the top edge of pads. Buds slowly elongate, with the ovary embedded in the lower half of the bud (Image 7, white arrow), and the rest of the flower, covered by sepals, developing on the upper half (Image 7, yellow arrow). Eventually sepals fold back to reveal yellow petals (Image 9, white arrow) before the flower opens.

OPEN FLOWERS

When the petals fold open, male (red arrows) and female (orange arrow) reproductive parts become visible. Flowers usually are open for only a single day before withering.

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

Opuntia santa-rita

(Santa Rita pricklypear)

Fruit phenophases

When a Santa Rita pricklypear flower's ovary has been fertilized, a fruit—called a "tuna"—will begin to develop.

The *Nature's Notebook* fruit definition reads "For *Opuntia santa-rita*, the fruit is fleshy and berry-like and changes from green to red. A fruit is considered ripe when it has turned red."

In some conditions, pads and unripe fruits will be a purplish color (Images 14-15). Fruits are not ripe until they become a brighter red than the pads.

The ovary (white arrow) is located below the withered petals. Not all ovaries will develop into fruits—when not fertilized, they will just shrivel and dry up.

FRUITS

An ovary has entered the "Fruits" phenophase once it starts to swell and get larger (white arrows). Do not worry if you do not catch the first subtle signs of swelling and begin reporting "yes" for "Fruits" once you notice the ovary getting larger.

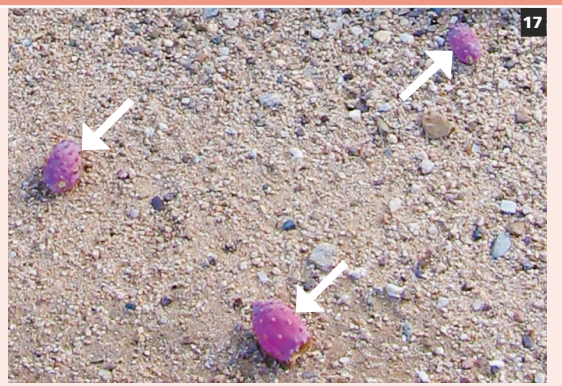
FRUITS

As fruits develop, they grow plumper and rounder (white arrows). Unfertilized ovaries will shrivel (yellow arrow) and eventually fall off the plant.

RIPE FRUITS

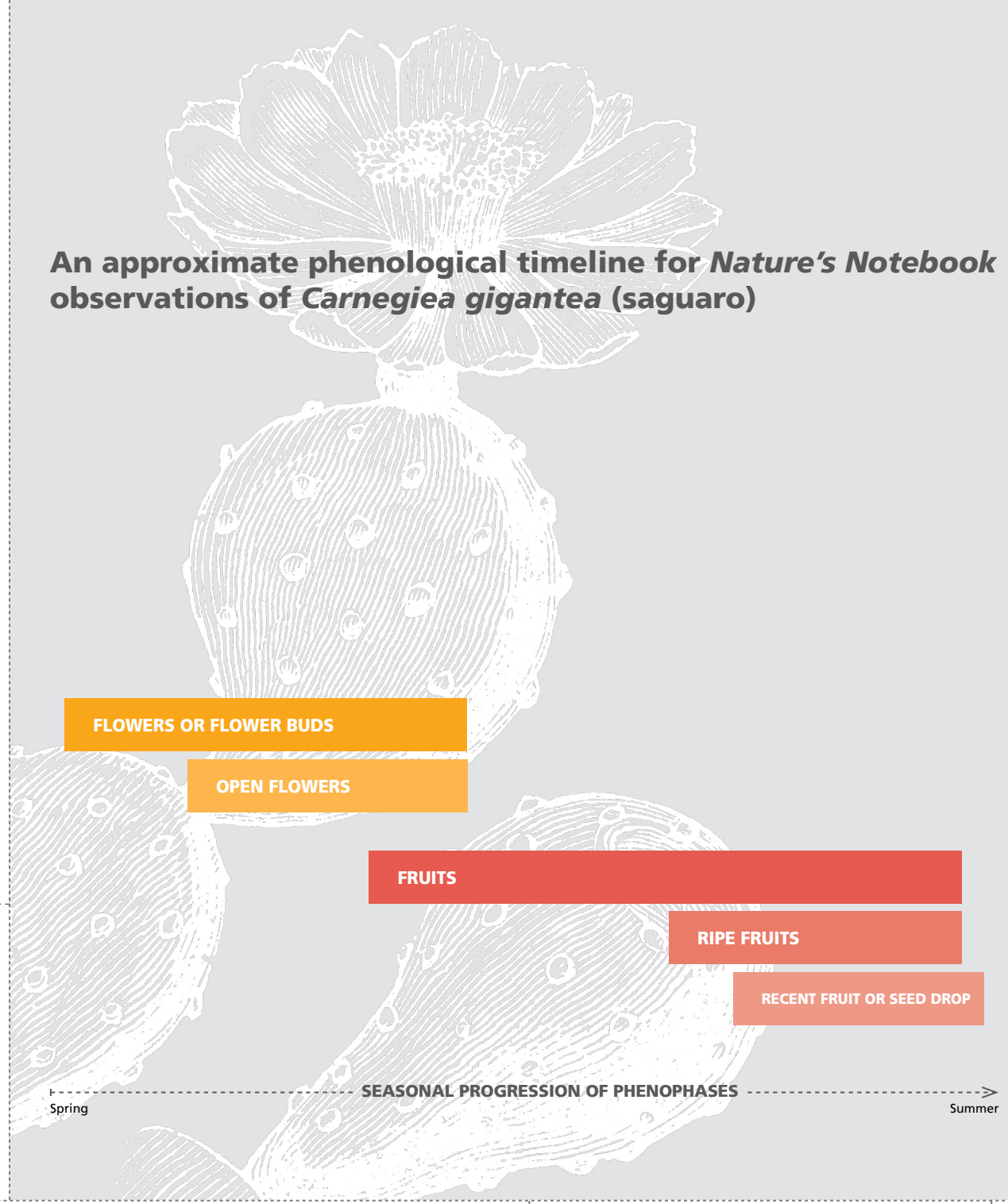
A fruit is ripe when in has turned bright red in color.

RECENT FRUIT OR SEED DROP



Mature fruits might drop to the ground (white arrows), or might be taken from the plant and eaten by wildlife. Report "yes" for "Recent fruit or seed drop" if you notice a fruit missing from the plant that was present at your last visit.

An approximate phenological timeline for *Nature's Notebook* observations of *Carnegiea gigantea* (saguaro)



Saguaro is found in the Sonoran desert and is the largest cactus that grows in the US, reaching up to 50 feet and weighing over a ton. Tall and columnar, with characteristic large "arms", it was often used in the backdrop landscapes of old Western movies.

Its white flowers open at night and last partway through the following day, providing nectar to attract bat, bird and insect pollinators. Fleshy fruits provide food for many bird and insect species, as well as humans. Woodpeckers and flickers carve out nest cavities in the large stems, and small owls and other birds use the abandoned holes in subsequent years. Saguaros are important to many species and Saguaro National Park in Arizona was established to preserve and honor this species' uniqueness.

Phenological characteristics of note:

- flower buds appear from top of stem
- fleshy fruits split open when ripe

Carnegiea gigantea

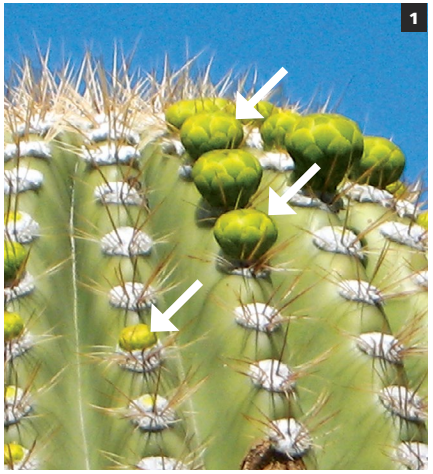
(saguaro)

Activity begins as floral buds emerge from "areoles"—specialized growth areas dotted across the plant—usually near the top of the main stem or its branches. Floral buds usually emerge in spring, but could appear at other times of the year if resources allow. Stem buds also occasionally appear—these become the characteristic "arms" of the saguaro cactus—but are usually lower down on the main stem. Stem and floral buds can be distinguished by different characteristics (Images 1-2).

Flower phenophases

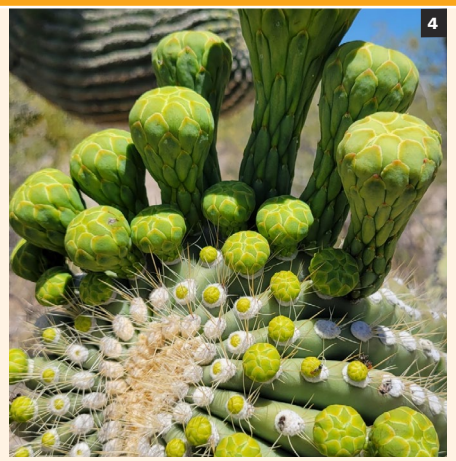
Saguaros usually produce many flower buds that open sequentially over several weeks. Once you see a flower bud begin to emerge (Image 3, white arrows), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

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



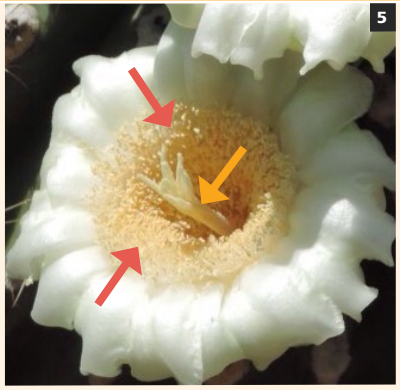
Stem and floral buds. Floral buds (Image 1, white arrows) are smooth and protected by sepals that cover the surface. They are usually located near the top of the plant. Stem buds (Image 2, white arrow) are lumpy and covered with protective spines. They are usually located partway down the main stem.

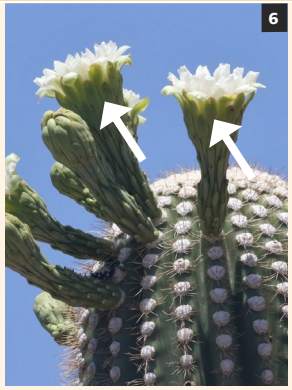
FLOWERS OR FLOWER BUDS



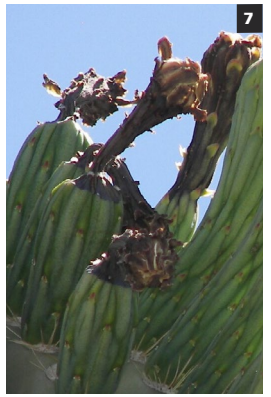
Flower buds emerge from areoles near the top of the plant (Image 3, white arrows) and gradually elongate. They usually emerge and develop sequentially—instead of all at once—so are at different sizes and stages of growth (Image 4).

OPEN FLOWERS





When flowers fold open, male (red arrows) and female (orange arrow) reproductive parts become visible, although they may be hard to see in flowers turned upward (Image 6, white arrows). Each flower lasts less than a day—opening at night then closing and withering the following day.



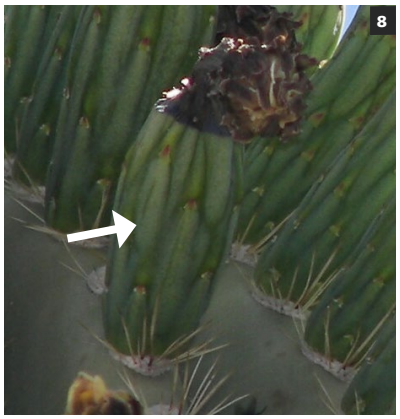
Spent flowers. The upper part of the flowers have withered and are no longer fresh.

Carnegiea gigantea
(saguaro)

Fruit phenophases

When a saguaro flower's ovary has been fertilized, the fruit will begin to develop.

The *Nature's Notebook* fruit definition reads "For *Carnegiea gigantea*, the fruit is a fleshy, juicy, very large berry that changes from green to yellow-green, reddish-green or red and splits open to expose red pulp filled with seeds. A fruit is considered ripe when it has turned yellow-green, reddish-green or red and has split open to expose red pulp filled with seeds. Do not include empty fruits that no longer have any red pulp or seeds."

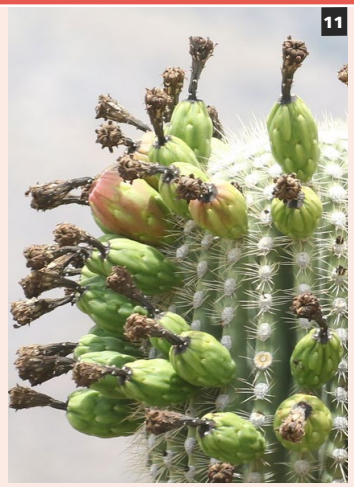


The ovary (white arrow) is located below the withered petals. Not all ovaries will develop into fruits—when not fertilized, they will shrivel and dry up.

FRUITS

An ovary has entered the "Fruits" phenophase once it starts to swell and get larger (white arrows). Do not worry if you do not catch the first subtle signs of swelling and begin reporting "yes" for "Fruits" once you notice the ovary getting larger.

FRUITS



As fruits develop, they grow plumper and rounder, and change from green to yellow-green and sometimes reddish-green or red before they split open.

RIPE FRUITS

A fruit is ripe when it has split open to expose the juicy red pulp with black seeds (white arrows).

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if you see a fruit that dropped off the plant since your last visit, or a fruit on the plant that has lost some or all of its seeds since your last visit.

Empty fruits that have lost all of their red pulp and seeds—most likely eaten by wildlife—should not be included in the "Fruits" or "Ripe fruits" phenophases.

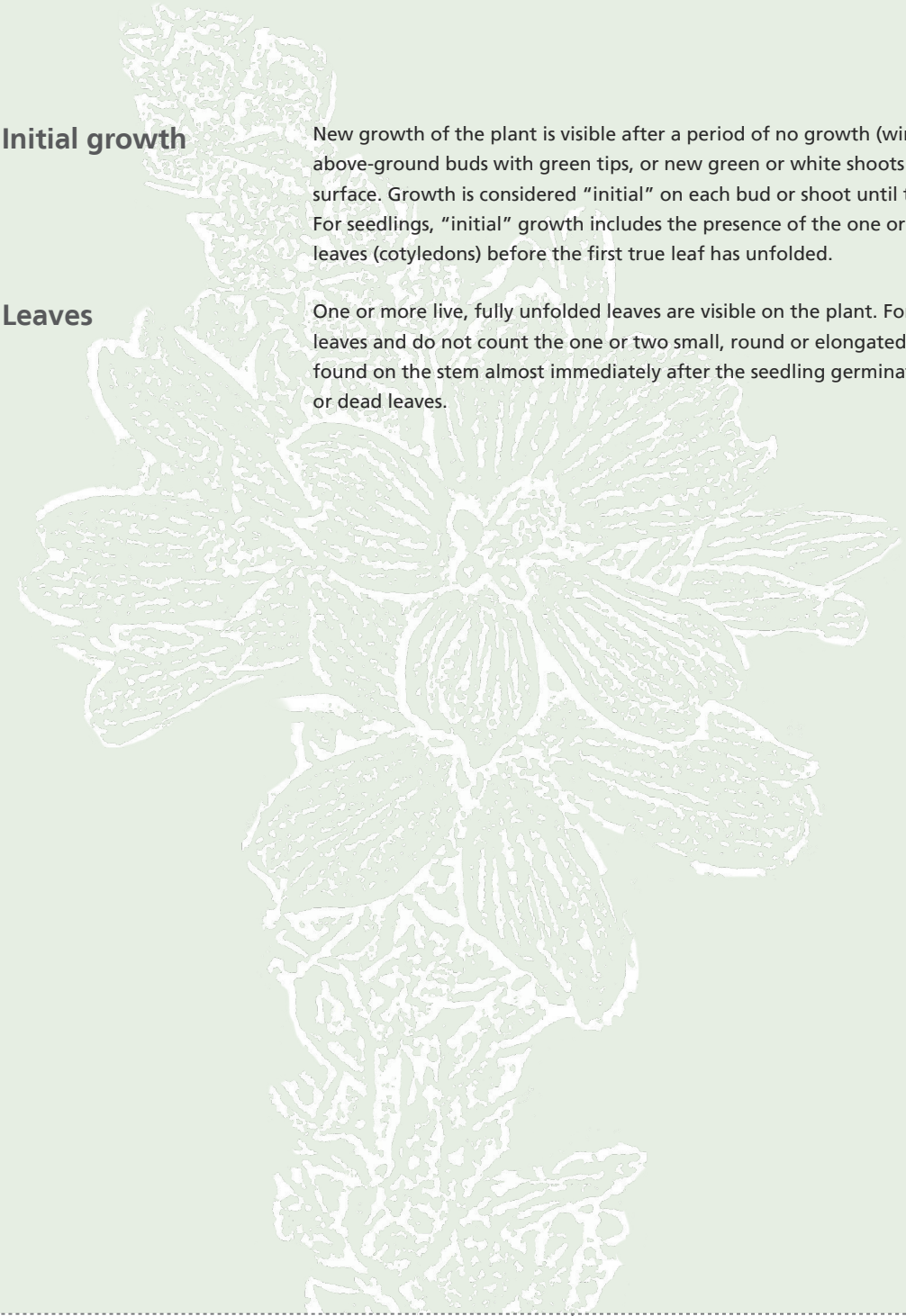
FORB

This functional group includes annual, biennial and perennial herbaceous plant species, as well as subshrubs that have no (or very little) aboveground, woody growth. The species in this group die back to the ground at the end of their growing season and, unless they are annuals, resprout after a dormant period (typically winter).

Many species in this group grow in clumps of clonal shoots or clusters of small individuals, and are most easily observed as a patch.

Representative species:

- *Erythronium americanum* (dogtooth violet)
- *Podophyllum peltatum* (mayapple)
- *Helianthus annuus* (common sunflower)



Initial growth

New growth of the plant is visible after a period of no growth (winter or drought), either from above-ground buds with green tips, or new green or white shoots breaking through the soil surface. Growth is considered "initial" on each bud or shoot until the first leaf has fully unfolded. For seedlings, "initial" growth includes the presence of the one or two small, round or elongated leaves (cotyledons) before the first true leaf has unfolded.

Leaves

One or more live, fully unfolded leaves are visible on the plant. For seedlings, consider only true leaves and do not count the one or two small, round or elongated leaves (cotyledons) that are found on the stem almost immediately after the seedling germinates. Do not include fully dried or dead leaves.

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; More than 1000

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

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.

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; More than 1000

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; More than 1000

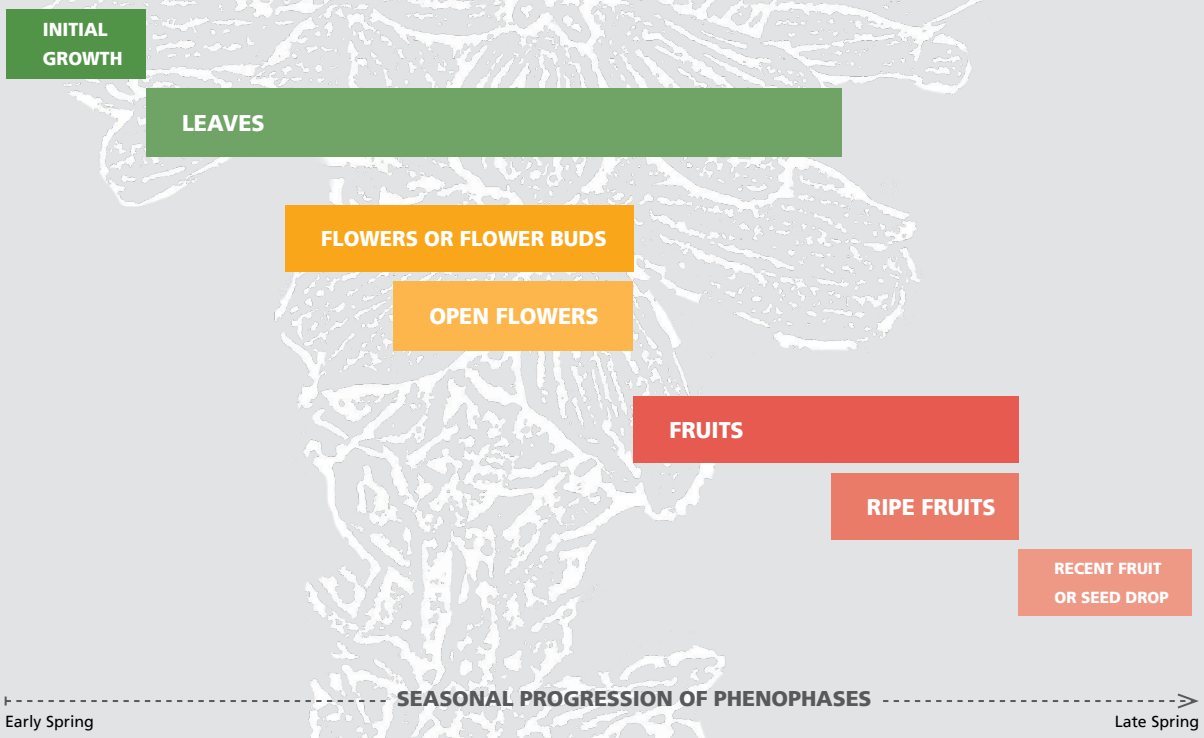
Dogtooth violet (also called trout lily) is a perennial forb found in deciduous forests of the eastern US, and is one of the earliest flowers to appear each spring. Known as a "spring ephemeral", it is one of many species that take advantage of sunlight reaching the forest floor beneath still-dormant and leafless trees, completing its growth cycle before the forest canopy is full with leaves. Until the plant is mature—which can take up to eight years—it initiates just one leaf each year. Once an individual plant is mature and ready to flower, it will produce two leaves before flowering. The yellow flowers are insect-pollinated.

The timeline represents an individual plant which has only one or two leaves and a single flower and fruit. If observed as a patch of individuals, the plants as a group could display more overlap in the phenophases.

Phenological characteristics of note:

- leaves unfold very quickly after emergence
- leaf out before flowering
- "dehiscent" fruit capsule splits open when ripe

An approximate phenological timeline for *Nature's Notebook* observations of *Erythronium americanum* (dogtooth violet)



Erythronium americanum

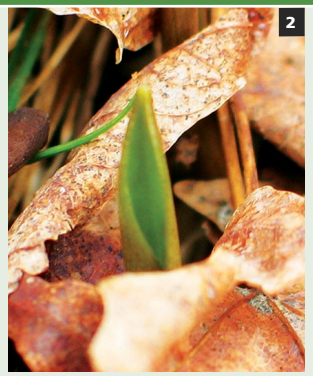
(dogtooth violet)

Activity begins early in spring as a narrow shoot—really just a tightly rolled leaf—pokes through the soil surface. Each plant will produce one or two leaves. A young individual will produce just one leaf and no flower. A reproductively mature individual will produce two leaves followed by a single flower.

Leaf phenophases

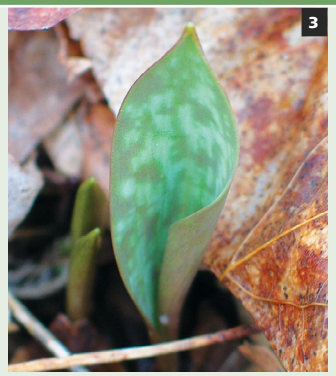
"Initial growth" begins when a shoot first pokes through the soil surface. Then, when the upper half of the shoot's first leaf becomes fully unfolded or unrolled (Image 3), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf has completely dried out or decomposed. If you are observing this species as a patch, some individuals will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last shoot's leaf has unrolled.

INITIAL GROWTH



Once a shoot is visible (Image 1, white arrow), the "Initial growth" phase has begun. The shoot remains in this phenophase until the leaf has unrolled (Image 3). If leaves unroll quickly, or if shoots are hidden under leaf litter, you may never see and be able to report "yes" for this phenophase.

LEAVES



Once the upper half of the leaf has unrolled (it may still be rolled at the base), the plant has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES

Large patches of dogtooth violet often include many young individuals with a single leaf (Image 4, white arrows) and only a few individuals mature enough to flower. These older individuals have two leaves emerging from the same shoot (Image 5). Leaves begin to yellow and wither shortly after flowering (Image 6) and often deteriorate and disappear into the leaf litter before the fruits ripen.

Erythronium americanum
(dogtooth violet)

Flower phenophases

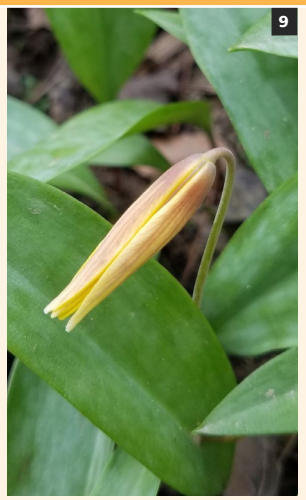
Dogtooth violets, when they are reproductively mature, will produce a single flower that emerges from between the pair of leaves. Once you see the flower bud and its stalk begin to emerge (Image 7, white arrow), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

The "Open flowers" phenophase begins when reproductive parts become visible and ends when the last flower is withered or dried. Each flower has three petals and three sepals, collectively called "tepals", that fold back to reveal male and female reproductive parts.

FLOWERS OR FLOWER BUDS


7


8


9

The single flower bud will emerge from between the two leaves (Image 7, white arrow). While the yellow tepals remain folded together, the flower is not yet open.

FLOWERS OR FLOWER BUDS

OPEN FLOWERS


10


11

Once the tepals fold back, male (red arrows) and female (orange arrow) reproductive parts become visible.


12


13

Spent flower. The tepals have closed back up and wilted and the flower is no longer fresh.

Erythronium americanum

(dogtooth violet)

Fruit phenophases

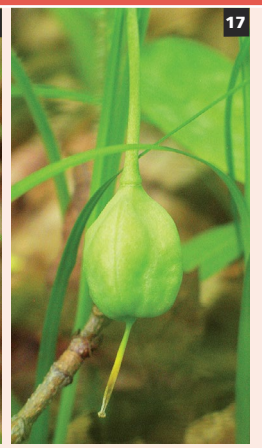
When a dogtooth violet flower's ovary has been fertilized, a fruit capsule will begin to develop not long after the tepals wilt.

The *Nature's Notebook* fruit definition reads "For *Erythronium americanum*, the fruit is a capsule that changes from green to brown and splits open 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."

Fruits often are lying on the ground, still attached to the stalk, while they develop.

The ovary becomes visible (white arrow) after tepals drop off. Not all ovaries will develop into fruits—when not fertilized, they will just wither and dry up.

FRUITS

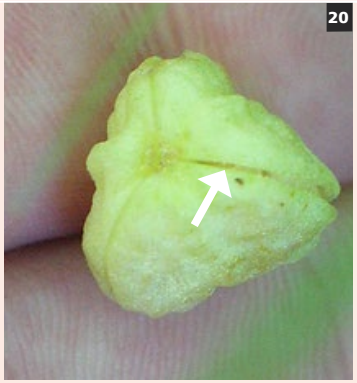


Begin reporting "yes" for "Fruits" once you notice the ovary starting to swell and get larger (Image 15, white arrow). Do not worry if you do not catch the first subtle signs of swelling and begin reporting "yes" for "Fruits" once you notice the ovary getting larger.

FRUITS

As the fruit gets heavier, its stalk bends until eventually the developing fruit may be lying on the ground, still attached to the stalk.

RIPE FRUITS



A fruit is ripe when it turns a yellow, tan or brown color and starts to split open along the seams (Image 20, white arrow). It will be difficult to keep track of fruit development if the capsule is lying on the ground and hidden among the leaves of other plants.

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if you see a capsule that has opened and lost some or all of its seeds since your last visit.

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

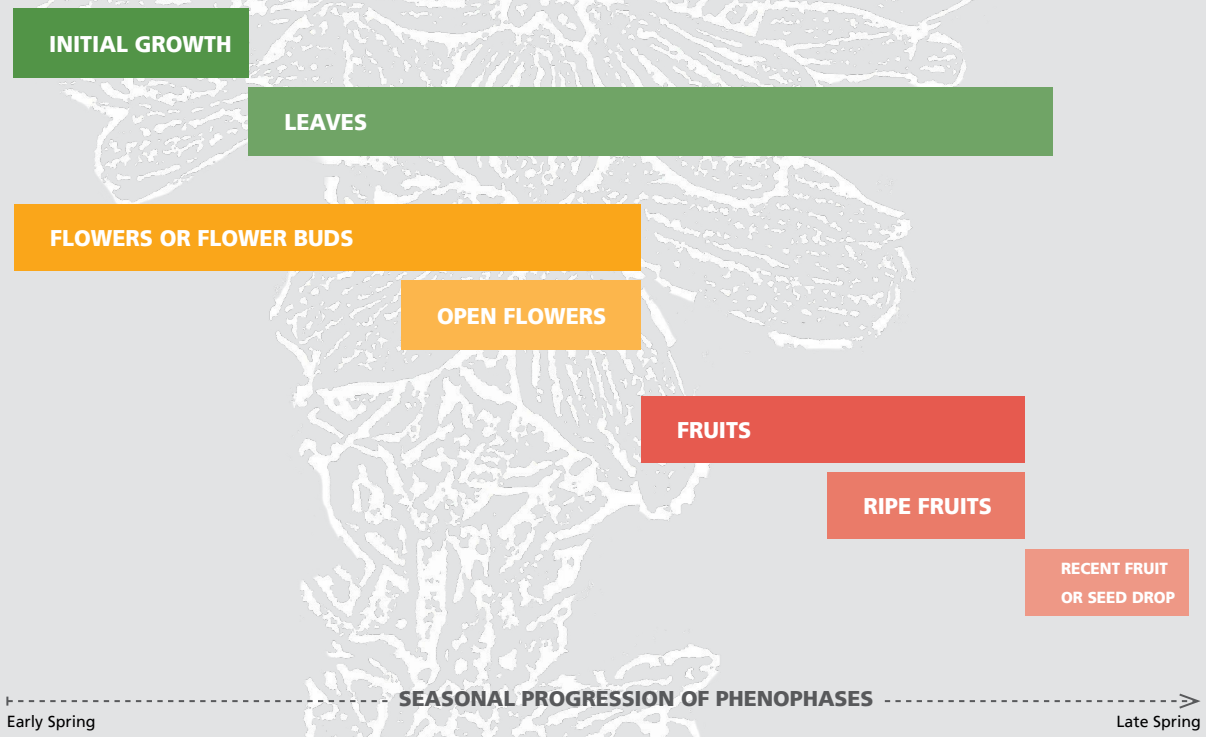
Mayapple is a another perennial forb of deciduous forests of the eastern US known as a "spring ephemeral". Its growth starts early in spring, taking advantage of sunlight reaching the forest floor beneath still-dormant and leafless trees. Until the plant is mature—which can take up to twelve years—it initiates just one leaf each year. Once an individual plant is mature and ready to flower, it will produce two leaves and one flower bud between the leaves. Flowers are insect-pollinated. After an individual plant flowers, it may rest in subsequent years before flowering again.

The timeline represents an individual plant which has only one or two leaves and a single flower and fruit. If observed as a patch of individuals, the plants as a group could display more overlap in the phenophases.

Phenological characteristics of note:

- flower bud and leaves emerge simultaneously on a new shoot
- fruit ripeness indicated by subtle color change

An approximate phenological timeline for *Nature's Notebook* observations of *Podophyllum peltatum* (mayapple)



Podophyllum peltatum

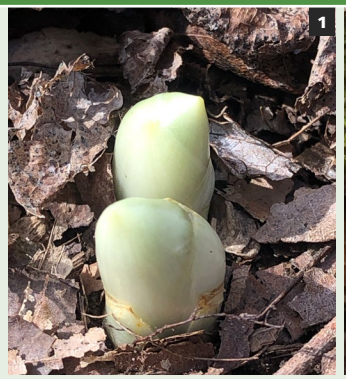
(mayapple)

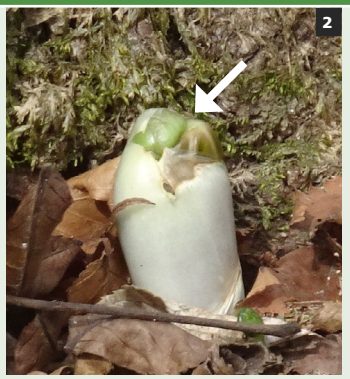
Activity begins early in spring as a thick, whitish green shoot pokes through the soil surface. Each plant will produce one or two umbrella-like leaves. A young individual will produce just one leaf and no flower. A reproductively mature individual will produce two leaves with a flower bud between them.

Leaf phenophases

"Initial growth" begins when the shoot first pokes through the soil surface (Image 1)—or if white shoots are visible aboveground all winter, when the green leaf or flower bud can be seen poking through the shoot's protective sheath (Image 2, white arrow). Then, when the shoot's leaf or leaves become fully unfolded (Images 11-12), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf is dried and dead. If you are observing this species as a patch, some individuals will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last shoot's leaf has unfolded enough to resemble a mostly open umbrella.

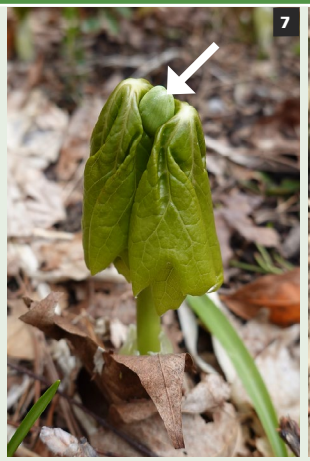
INITIAL GROWTH

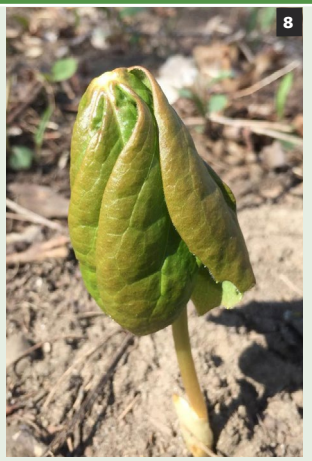




Once a shoot is visible (Image 1 shows two shoots), the "Initial growth" phase has begun. Sometimes dormant shoots are visible over the winter, in which case do not start reporting "yes" for "Initial growth" until the plant is clearly starting to grow and push through the shoot's white, protective sheath (Image 2, white arrow).

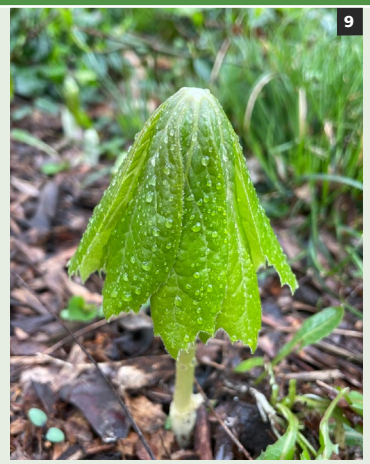
INITIAL GROWTH

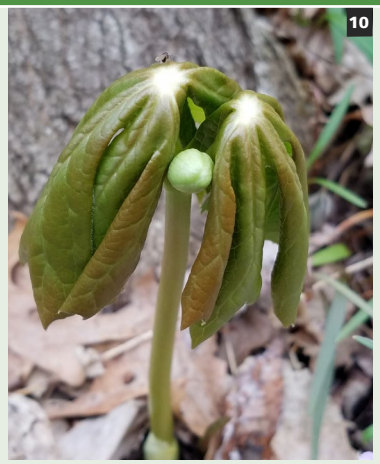




The shoot remains in the "Initial growth" phenophase while it emerges from the ground and grows taller, the one or two leaves still folded down next to the stem like a closed umbrella. Images 3-8 show this progression in young (Images 3, 6 and 8) and reproductively mature (Images 4, 5, and 7) individuals. The single flower bud is evident in the reproductively mature plants (white arrows).

INITIAL GROWTH


9


10

Eventually the leaf begins to fold upward like an opening umbrella. The plant remains in the "Initial growth" phenophase until the leaf resembles a mostly open umbrella (Images 11-12).

LEAVES


11


12

Once the lobes of the leaf have folded upward and spread out enough that they are barely overlapping, like a mostly open umbrella, the plant has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES


13


14

A plant remains in the "Leaves" phenophase until its leaves are dried and dead. Leaves begin to senesce and turn yellow (Image 14) while fruits are developing.


15

Dried and dead leaves.

Podophyllum peltatum

(mayapple)

Flower phenophases

Mayapples, when they are reproductively mature, will produce a single flower the hangs below the leaves. The single flower bud is the first thing that can be seen pushing through the shoot's protective sheath as the shoot emerges from the ground. Report "yes" for "Flowers or flower buds" when you see the flower bud emerge—most likely at the same time or shortly after you begin reporting "yes" for "Initial growth"—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.

FLOWERS OR FLOWER BUDS

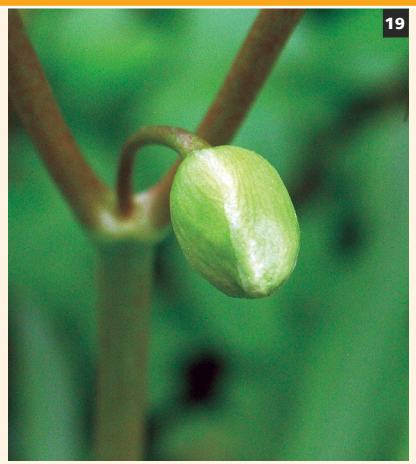

16


17


18

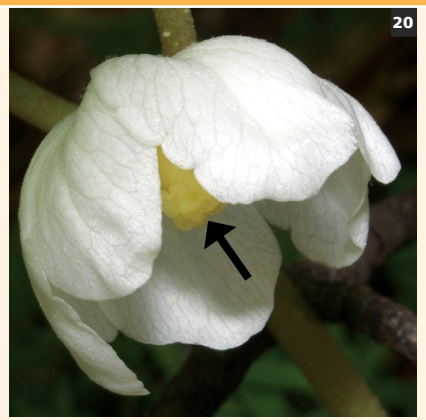
The single flower bud (white arrows) is at the top of the emerging shoot and will be the first thing to push through the protective sheath (Image 16). The flower bud is positioned on the stem between the two leaves and becomes hidden under the leaves as they fold upward.

FLOWERS OR FLOWER BUDS


19

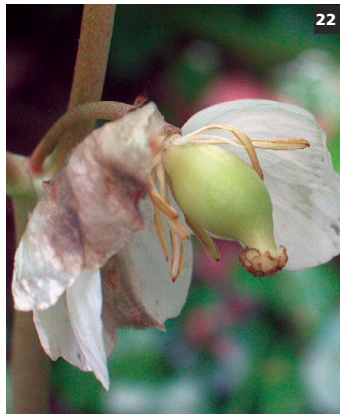
As the flower bud grows larger and heavier, it begins to bend downwards.

OPEN FLOWERS


20


21

When the petals fold open, reproductive parts become visible (Image 20, black arrow). Male (red arrows) and female (orange arrow) reproductive parts are clustered together in the center of the white (or sometimes pink) petals.


22

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

Podophyllum peltatum

(mayapple)

Fruit phenophases

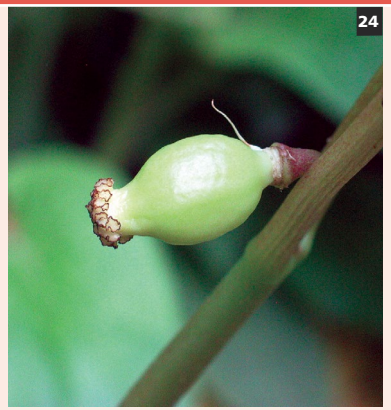
When a mayapple flower's ovary has been fertilized, a fruit will begin to develop soon after—sometimes even before—the petals wilt.

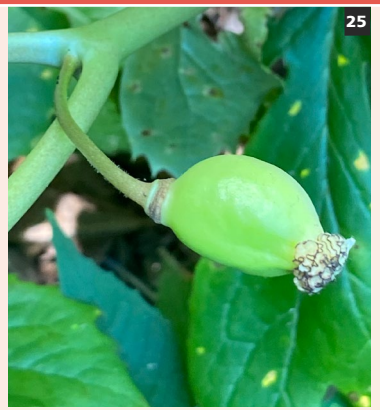
The *Nature's Notebook* fruit definition reads "For *Podophyllum peltatum*, the fruit is berry-like and changes from green to yellow or occasionally orange, red or purplish. A fruit is considered ripe when it has turned yellow, orange, red or purplish."

Fruits may be lying on the ground, still attached to the stalk, while they develop and ripen.

The ovary (white arrow) becomes visible after petals drop off. Not all ovaries will develop into fruits—when not fertilized, they will just wither and dry up.

FRUITS



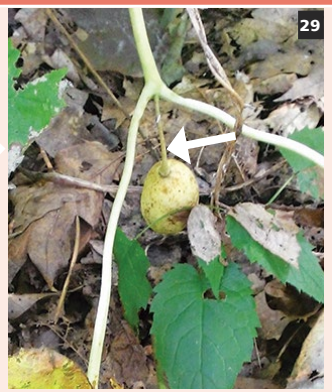


The ovary has entered the "Fruits" phenophase once it starts to swell and get larger. Do not worry if you do not catch the first subtle signs of swelling and begin reporting "yes" for "Fruits" once you notice the ovary getting larger.

FRUITS

As the fruit develops it gets larger and heavier and hangs closer to the ground (Image 27, white arrow). It gradually changes to its ripened color of yellow, or occasionally orange, red or purplish. Often the color change is subtle and the ripened color is more yellowish-green than yellow (Image 30).

RIPE FRUITS

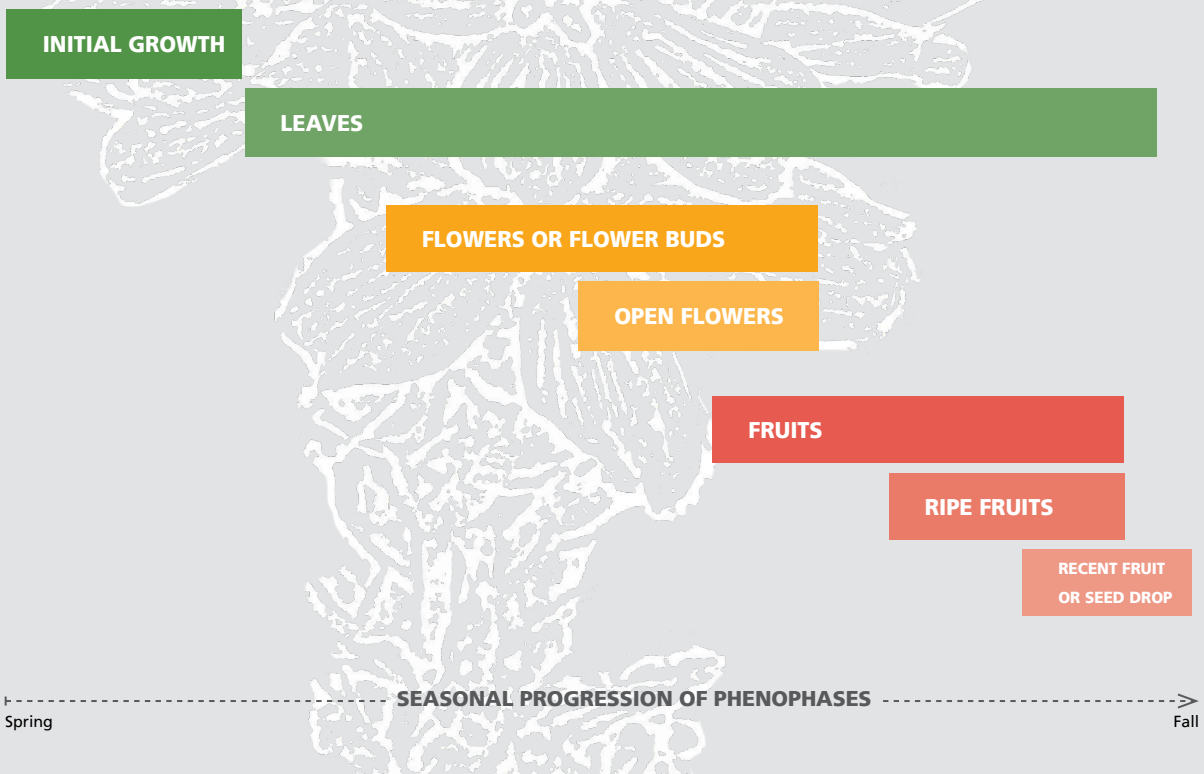


A fruit is ripe when it has turned yellow, orange, red or purplish. Often fruits are resting or lying on the ground, still attached to the stalk (white arrows), when they become ripe.

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if you see a fruit that dropped off the plant since your last visit, or if the fruit was already lying on the ground, then when the stalk seems withered and no longer firmly attached.

An approximate phenological timeline for *Nature's Notebook* observations of *Helianthus annuus* (common sunflower)



The common sunflower is widespread across the US and can be found in a variety of forms on the landscape—roadside wild types as well as hundreds of domesticated agricultural and garden varieties. This species is an example of a plant with an annual life cycle—germinating from seed, maturing, and dying in one growing season. Even though the many forms differ in size, they all share the phenological characteristics illustrated here, most notably a complex floral structure where many tiny, individual flowers—and then fruits—are clustered in one or more showy flower heads. For a broad overview of floral characteristics of the sunflower family (Asteraceae), see page 64 in Section 1 of this *Primer*.

Phenological characteristics of note:

- growth starts with a seedling
- complex floral structure with multiple types of tiny flowers
- individual fruits arranged in large spent flower head
- fruit ripeness indicated by readiness to drop

Helianthus annuus

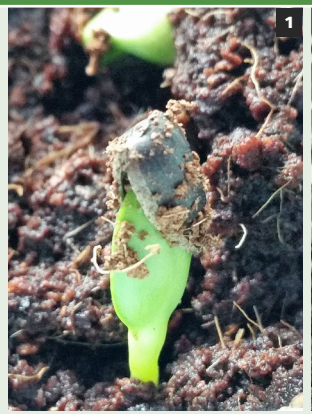
(common sunflower)

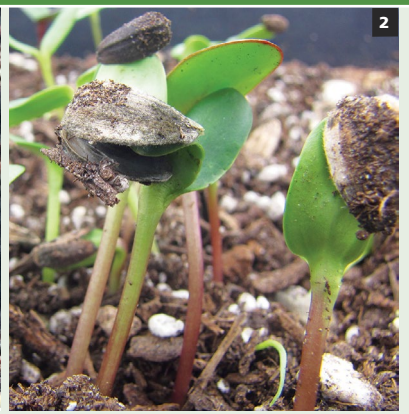
Activity begins with the emergence of a seedling from the soil surface after the conditions required for seed germination have been met. Common sunflower is a dicotyledonous plant, meaning that the first two "leaves" to appear are its cotyledons or seed leaves. The next two leaves that emerge from between the cotyledons at the top of the stem are the plant's first true leaves.

Leaf phenophases

"Initial growth" begins when the seedling shoot and cotyledons first poke through the soil surface. Then, when the first tiny pair of true leaves have unfolded enough to see at least one entire leaf blade (Image 4), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf is dried and dead. If you are observing this species as a patch, some individuals will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last seedling's first true leaf has unfolded.

INITIAL GROWTH


1


2

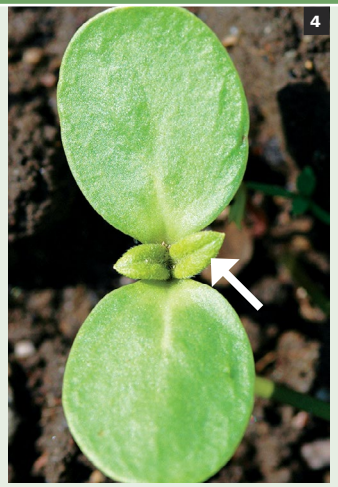
Once a sprouting seedling is visible (Image 2 shows several seedlings), the "Initial growth" phase has begun. The seedling remains in this phenophase until the first true leaf has unfolded (Image 4). If true leaves unfold quickly, you may never see and be able to report "yes" for this phenophase.

INITIAL GROWTH


3

Two round cotyledons unfold before the first true leaves appear.

LEAVES


4


5


6


7

Once the first tiny pair of true leaves (with pointed leaf tips) has emerged from between the cotyledons and unfolded such that at least one entire leaf blade is visible (Image 4, white arrow), the plant has left the "Initial growth" phase and entered the "Leaves" phenophase. Cotyledons fall off the stem as the plant gets taller and produces more leaves (Images 5-6). As leaves senesce in the fall, they often turn yellow (Image 7) before the plant dries up and dies.

Helianthus annuus

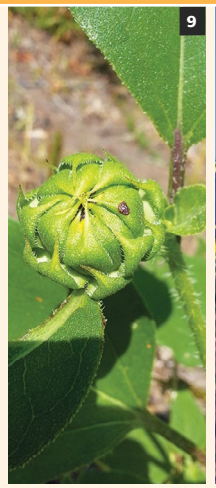
(common sunflower)

Flower phenophases

Common sunflowers have yellow or orange flowers arranged in a disc-shaped inflorescence—called a "capitulum"—that emerges from the stem tip after leaves have been produced. Some types of common sunflower have only one inflorescence per plant and others have many. Once you see an inflorescence bud begin to emerge (Image 8, white arrow), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

Although a sunflower inflorescence might seem like a single flower with petals around the edge, there are actually lots of very tiny, individual flowers in the flower head. These tiny flowers are of two different types: ray florets are the yellow petals around the edge, and disc florets are crowded in the center. As the inflorescence opens, the petals of the ray florets fold back to reveal the disc florets which are usually starting to open and expose their tiny male and female reproductive parts (which may be hard to see without a hand lens). Begin reporting "yes" for "Open flowers" when reproductive parts become exposed on any of the disc florets, and continue reporting "yes" until the last disc floret on the plant is withered or dried.

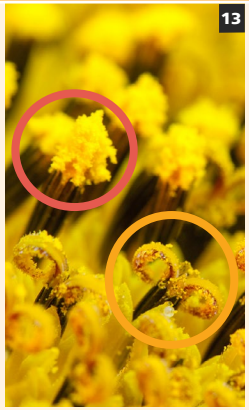
FLOWERS OR FLOWER BUDS



Inflorescence buds will emerge from stem tips (Image 8, white arrow). While the yellow petals remain folded over the center (Image 10), the tiny disc florets are probably not yet open.

FLOWERS OR FLOWER BUDS

OPEN FLOWERS



When ray floret petals fold back to uncover the disc florets in the center of the flower head, the first flowers usually start to open (Images 11-12, white arrows). Each tiny disc floret has a fused cluster of male anthers (Image 13, red circle) from the center of which a female stigma (Image 13, orange circle) eventually emerges. Disc florets open sequentially, with those on the outer edge of the flower head opening first (Image 14, white arrow), followed by those closer to the center. Image 15 shows the outer florets spent, while the innermost florets (white circle) are still open and fresh.

Spent flowers. The disc florets have all withered and are no longer fresh. Yellow petals of the ray florets may or may not be withered when the "Open flowers" phase ends.

Helianthus annuus

(common sunflower)

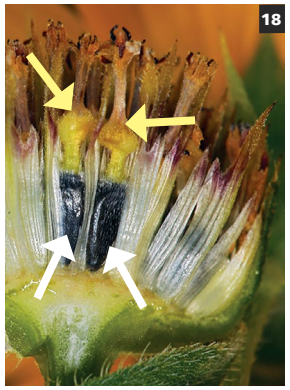
Fruit phenophases

Once the tiny ovary of a disc floret has been fertilized, a fruit will begin to develop soon afterwards. The edible snack food we know as the unhulled "sunflower seed" is technically the fruit of the plant.

The *Nature's Notebook* fruit definition reads "For *Helianthus annuus*, the fruit is very tiny and seed-like and is crowded into a large spent flower head. The seed-like fruit changes from white or light yellow-green to gray or black, often striped with white, and drops from the plant. A fruit is considered ripe when it has turned gray or black, often striped with white, or when it readily drops from the spent flower head when touched. Do not include empty flower heads that have already dropped all of their fruits."

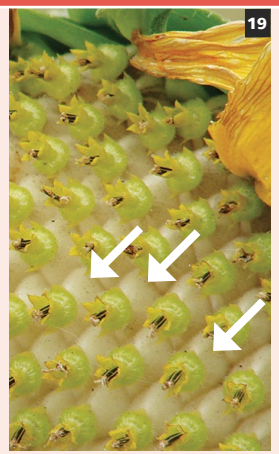
Since florets open gradually across the inflorescence instead of all at once, it is possible for a single flower head to have some of the inner disc florets in the "Open flowers" phenophase, while outer florets are in the "Fruits", or even "Ripe fruits", phenophases.


17


18

Spent flower parts may remain attached to the top of the ovary for some time, and with so many florets crowded together in the flower head (Image 17), it might be difficult to determine when the ovaries hidden underneath start to swell and begin developing into fruits. Do not worry if you do not catch the first subtle signs of swelling. Image 18 shows a cross-section of a flower head and the location of the developing fruit (white arrows) and dried flower parts on top (yellow arrows).

FRUITS

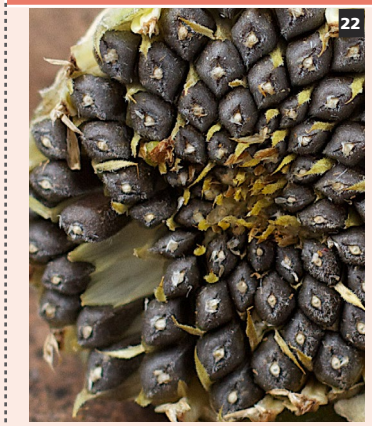

19


20


21

Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger (Image 19, white arrows). Fruits gradually get larger and change color from white to intermediary colors (Image 21, white arrows) to black. Dried flower parts eventually drop from the top of the fruit.

RIPE FRUITS


22

A fruit is ripe when it has turned black and is loose in the flower head and ready to drop.

RECENT FRUIT OR SEED DROP


23

Report "yes" for "Recent fruit or seed drop" if you notice fruits missing that were present at your last visit (white arrows).


24

Empty flower heads that have dropped all their fruits should not be included in the "Fruits" or "Ripe fruits" phenophases.

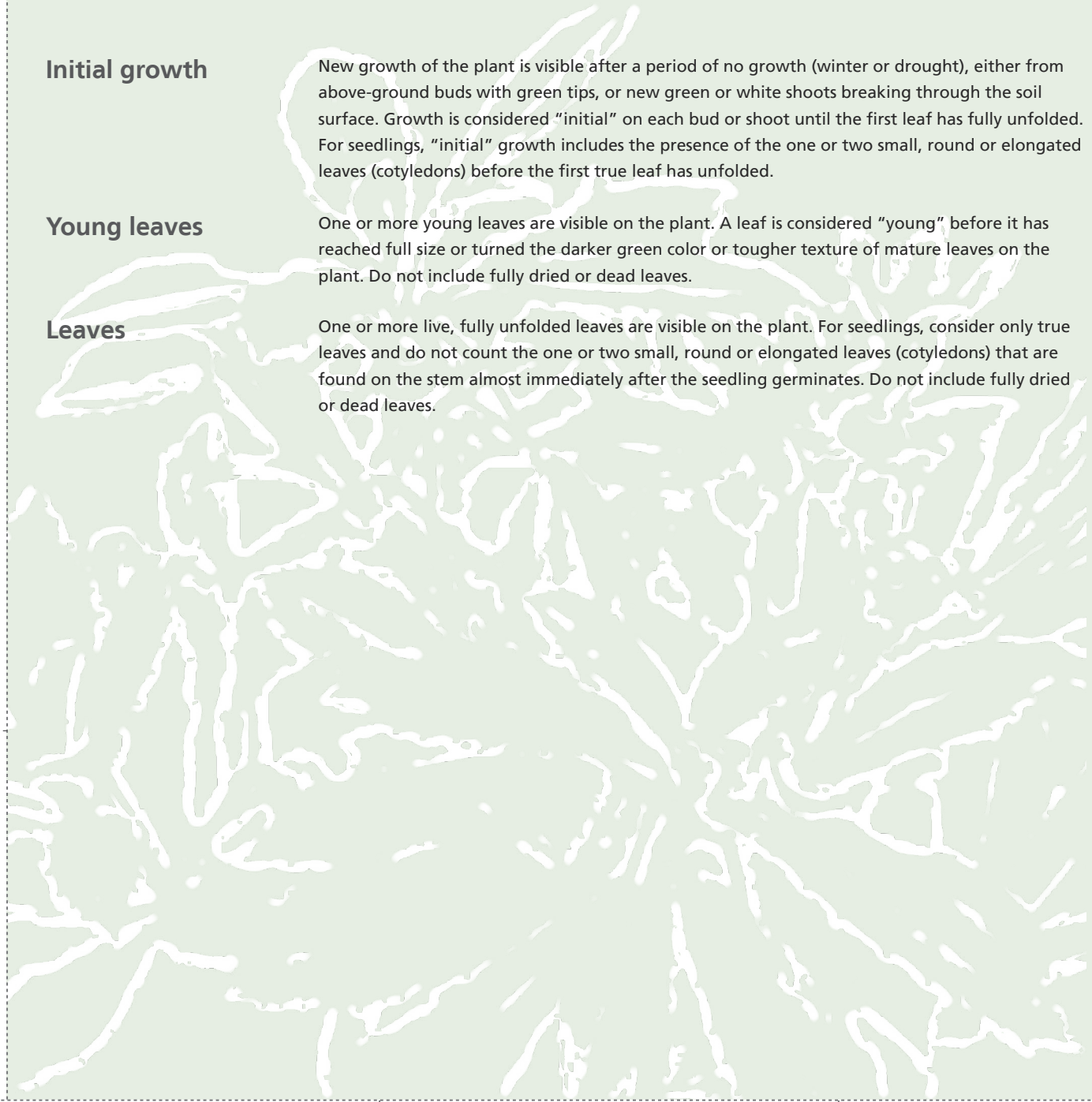
FORB—SEMI-EVERGREEN

This functional group includes herbaceous plant species—and subshrubs that have no (or very little) aboveground, woody growth— with leaves that may or may not remain green on the plant year-round. These species often retain green leaves in some locations or years (typically milder climates and weather conditions), but die back to the ground at the end of the growing season in other locations or years (in more extreme conditions).

Many species in this group grow in clumps of clonal shoots or clusters of small individuals, and are most easily observed as a patch.

Representative species:

- *Fragaria virginiana* (Virginia strawberry)



Initial growth

New growth of the plant is visible after a period of no growth (winter or drought), either from above-ground buds with green tips, or new green or white shoots breaking through the soil surface. Growth is considered "initial" on each bud or shoot until the first leaf has fully unfolded. For seedlings, "initial" growth includes the presence of the one or two small, round or elongated leaves (cotyledons) before the first true leaf has unfolded.

Young leaves

One or more young leaves are visible on the plant. A leaf is considered "young" before it has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

Leaves

One or more live, fully unfolded leaves are visible on the plant. For seedlings, consider only true leaves and do not count the one or two small, round or elongated leaves (cotyledons) that are found on the stem almost immediately after the seedling germinates. Do not include fully dried or dead leaves.

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; More than 1000

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

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.

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; More than 1000

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; More than 1000

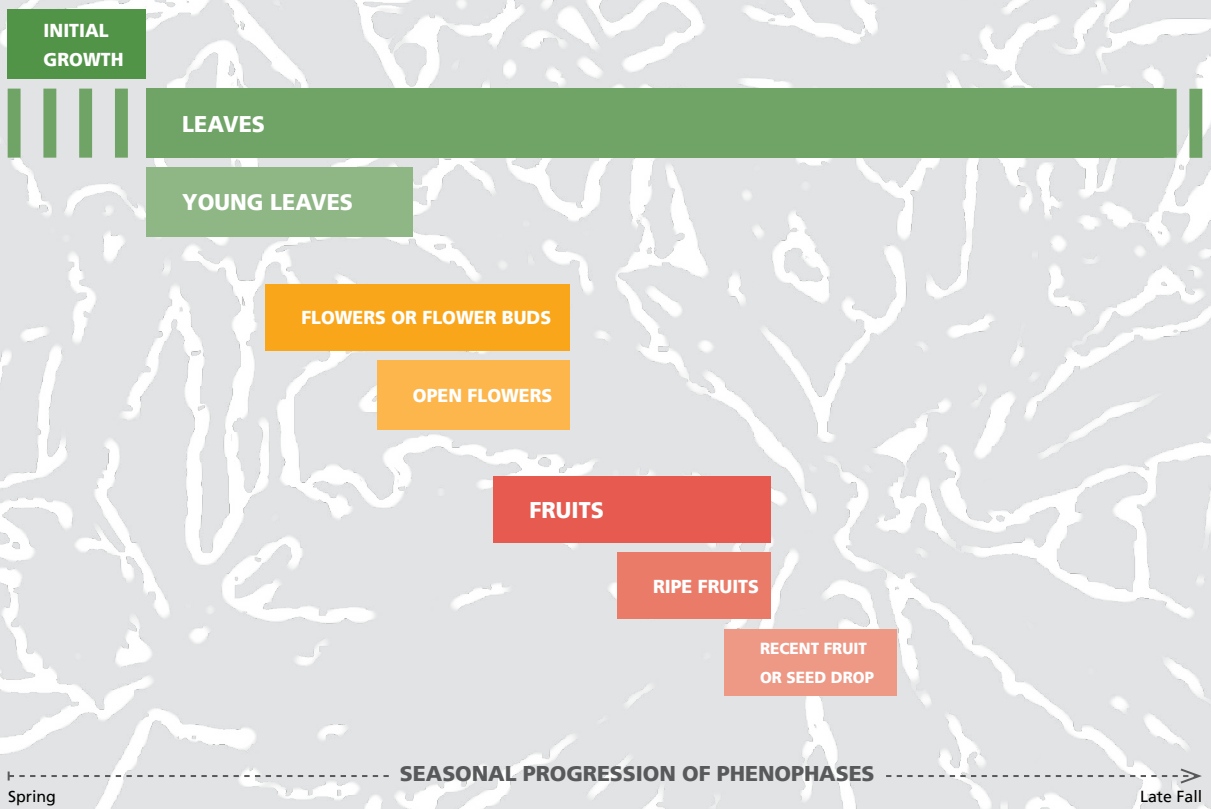
Virginia strawberry is a low-growing perennial forb found across the US. It reproduces both by seed and by stolons (aboveground horizontal stems or "runners"). It is usually found in large patches of individual "plantlets" that form where the plant's stolons come in contact with the soil. Often several leaves, although they may appear battered, will remain alive and green all winter long (represented by the hashed section of the "Leaves" phenophase bar on the timeline).

Its white flowers are insect-pollinated and its fruit is eaten by many birds and animals, including humans who have created the hybrid commercial strawberry. The true botanical fruits of the plant are what we commonly refer to as the "seeds". They are small "achenes" attached and growing on a swollen floral "receptacle" which matures into what we call a strawberry.

Phenological characteristics of note:

- new leaves before flowering
- tiny individual fruits arranged on the surface of an enlarged flower "receptacle"
- fruit ripeness indicated by color change

An approximate phenological timeline for *Nature's Notebook* observations for *Fragaria virginiana* (Virginia strawberry)



Fragaria virginiana

(Virginia strawberry)

Activity begins in spring as new leaves emerge from the locations where stolons are rooted in the soil. These points of growth in a network of stolons represent individual shoots or "plantlets". As new leaves continue to appear throughout spring, they all emerge from the base of the plantlet at this point on the ground.

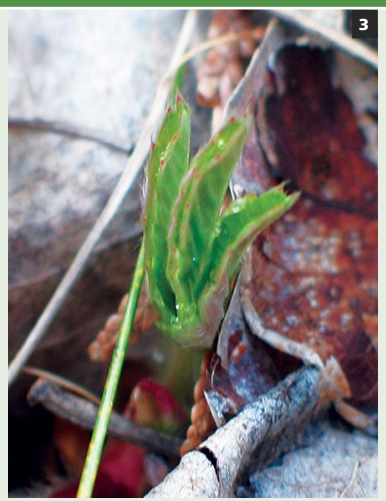
Leaf phenophases

"Initial growth" begins for each plantlet when the first leaf is visible emerging from the ground (Image 1, white arrow) and ends when this first leaf has unfolded (Image 4). "Young leaves" begins with this first unfolded leaf, and ends when all leaves have reached their mature size, color and texture. "Leaves" also begins with this first unfolded leaf, and continues until the last leaf is dried and dead. However, since Virginia strawberry often retains a few live, green leaves throughout the winter, you may be reporting "yes" for "Leaves" all year round. If you are observing this species as a patch, some individual plantlets will be in the "Initial growth" stage while others are in the "Young leaves" stage. "Initial growth" ends in the patch when the last plantlet's first leaf has unfolded.

INITIAL GROWTH

Once the first new leaf of a plantlet becomes visible emerging from the ground (white arrow), the "Initial growth" phase has begun.

INITIAL GROWTH



Each leaf has three leaflets which are initially folded in half and gradually open like a book. The plantlet remains in this phenophase until the leaflets of its first leaf have folded open (Image 4).

LEAVES

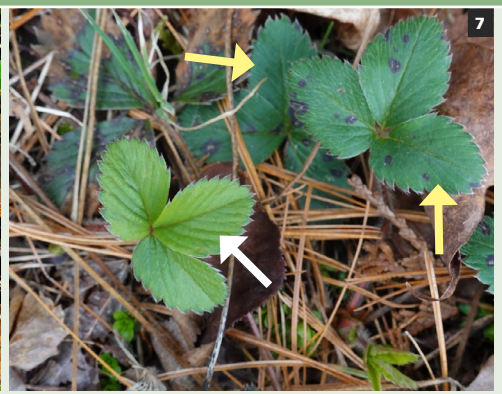
YOUNG LEAVES

Once its three leaflets are most of the way open (Image 4), the first leaf is considered "unfolded" and the plantlet has left the "Initial growth" phase and entered the "Young leaves" phenophase. New leaves will continue to emerge from the base of the plantlet (Image 5, white arrow), but are not considered "Initial growth" because the first leaf from the plantlet (yellow arrow) has already unfolded.

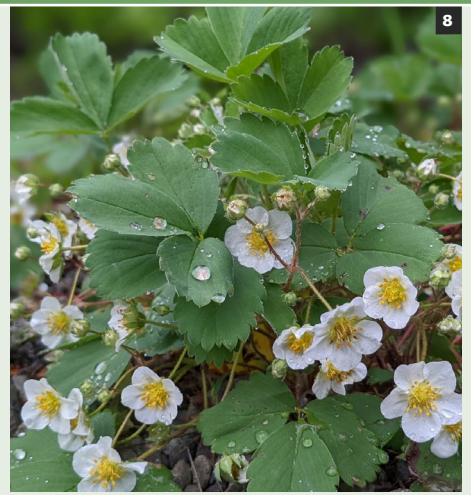
LEAVES

YOUNG LEAVES


6


7

The plantlet remains in the "Young leaves" phase as its new leaves grow larger. During this period, the young leaves (Image 7, white arrow) are lighter in color and thinner in texture than mature leaves from the previous year (yellow arrows).


8


9

When new leaves stop growing larger and have reached their full size, the "Young leaves" phase has ended.

LEAVES


10


11


12

Most leaves will senesce and change color, then dry up in the fall, but a few leaves often remain green all winter.


13

Dried and dead leaves.

Fragaria virginiana

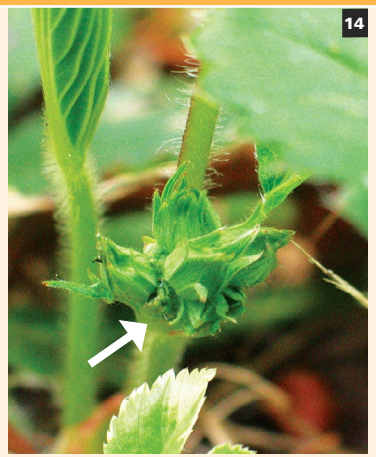
(Virginia strawberry)

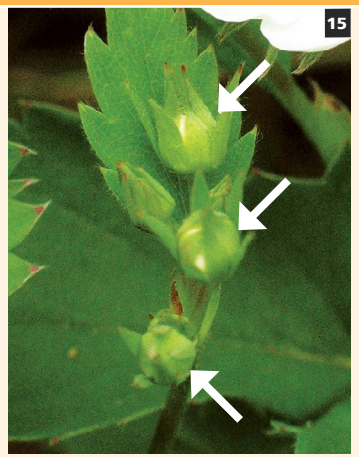
Flower phenophases

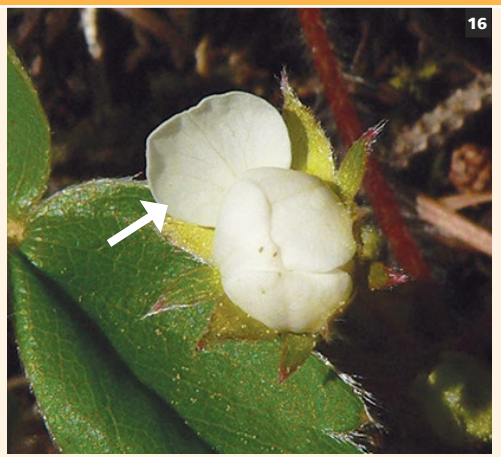
Virginia strawberry plantlets will produce several flower buds on a single stalk that emerges from the base of the plantlet. Once you see the flower bud and its stalk begin to emerge (Image 14, white arrow), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is withered or dried.

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

FLOWERS OR FLOWER BUDS


14


15

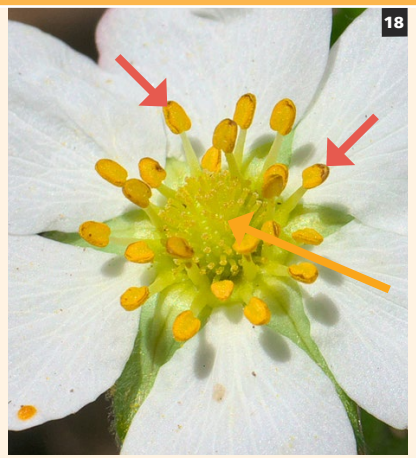

16

The flower stalk with several buds clustered together (Image 14, white arrow) will emerge from the ground at the base of plantlet. As the stalk lengthens, the flower buds become more spread out (Image 15, white arrows). As buds swell, white petals become visible and start to fold open (Image 16, white arrow).

FLOWERS OR FLOWER BUDS

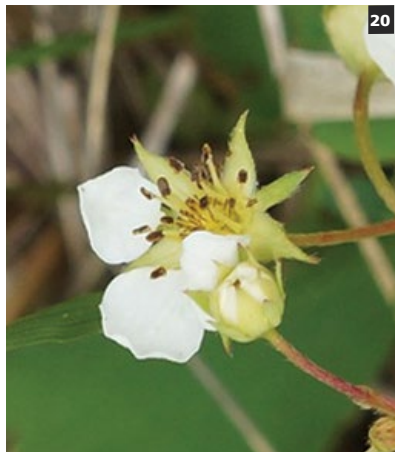
OPEN FLOWERS


17


18


19

Petals unfold to reveal yellow reproductive parts. Virginia strawberry flowers can have both male (red arrows) and female (orange arrows) reproductive parts (as in Image 18), or they can be unisexual, having only male (Image 19) or only female (Image 17) parts. Flowers than have only male parts will not develop into fruits.


20

Spent flower. The petals have started to fall off and the flower is no longer fresh.

Fragaria virginiana

(Virginia strawberry)

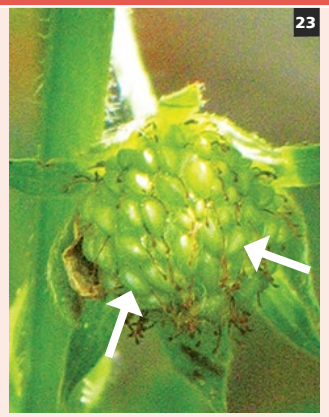
Fruit phenophases

When a Virginia strawberry flower has been fertilized, soon afterwards the numerous ovaries will develop into small, seed-like structures called "achenes". The achenes—which are technically the fruits of the plant—are attached to another part of the flower, called a "receptacle". As the receptacle swells, the achenes become imbedded in its surface to form the familiar "strawberry".

The *Nature's Notebook* fruit definition reads "For *Fragaria virginiana*, the fruit is tiny and seed-like and is imbedded on the surface of a berry-like 'strawberry'. The strawberry changes from greenish-white or green to bright red. A fruit is considered ripe when the strawberry has turned bright red."

After petals drop, the flower's cluster of many ovaries with styles still attached becomes apparent (white circle). Not all flowers will be fertilized and produce a strawberry.

FRUITS



Begin reporting "yes" for "Fruits" once you notice the strawberry starting to swell and get larger (Image 22). At first you will only see a crowd of green achenes developing (Image 23, white arrows), and not the flower receptacle they are attached to.

FRUITS

Eventually the receptacle will become visible as it swells and the achenes on its surface spread further apart from each other (Image 24). As the receptable expands, the achenes will become imbedded in the surface, looking like tiny "seeds" (Image 25, black arrow). The strawberry gradually starts to turn red.

RIPE FRUITS

The achene fruits are ripe when the strawberry has turned bright red.

RECENT FRUIT OR SEED DROP

Mature strawberries might drop off the plant, but more often will be plucked off the plant and eaten by wildlife. Report "yes" for "Recent fruit or seed drop" if you notice a strawberry missing from the plant that was present at your last visit.

FORB—EVERGREEN

This functional group includes herbaceous plant species—and subshrubs that have no (or very little) aboveground, woody growth—with leaves that remain on the plant for multiple growing seasons. Leaves are present year-round and there is no distinct dormant period, although there are periods of new leaf growth.

Many species in this group grow in clumps of clonal shoots or clusters of small individuals, and are most easily observed as a patch.

Representative species:

- *Chimaphila umbellata* (pipsissewa)
- *Sarracenia purpurea* (purple pitcherplant)

Young leaves

One or more young leaves are visible on the plant. A leaf is considered "young" before it has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

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; More than 1000

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

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.

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; More than 1000

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.

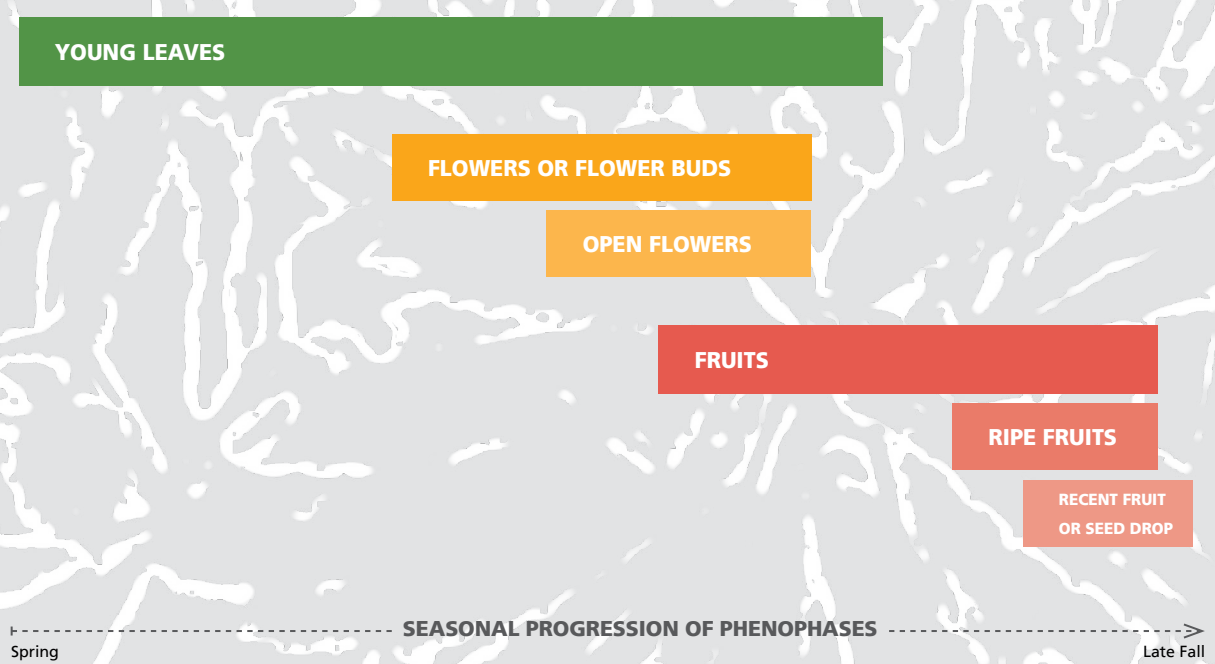
How many mature fruits have dropped seeds or have completely dropped or been removed from the plant since your last visit? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; More than 1000

Pipsissewa is a small, evergreen sub-shrub found in woodlands across much of the US. It is rhizomatous, forming clonal clumps of plants with aboveground stems that can be woody. New leaves emerge in spring, followed by an inflorescence with a few small, pink or white flowers that are insect-pollinated. Fruit capsules progress through shades of green and pink before ripening to brown and splitting open in fall.

Phenological characteristics of note:

- new leaves before flowering
- "dehiscent" fruit capsules split open when ripe

An approximate phenological timeline for *Nature's Notebook* observations of *Chimaphila umbellata* (pipsissewa)



Chimaphila umbellata

(pipsissewa)

Although leaves are present on the plant year-round, there is a distinct period of growth in spring as dormant leaf buds at stem tips come to life.

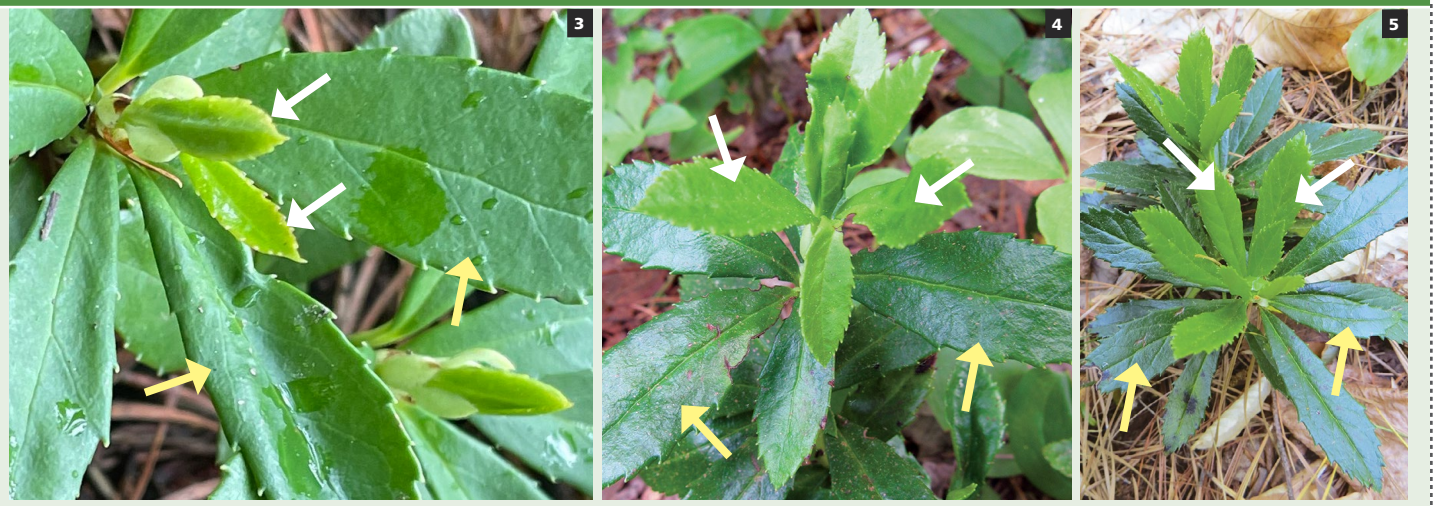
Leaf phenophases

Begin reporting "yes" for the "Young leaves" phenophase when the first new leaf has unfolded, and continue reporting "yes" until all leaves have become the color and texture of mature leaves on the plant.

Although pipsissewa leaf buds break in a way similar to leaf buds in trees and shrubs, the "Breaking leaf buds" phenophase is not included for species in the Forb functional groups.

Dormant and breaking leaf buds. While the leaf buds are dormant (Image 1, white arrow) or breaking (Image 2, white arrow), report no for "Young leaves" until the first leaf unfolds from the bud (Image 3).

YOUNG LEAVES



Once a leaf has unfolded from the bud (Image 3, white arrows) the "Young leaves" phenophase has begun. A plant remains in the "Young leaves" phase as new leaves grow larger. During this period, the young leaves (white arrows) are lighter in color, and thinner in texture than the dark green mature leaves on the plant (yellow arrows).

When new leaves have become the same color and texture as older leaves on the plant, the "Young leaves" phase has ended.

Chimaphila umbellata

(pipsissewa)

Flower phenophases

Pipsissewa has small, pink or white flowers arranged in an inflorescence that emerges from the tip of a stem after new leaves appear. Once you see the flower buds of an inflorescence begin to emerge (Image 7, white arrow), 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.

FLOWERS OR FLOWER BUDS


7


8


9

Flower buds will emerge from the tip of the plant stem (Image 7, white arrow). As the flower stalk lengthens, individual flower buds grow larger and hang downwards from the top of the stalk.

FLOWERS OR FLOWER BUDS

OPEN FLOWERS


10


11


12

When petals fold open, reproductive parts become visible (Image 10, white arrow). Male (red arrows) and female (orange arrow) reproductive parts are clustered together in the center of the pink or white petals.


13

Spent flower. The petals have fallen off and the flower is no longer fresh.

Chimaphila umbellata

(pipsissewa)

Fruit phenophases

When a pipsissewa flower has been fertilized, the ovary will develop into a fruit soon afterwards.

The *Nature's Notebook* fruit definition reads "For *Chimaphila umbellata*, the fruit is a small capsule that changes from green to red to brown and splits open 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."

Green ovaries (white arrows) are visible in the center of the open flower (left) and in the spent flower that has just lost its petals (right). It may take a few days before the ovary begins to visibly swell into a fruit.

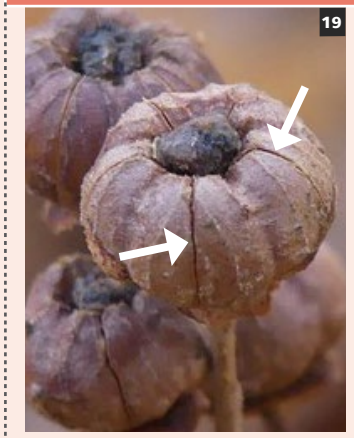
FRUITS

Ovaries have entered the "Fruits" phenophase once they start to swell and get larger. As in Image 15, a plant may have unopened flower buds, open flowers, and fruits (white arrows) all at the same time.

FRUITS

As fruits develop they gradually get larger and change color from red to brown. A fruit is considered ripe when it has turned brown and begins to split open (Image 19).

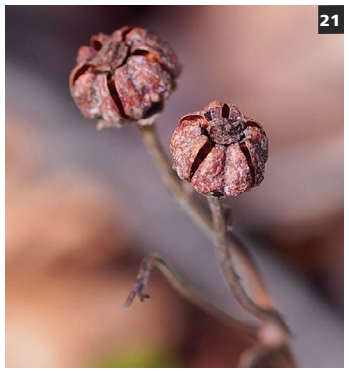
RIPE FRUITS



A fruit is ripe when it has turned brown and starts to split open along the seams (white arrows).

RECENT FRUIT OR SEED DROP

Once a capsule has opened far enough, seeds will start to shake out as the wind blows. Report "yes" for "Recent fruit or seed drop" if you see an open capsule that is likely to have lost some or all of its tiny seeds since your last visit.



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

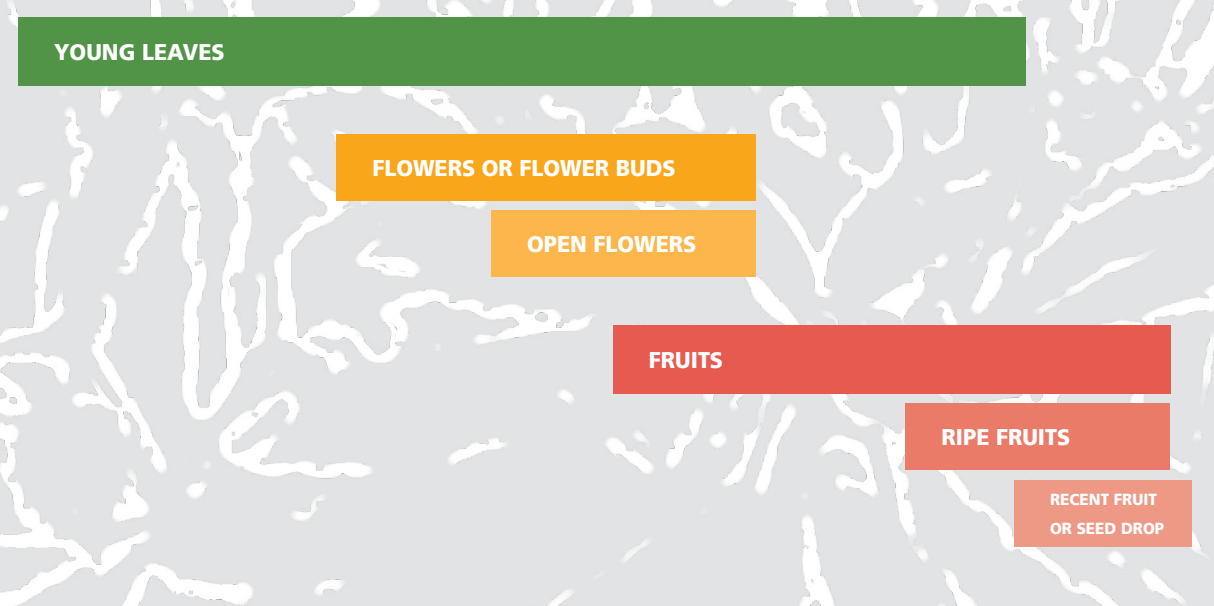
Purple pitcherplant is a carnivorous, evergreen forb found in acidic bogs in the eastern and northern US. Rhizomes produce a rosette of highly modified tubular leaves which fill with rainwater, enzymes and bacteria to attract, trap and digest insects and other tiny creatures. Subsequently, the leaves absorb the digested nutrients to help sustain the plant. The rhizomes of a plant can live twenty to thirty years, and each of the leaves generally lives longer than a year.

The unusual flowers emerge in spring and feature a greatly expanded, umbrella-like style. The style obscures the stamens from view, but aids in pollination by trapping the flower's own pollen so that visiting insect pollinators walk through and transfer some of the grains to the female stigmas on the style.

Phenological characteristics of note:

- unusual leaf structure
- new leaves can emerge any time of year
- unusual flowers with hidden reproductive parts
- "dehiscent" fruit capsules split open when ripe

An approximate phenological timeline for *Nature's Notebook* observations of *Sarracenia purpurea* (purple pitcherplant)



Sarracenia purpurea

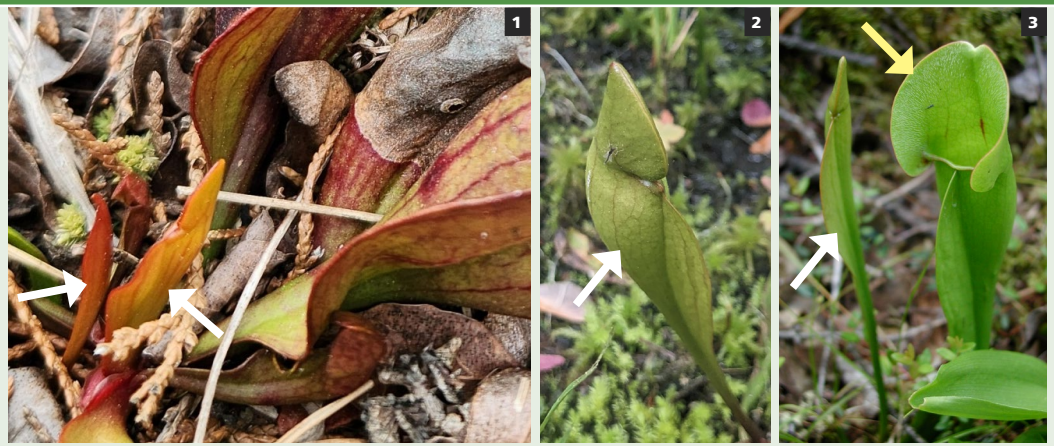
(purple pitcherplant)

Activity begins in spring as new leaves emerge from underground rhizomes. Purple pitcherplant leaves are highly modified structures, technically called "ascidia". They are tubular in shape and vary from yellow-green to deep purple in color, often surviving over the winter, but sometimes browning and dying if conditions are too harsh. Plants can produce new leaves at any time throughout the growing season.

Leaf phenophases

Begin reporting "yes" for the "Young leaves" phenophase with the first appearance of a newly emerging leaf, and continue reporting "yes" until all leaves have attained their mature, open, tubular form and full size. Leaf color varies with environment conditions, so may not be a reliable indicator of leaf maturity.

YOUNG LEAVES



Once a leaf emerges from the ground (Image 1, white arrows) the "Young leaves" phenophase has begun. This can happen at any time during the growing season, not just in spring. A plant remains in the "Young leaves" phase as leaves grow larger and transform from a flattened state (white arrows), to a tubular shape open at the top (Image 3, yellow arrow).

YOUNG LEAVES

As new leaves (white arrows) are developing to their mature form, they may be lighter in color, thinner in texture, and smaller in size than mature leaves (yellow arrows), but this is not always the case. Once a leaf opens, if it does not appear to be growing larger or thicker in texture, it can be considered mature.

Full-size, mature leaves. Depending on environmental conditions and time of year, mature leaves can range in color from yellow-green to reddish to deep purple to brownish.

Sarracenia purpurea

(purple pitcherplant)

Flower phenophases

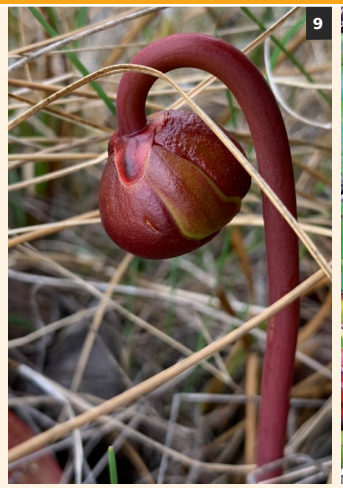
Purple pitcherplant has red-purple flowers, each on its own stalk, that emerge from underground rhizomes in the spring. Once you see the flower bud and its stalk begin to emerge (Image 8, white arrow), report "yes" for "Flowers or flower buds" and continue reporting "yes" until the last flower is spent.

The "Open flowers" phenophase begins when reproductive parts become visible and ends when the last flower is spent. These unusual flowers have five sepals and five petals, collectively called "tepals", that fold back to reveal a greatly expanded, umbrella-like style that obscures male stamens and female stigmas in the interior of the flower. These reproductive parts can be viewed in a "spent" flower after the petals drop (Image 13).

Purple pitchplant flowers sometimes emerge from rhizomes without nearby leaves.

FLOWERS OR FLOWER BUDS


8

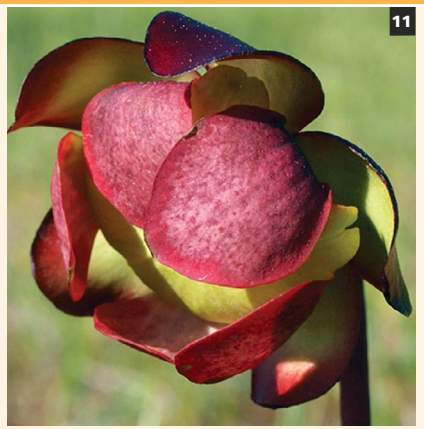

9


10

Green or reddish flower buds will emerge from the ground (Image 8, white arrow) often, but not always, near a cluster of leaves. As the flower bud grows larger and heavier, it bends downward from its stalk so the flower hangs upside down.

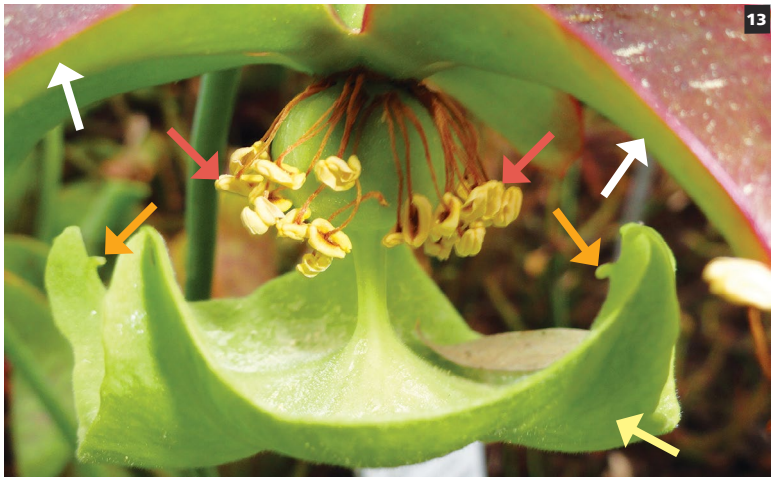
FLOWERS OR FLOWER BUDS

OPEN FLOWERS


11


12

When the red-purple tepals fold open, the large, green, umbrella-like style (Image 12, white arrow) becomes visible. Hidden behind the style are male stamens (Image 13, red arrows) and female stigmas (Image 13, orange arrows), which are tiny protrusions on the underside of the large style (Image 13, yellow arrow).


13

Spent flower. When the petals drop and the dried stamens (red arrows) are visible from the side, the flower is considered "spent" and no longer fresh. The sepals (white arrows) and style (yellow arrow) remain fresh and gradually wither as the fruit develops.

Sarracenia purpurea

(purple pitcherplant)

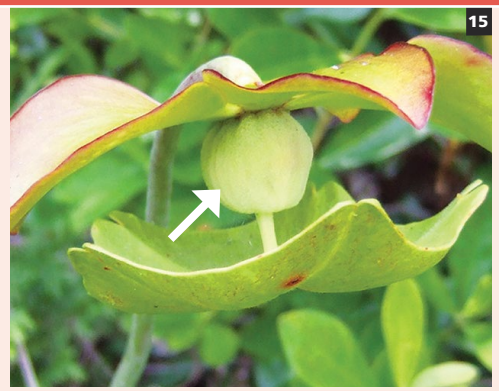
Fruit phenophases

When a purple pitcherplant flower's ovary has been fertilized, a fruit capsule will begin to develop soon after—sometimes even before—the petals have dropped. The spent flower's sepals and style will remain alive and fresh at first, gradually withering as the fruit develops.

The *Nature's Notebook* fruit definition reads "For *Sarracenia purpurea*, the fruit is a capsule that changes from green to yellow or green-red to red to brown and splits open 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."

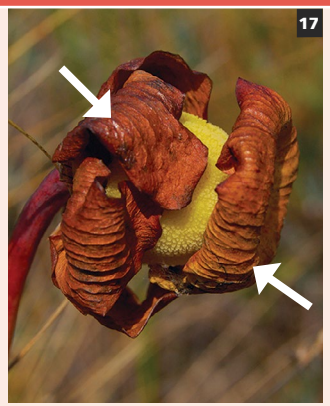
The ovary (white arrow) becomes visible behind the male anthers after petals drop off. Not all ovaries will develop into fruits—when not fertilized, it will just wither and dry with the rest of the flower.

FRUITS



An ovary (white arrow) has entered the "Fruits" phenophase once it starts to swell and get larger. Do not worry if you do not catch the first subtle signs of swelling and begin reporting "yes" for "Fruits" once you notice the ovary getting larger.

FRUITS



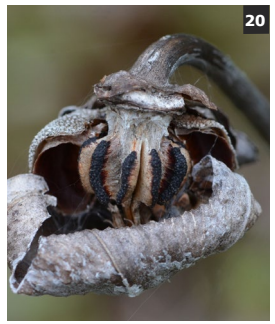
As the fruit develops, it gradually gets larger and changes color while the sepals and style surrounding it wither and dry (Image 17, white arrows). A fruit is considered ripe when it has turned brown and has split open to expose the seeds inside.

RIPE FRUITS

A fruit is ripe when it starts to split open along the seams to expose the light brown seeds inside (white arrow).

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if a capsule has lost some or all of its seeds since your last visit. This capsule has a few seeds left attached (white circle) and is still considered a ripe fruit.



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

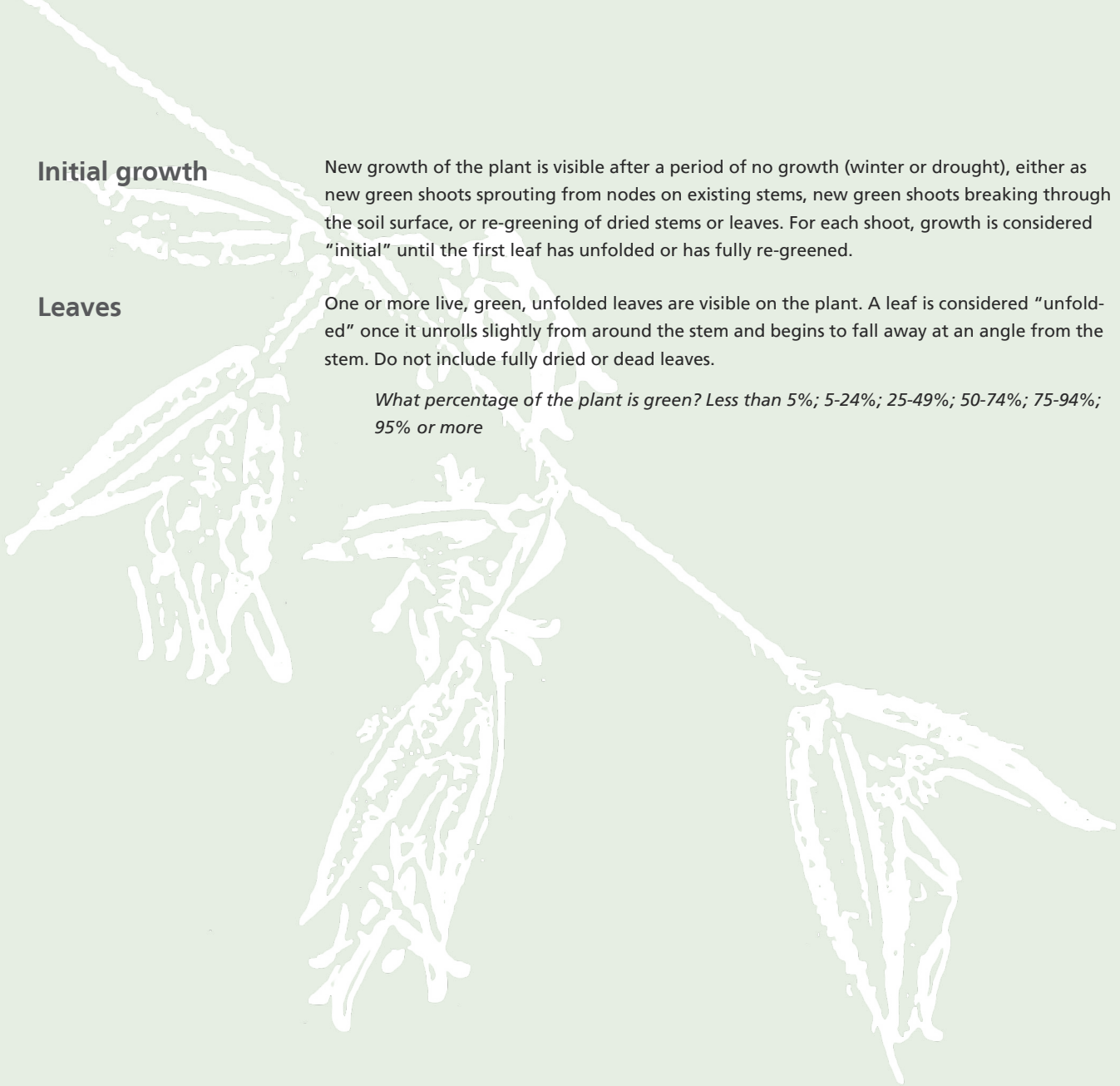
GRASS

This functional group includes species that belong to the Poaceae (true grasses) plant family. They may be annual or perennial, and are characterized by hollow stems around which the base of each leaf blade is wrapped. Depending on the species and growth environment, they may die back to the ground in the cold or dry season, or they may retain some green leaves year-round. Since the species in this group often grow in bunches or dense mats of stems, they are most easily observed as a patch.

Flower heads contain tiny, wind-pollinated flowers, called florets, that are highly modified from what we think of as a flower. Thus, flower and fruit phenophases can be a challenge for many observers. For an overview of floral characteristics of the grasses, see page 52 in Section 1 of this *Primer*.

Representative species:

- *Echinochloa crus-galli* (barnyardgrass)
- *Spartina patens* (saltmeadow cordgrass)



Initial growth

New growth of the plant is visible after a period of no growth (winter or drought), either as new green shoots sprouting from nodes on existing stems, new green shoots breaking through the soil surface, or re-greening of dried stems or leaves. For each shoot, growth is considered "initial" until the first leaf has unfolded or has fully re-greened.

Leaves

One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once it unrolls slightly from around the stem and begins to fall away at an angle from the stem. Do not include fully dried or dead leaves.

> *What percentage of the plant is green? Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more*

Flower heads

One or more fresh flower heads (inflorescences) are visible on the plant. Flower heads, which include many small flowers arranged in spikelets, emerge from inside the stem and gradually grow taller. Include flower heads with unopened or open flowers, but do not include heads whose flowers have all wilted or dried or begun to develop into fruits (grains).

How many fresh flower heads are present? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; More than 1,000

Open flowers

One or more open, fresh flowers are visible on the plant. A flower is considered "open" when reproductive parts (male anthers or female stigmata) can be seen protruding from the spikelet. Do not include flowers with wilted or dried reproductive parts.

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

Pollen release

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.

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; More than 1000

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; More than 1000

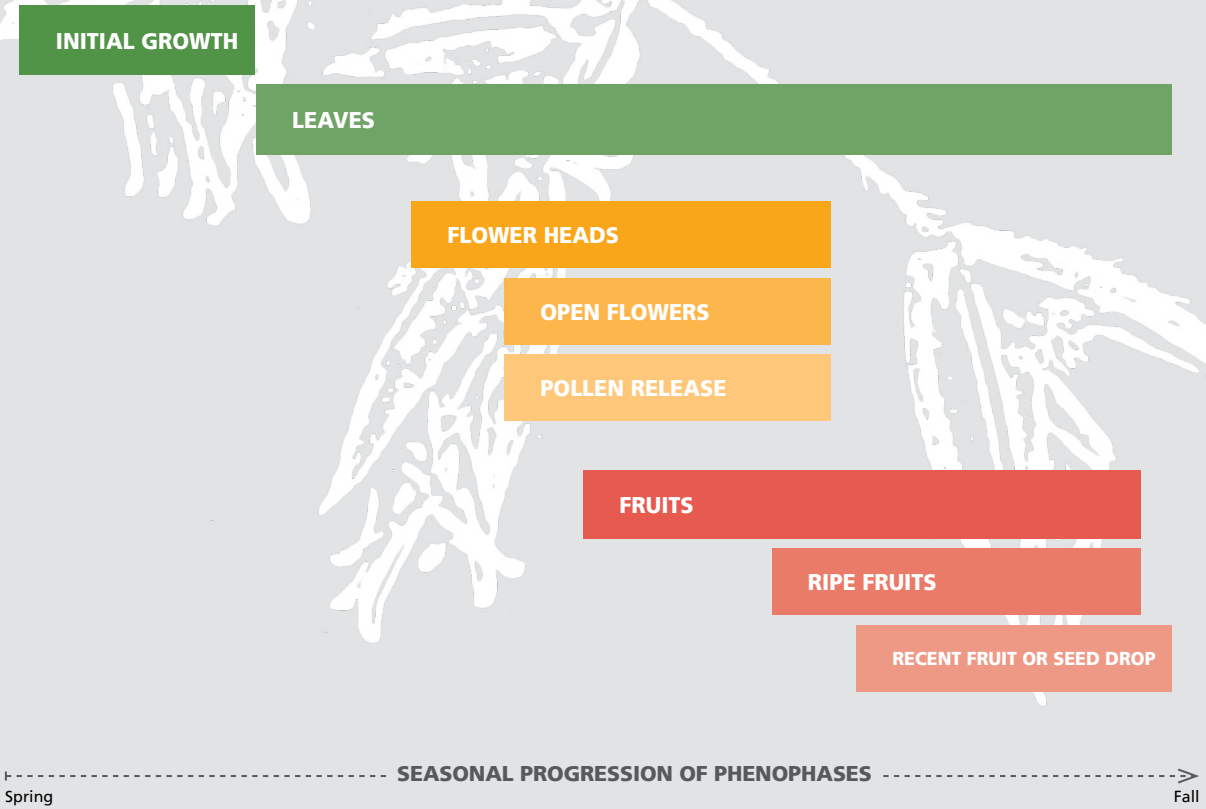
Barnyardgrass is a common weedy species found across the US and the globe. It is highlighted here as an example of an annual grass species—germinating from seed, producing leaves, flowers and fruits, then dying at the end of growing season and leaving many seeds to start the next generation of plants.

As is typical of grasses, very tiny wind-pollinated flowers, or florets, are organized in flower heads. Once fertilized, the floret ovaries turn into small fruit grains that drop when ripe.

Phenological characteristics of note:

- growth starts with a seedling
- leaves unfold very quickly after emergence
- fruit ripeness indicated by readiness to drop

An approximate phenological timeline for *Nature's Notebook* observations of *Echinochloa crus-galli* (barnyardgrass)



Echinochloa crus-galli

(barnyardgrass)

Activity begins with the emergence of a seedling from the soil surface after the conditions required for seed germination have been met. The first part of the seedling to appear is a leaf, followed by a stem that produces more leaves as it grows taller.

Leaf phenophases

"Initial growth" begins as the first leaf of the seedling pokes through the soil surface. When a stem—that will have a second leaf—begins to emerge from inside the rolled base of the first leaf (Image 2, white arrow), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf is dried and dead. If you are observing this species as a patch, some individuals will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last seedling's stem begins to emerge from inside the rolled base of its first leaf.

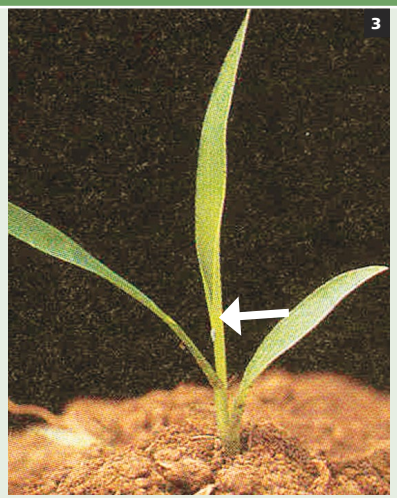
INITIAL GROWTH

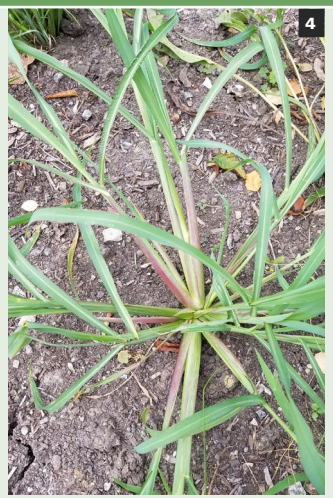
Once a leaf becomes visible, the "Initial growth" phase has begun. The seedling remains in this phenophase until the emerging stem becomes visible (Image 2, white arrow). If stems emerge quickly, you may never see and be able to report "yes" for this phenophase.

LEAVES

Once the stem (which will have a second leaf) begins to emerge from inside the rolled base of the first leaf (white arrow) the seedling has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES





As the stem grows taller, a third leaf emerges (Image 3, white arrow), then more leaves follow. Eventually many stems emerge from the base of the plant, either lying close to the ground (Image 4) or standing upright (Image 5). A plant remains in the "Leaves" phenophase until its leaves are dried and dead. Leaves turn yellow and reddish as they begin to senesce (Image 6).

Dried and dead leaves and stems have no green color left in them.

Echinochloa crus-galli

(barnyardgrass)

Flower phenophases

Barnyardgrass flowers, called florets, are organized within tiny spikelets, and many spikelets are arranged along the branches of an inflorescence, or flower head. Once you see an inflorescence begin to emerge from the top of a grass stem (Image 8), report "yes" for "Flower heads" 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. Grass flowers have no petals, so it is the withering of the reproductive parts that signals an end to the "Open flowers" and "Flower heads" phenophases.

For an overview of floral characteristics of the grasses, see page 52 in Section 1 of this *Primer*.

FLOWER HEADS


8

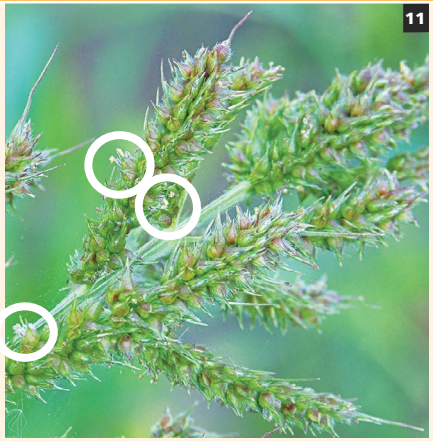

9


10

Flower heads emerge from the top of a grass stem at the point where the base of the uppermost leaf is wrapped around the stem (Image 8, white arrow). As the flower head stem continues to emerge and lengthen, the many individual branches arranged along the stem become apparent (Images 9-10).

FLOWER HEADS

OPEN FLOWERS


11


12


13

Tiny reproductive parts protrude from the florets within the spikelets (Image 11, white circles) and can be difficult to detect without looking very closely. Feathery, red-purple female stigmas (orange arrows) and yellow male anthers (red arrows) emerge at the same time (Image 12), but the male anthers shed their pollen and dry up quickly (Image 13, red arrows) while female stigmas still appear fresh (Image 13, orange arrows).

POLLEN RELEASE

Report on "Pollen release" only if you can actually see pollen grains being released from male anthers.


14

Spent flowers. Both the male (red arrows) and female (orange arrows) reproductive parts are brown and dried.

Echinochloa crus-galli

(barnyardgrass)

Fruit phenophases

When reproductive parts wither and the tiny, hidden ovaries of grass florets are fertilized, the flower head becomes a seed head. The ovaries begins to develop soon afterwards into small, hidden fruit grains which can be hard to detect. Therefore, you can begin reporting "yes" for "Fruits" once all the reproductive parts on the flower head have withered or dropped.

The *Nature's Notebook* fruit definition reads "For *Echinochloa crus-galli*, the fruit is a tiny grain, hidden within tiny bracts and grouped into small clusters that are closely arranged along branches on an open-branched seed head, that changes texture from soft or watery to hard and drops from the plant. A fruit is considered ripe when it is hard when squeezed and difficult to divide with a fingernail, or when it readily drops from the plant when touched. Do not include seed heads that have already dropped all of their grains."

Since grains are so small in this species (as they are in many grass species), the hard texture of a ripe fruit may be difficult to feel. Readiness to drop is a more reliable indicator of ripeness.

FRUITS

Begin reporting "yes" for "Fruits" once the reproductive parts have withered or dropped. Fruits usually do not get visibly larger as they develop.

FRUITS

As fruits develop within, the seed head gradually loses its green color and turns tan, reddish-brown or brown.

RIPE FRUITS

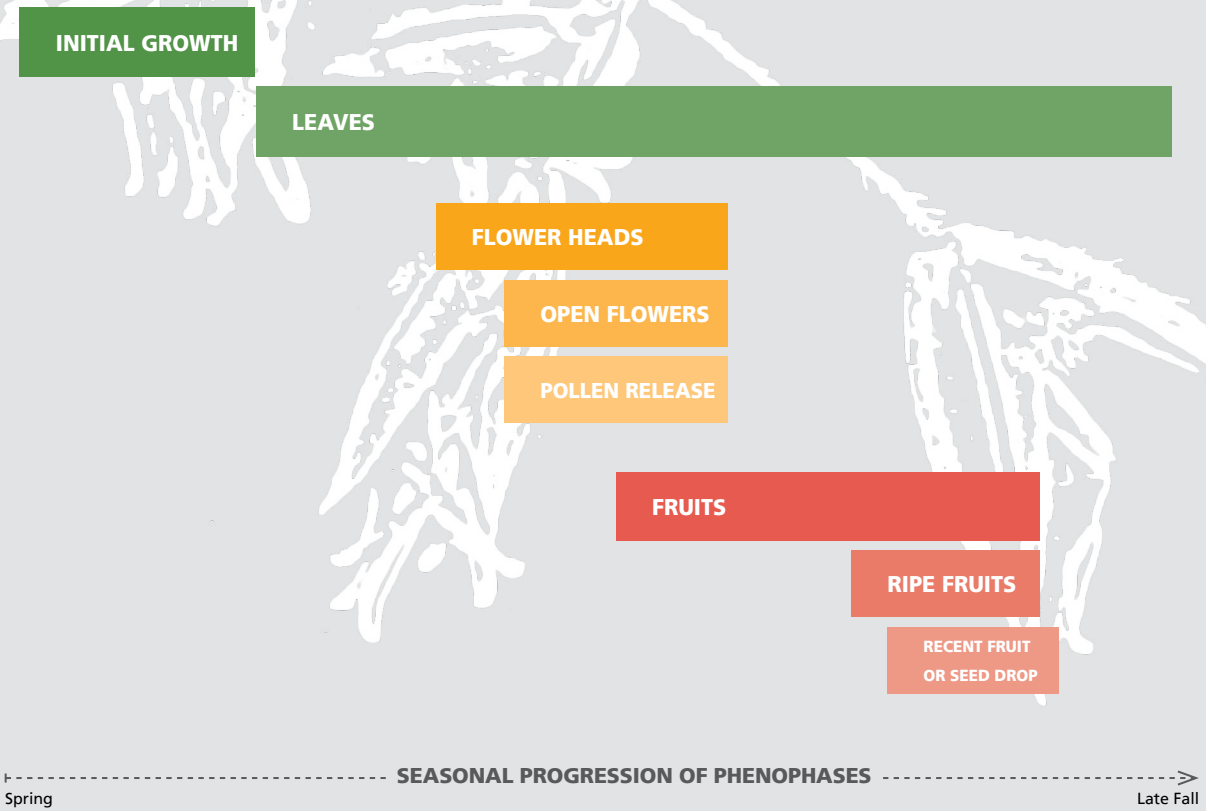
Fruit grains are ripe when they easily drop from the seed head stem—called a "rachis"—if gently touched (white arrows).

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if you notice fruit grains missing from the rachis that were present at your last visit (white arrows).

Empty seed head rachises that have dropped all their grains should not be included in the "Fruits" or "Ripe fruits" phenophases.

An approximate phenological timeline for *Nature's Notebook* observations of *Spartina patens* (saltmeadow cordgrass)



Saltmeadow cordgrass is an imporant native grass of coastal saltmarshes in the eastern US, where it often grows in an expansive swath across the high elevation of a marsh. It can also be found on coastlines of the western US, where it is often considered invasive. It is a perennial species, sprouting from underground rhizomes in spring and dying back to the ground in late fall over much of its range. However, it may remain green year-round in warmer climates.

As is typical of grasses, very tiny wind-pollinated flowers, or florets, are organized in flower heads. Once fertilized, the floret ovaries turn into small fruit grains that drop when ripe.

Taxonomy of this species has recently changed and some sources use a new scienticfic name, *Sporobolus pumilus*.

Phenological characteristics of note:

- leaves unfold very quickly after emergence
- fruit ripeness indicated by readiness to drop

Spartina patens

(saltmeadow cordgrass)

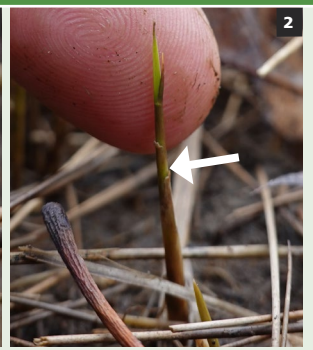
Activity begins in spring as brownish-green shoots poke through the soil surface from underground roots and rhizomes. Each shoot produces a stem with several long, slender leaves. Some stems will produce a flower head later in the season.

Leaf phenophases

"Initial growth" begins when a shoot first pokes through the soil surface, or when a new shoot emerges from a seemingly dried and dead aboveground stem. When the shoot's first leaf unrolls slightly from around the stem and begins to fall away at an angle (Image 2, white arrow), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf and stem is dried and dead. In some climates, this species might retain green color throughout the year, in which case you may be reporting "yes" for "Leaves" all year round. When you are observing this species as a patch, some shoots will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last shoot's first leaf begins to fall away at an angle from the stem.

INITIAL GROWTH


1


2

Once a new shoot becomes visible (white arrows), the "Initial growth" phase has begun. The shoot remains in this phenophase until the first green leaf begins to fall away at an angle from the stem (Image 3, white arrow). If new shoots are hidden under dead leaves, you may never see and be able to report "yes" for this phenophase.

LEAVES

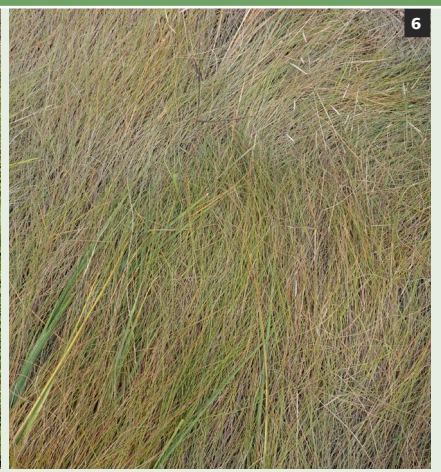

3

Once the first green leaf begins to fall away at an angle from the stem, the shoot has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES


4


5


6

As stems grow taller, more leaves will emerge from near the base. Stems remain in the "Leaves" phenophase until their leaves are dried and dead and they have lost all green color. Saltmeadow cordgrass often grows as a dense mat of stems which stand upright in the beginning of the growing season (Image 4), and gradually fall over as the season progresses (Image 5), eventually lying flat on the ground (Image 6). Leaves and stems turn yellow and then brown as they senesce (Image 6).


7

Dried and dead leaves and stems have no green color left in them.

Spartina patens

(saltmeadow cordgrass)

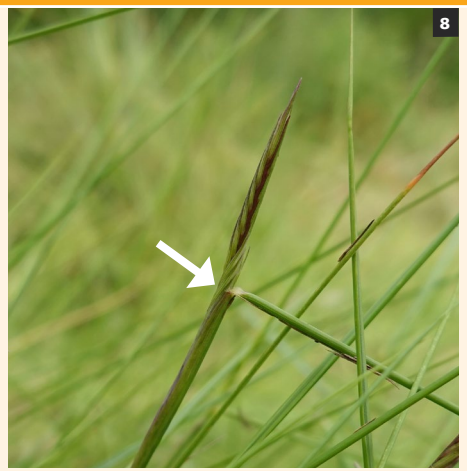
Flower phenophases

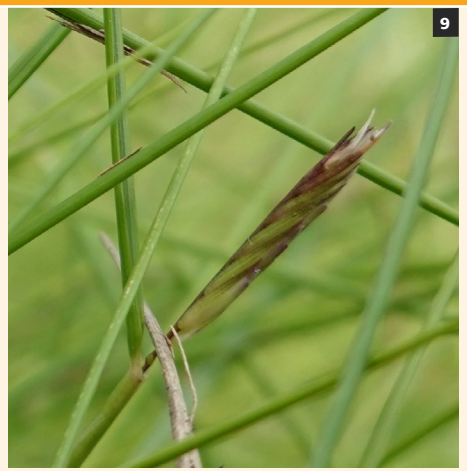
Saltmeadow cordgrass flowers, called florets, are organized within tiny spikelets, and a many spikelets are arranged along the branches of an inflorescence, or flower head. Once you see an inflorescence begin to emerge from the top of a grass stem (Image 8), report "yes" for "Flower heads" and continue 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. Grass flowers have no petals, so it is the withering of the reproductive parts that signals an end to the "Open flowers" and "Flower heads" phenophases.

For an overview of floral characteristics of the grasses, see page 52 in Section 1 of this *Primer*.

FLOWER HEADS


8

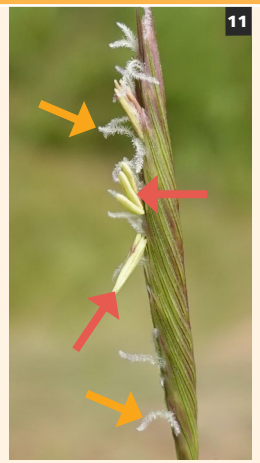

9

Flower heads emerge from the top of a grass stem at the point where the base of the uppermost leaf is wrapped around the stem (Image 8, white arrow). Not all grass stems will produce flower heads.

FLOWER HEADS

OPEN FLOWERS


10


11


12

Reproductive parts protrude from the florets within the spikelets. Feathery, white female stigmas (orange arrows) usually appear first, followed by yellow to purplish male anthers (red arrows).

POLLEN RELEASE


13

Pollen grains (white arrow) are visible when released by male anthers.


14

Spent flowers. The reproductive parts are withered and dried.

Spartina patens

(saltmeadow cordgrass)

Fruit phenophases

When reproductive parts wither and the tiny, hidden ovaries of grass florets are fertilized, the flower head becomes a seed head. The ovary develops into a tiny, hidden fruit grain which can be very difficult to detect. Therefore, you can begin reporting "yes" for "Fruits" once all the reproductive parts on the flower head have withered or dropped.

The *Nature's Notebook* fruit definition reads "For *Spartina patens*, the fruit is a tiny grain, hidden within tiny bracts and grouped into small clusters that are closely arranged along alternating branches on a large, open plume (or seed head), that changes texture from soft or watery to hard and drops from the plant. A fruit is considered ripe when it is hard when squeezed and difficult to divide with a fingernail, or when it readily drops from the plant when touched. Do not include seed heads that have already dropped all of their grains."

Since grains are so tiny in this species (as they are in many grass species), the hard texture of a ripe fruit may be difficult to feel. Readiness to drop is a more reliable indicator of ripeness.

FRUITS

Begin reporting "yes" for "Fruits" once the reproductive parts have withered or dropped. As fruits develop within, the seed head gradually loses its green color and turns brown.

FRUITS

Plump individual grains (white arrow) may become apparent as they get larger. Not all ovaries develop into plump fruit grains.

RIPE FRUITS

Fruit grains are ripe when they easily drop from the seed head stem—called a "rachis"—if gently touched.

RECENT FRUIT OR SEED DROP

Report "yes" for "Recent fruit or seed drop" if you notice fruit grains missing from the rachis that were present at your last visit (white arrows).

Empty seed head rachises that have dropped all their grains should not be included in the "Fruits" or "Ripe fruits" phenophases.

SEDGE

This functional group includes grass-like species that belong to the Cyperaceae (sedges) plant family. They may be annual or perennial, and oftentimes have triangular stems around which leaf blade bases are attached in a "V" or "U" shape. Emerging leaf blades are often rolled or folded in half with a central crease. Depending on the species and growth environment, they may die back to the ground in the cold or dry season, or they may retain some green leaves year-round. Since the species in this group often grow in bunches or dense mats of stems, they are most easily observed as a patch.

Flower heads contain tiny, wind-pollinated flowers, called florets, that are highly modified from what we think of as a flower. Thus, flower and fruit phenophases can be a challenge for many observers. For an overview of floral characteristics of the sedges, see page 54 in Section 1 of this *Primer*.

Representative species:

- *Carex pensylvanica* (Pennsylvania sedge)

Initial growth

New growth of the plant is visible after a period of no growth (winter or drought), either as new green shoots sprouting from nodes on existing stems, new green shoots breaking through the soil surface, or re-greening of dried stems or leaves. For each shoot, growth is considered "initial" until the first leaf has unfolded or has fully re-greened.

Leaves

One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once it has grown long enough that the two halves of the leaf blade have begun to spread apart like an open book. Do not include fully dried or dead leaves.

> *What percentage of the plant is green? Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more*

Flower heads

One or more fresh flower heads (inflorescences) are visible on the plant. Flower heads, which include many small flowers arranged in spikelets, emerge from inside the stem and gradually grow taller. Include flower heads with unopened or open flowers, but do not include heads whose flowers have all wilted or dried or begun to develop into fruits (grains).

How many fresh flower heads are present? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; More than 1,000

Open flowers

One or more open, fresh flowers are visible on the plant. A flower is considered "open" when reproductive parts (male anthers or female stigmata) can be seen protruding from the spikelet. Do not include flowers with wilted or dried reproductive parts.

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

Pollen release

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.

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; More than 1000

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; More than 1000

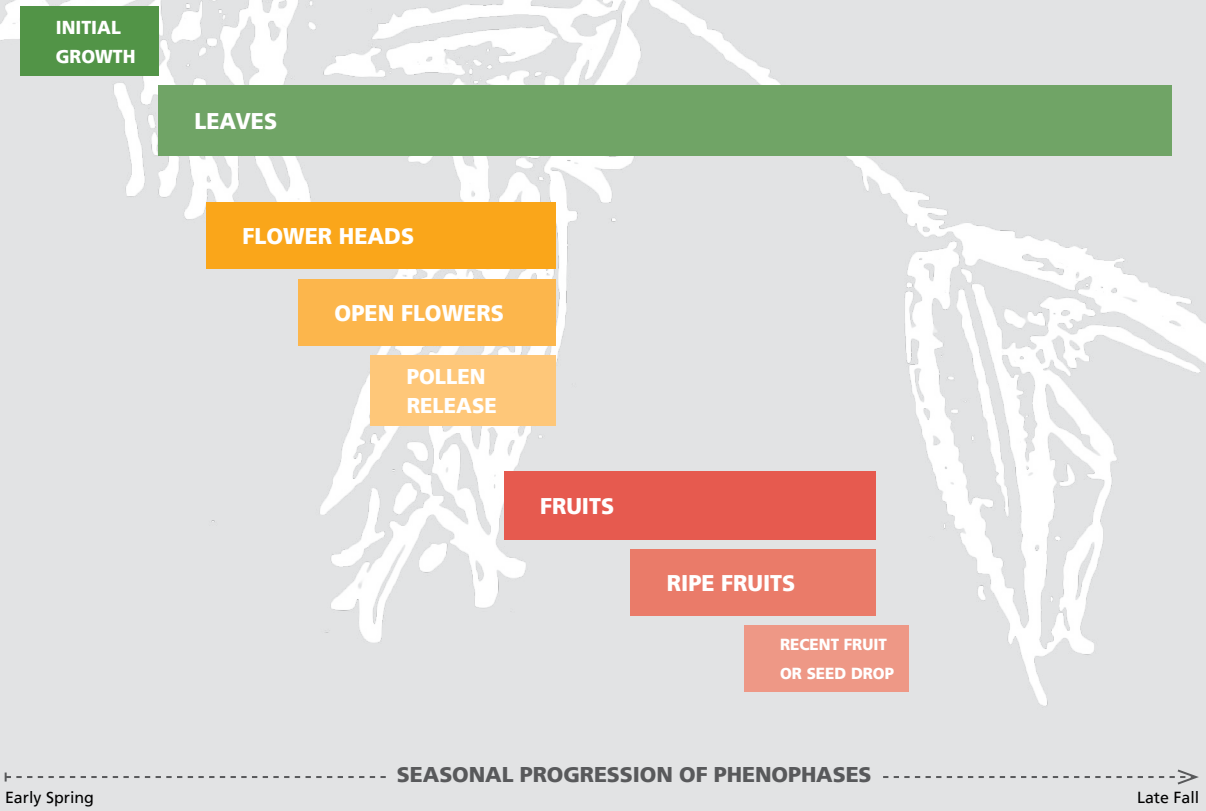
Pennsylvania sedge is a shade-loving perennial found in dry woodlands of the eastern US, often near oak trees. It grows in bunches or dense mats, sprouting from underground rhizomes in spring. Though it dies back to the ground in very cold winters, it often remains semi-evergreen in moderately cold winter climates.

Tiny wind-pollinated flowers, or florets, are arranged in flower heads with small spikes of female florets located below a large spike of male florets. Once fertilized, the floret ovaries turn into small seed-like fruits that dry out and turn brown when ripe.

Phenological characteristics of note:

- leaves unfold very quickly after emergence
- male and female parts in separate flowers arranged in spikes
- fruit ripeness indicated by color and texture change

An approximate phenological timeline for *Nature's Notebook* observations of *Carex pensylvanica* (Pennsylvania sedge)



Carex pensylvanica

(Pennsylvania sedge)

Activity begins in spring as new green shoots poke through the soil surface from underground roots and rhizomes. Each shoot produces a short stem with several leaves. Some stems will produce a flower head shortly after leaves emerge.

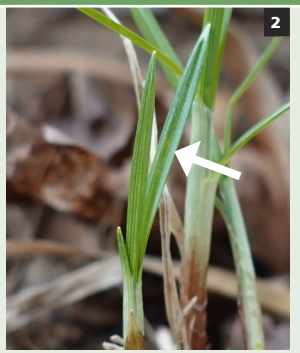
Leaf phenophases

"Initial growth" begins when a new shoot first pokes through the soil surface. When the shoot's first leaf has grown long enough that the two halves of the leaf blade have begun to spread apart like an open book (Image 2, white arrow), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf is dried and dead. This species often retains some green leaf color throughout the year, in which case you may be reporting "yes" for "Leaves" all year round. When you are observing this species as a patch, some shoots will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last shoot's first leaf blade begins to spread apart like an open book.

INITIAL GROWTH

Once a new shoot becomes visible (white arrow), the "Initial growth" phase has begun. The shoot remains in this phenophase until its first leaf has unfolded (Image 2). If new shoots are hidden under leaf litter, you may never see and be able to report "yes" for this phenophase.

LEAVES



Initially rolled closed at the tip, when the shoot's first leaf blade begins to spread open like a book (white arrow), the shoot has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES

Stems remain in the "Leaves" phenophase until their leaves are dried and dead. Pennsylvania sedge grows in bunches or dense mats of stems with leaves upright in the beginning of the growing season (Image 3), and gradually bending over and lying on the ground as the season progresses (Image 4-6). Leaves turn yellowish and then tan as they senesce (Images 5-6), and often will retain some green color over the winter dormant season (Image 6).

Carex pensylvanica

(Pennsylvania sedge)

Flower phenophases

Pennsylvania sedge flowers, called florets, are organized in a series of spikes along an inflorescence, or flower head. The large spike at the top of the flower head contains only male flowers. Just below this on the flower head stem, there are a few very small spikes that each contain a few female flowers.

Once you see an flower head begin to emerge from between the bases of leaf blades on a sedge stem (Image 7, white arrow), report "yes" for "Flower heads" 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. Sedge flowers have no petals, so it is the withering of the reproductive parts that signals an end to the "Open flowers" and "Flower heads" phenophases.

For an overview of floral characteristics of the sedges, see page 54 in Section 1 of this *Primer*.

FLOWER HEADS


7

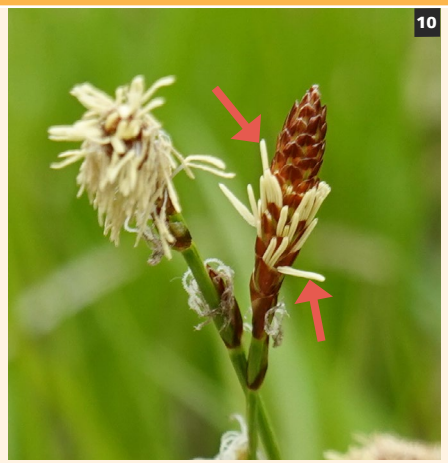

8

Flower heads emerge from between leaf blades at the top of a sedge stem (Image 7, white arrow). Initially pale in color, they become reddish-brown or dark brown as they develop (Image 8, white arrows).

FLOWER HEADS

OPEN FLOWERS


9


10

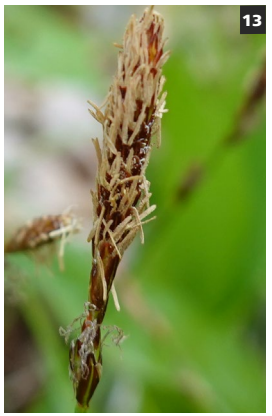

11

Reproductive parts protrude from the florets within the flower head. Feathery, white female stigmas (Image 9, orange arrows) appear first from the small spikes at the base of the flower head, followed by yellow male anthers (Image 10, red arrows) from the large upper spike of the flower head.

POLLEN RELEASE


12

Pollen grains (white arrow) are visible when released by male anthers.


13

Spent flowers. The reproductive parts are withered and dried.

Carex pensylvanica

(Pennsylvania sedge)

Fruit phenophases

Once the tiny ovary of a female floret has been fertilized, a fruit will begin to develop soon afterwards and the flower head becomes a seed head. Fruits are clustered in small spikes and are located on the seed head stem below the large spike of withered male florets (Image 14, white arrows).

The *Nature's Notebook* fruit definition reads "For *Carex pensylvanica*, the fruit is tiny and seed-like, hidden in a small, papery, sac-like bract and grouped with others that are tightly arranged along several small, erect spikes in the seed head. The seed-like fruit changes from green to dark brown, hardens as it dries out, and drops from the plant. A fruit is considered ripe when it has turned brown and hard, or when it readily drops from the plant when touched. Do not include seed heads that have already dropped all of their fruits."

FRUITS


14


15

Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger. Fruits (white arrows) are so small, you might not see them until they are almost full size.

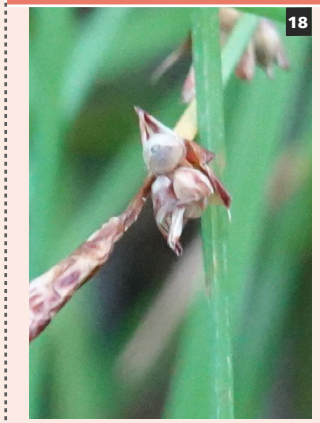
FRUITS


16


17

As fruits develop, they gradually dry out and change from green to tan or brown. A fruit is considered ripe when it has turned brown and hard, or when it readily drops when touched.

RIPE FRUITS


18

A fruit is ripe when it has dried out and turned brown and hard.

RECENT FRUIT OR SEED DROP


19

A fruit missing (white arrow) since the last visit in Image 18 indicates recent drop.


20

Empty seed head stems that have dropped all their fruits should not be included in the "Fruits" or "Ripe fruits" phenophases.

RUSH

This functional group includes grass-like species that belong to the Juncaceae (rushes) plant family. They may be annual or perennial and many species have round, green stems with no apparent leaves. Depending on the species and growth environment, they may die back to the ground in the cold or dry season, or they may retain some green color year-round. Since the species in this group often grow in bunches or dense mats of stems, they are most easily observed as a patch.

The characteristic tiny, wind-pollinated flowers are somewhat different from what we think of as a flower, thus flower and fruit phenophases can be a challenge for many observers. For an overview of floral characteristics of the rushes, see page 58 in Section 1 of this *Primer*.

Representative species:

- *Juncus gerardii* (saltmeadow rush)

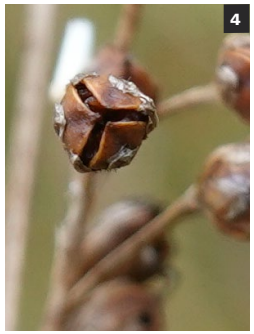
Initial growth

New growth of the plant is visible after a period of no growth (winter or drought) as new green shoots breaking through the soil surface. For each shoot, growth is considered "initial" until the exposed, green portion of the shoot has reached approximately 2 inches (5 cm) in length.

Leaves

One or more live, green, unfolded leaves are visible on the plant. A leaf is considered "unfolded" once the exposed, green portion of the leaf (or shoot) has reached approximately 2 inches (5 cm) in length. Do not include fully dried or dead leaves.

What percentage of the plant is green? Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more



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; More than 1000

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

Pollen release

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.

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; More than 1000

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; More than 1000

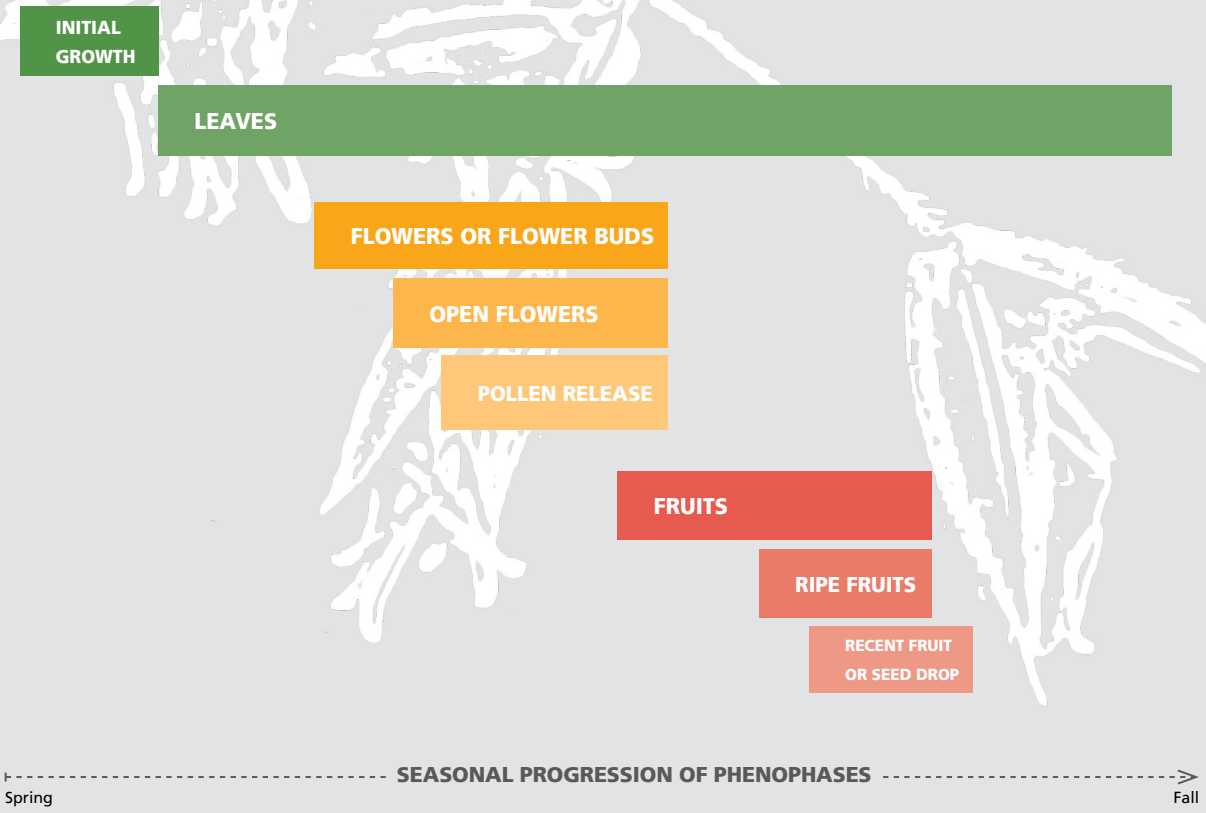
Saltmeadow rush is a perennial plant native to coastal marshes of the eastern US, where is occurs near the high tide line. It has spread from its native range and can now be found in wetlands across much of the US. It grows in bunches or dense mats of stems, sprouting from underground rhizomes in spring and dying back to the ground in fall.

Tiny, wind-pollinated flowers with colorful reproductive parts are organized in inflorescences. Fruits are small brown capsules that split open to release seeds when ripe.

Phenological characteristics of note:

- green stems with very few leaves
- "dehiscent" fruit capsules split open when ripe

An approximate phenological timeline for *Nature's Notebook* observations of *Juncus gerardii* (saltmeadow rush)



Juncus gerardii

(saltmeadow rush)

Activity begins in spring as green shoots poke through the soil surface from underground roots and rhizomes. Each shoot produces a stem that may develop a few long slender leaves attached near the base. Some stems will produce an inflorescence later in the season.

Leaf phenophases

"Initial growth" begins when a new shoot first pokes through the soil surface. When the shoot reaches approximately 2 inches (5 cm) in length (Image 2, white arrow), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf and stem is dried and dead. When you are observing this species as a patch, some shoots will be in the "Initial growth" stage while others are in the "Leaves" stage. "Initial growth" ends in the patch when the last shoot reaches 2 inches in length.

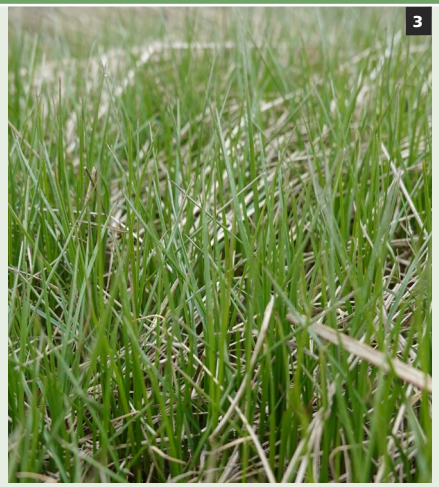
INITIAL GROWTH

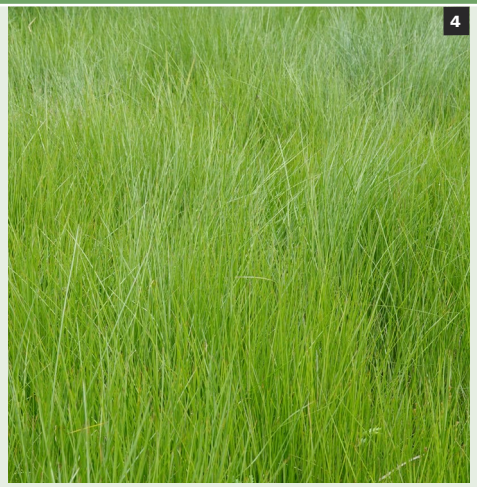
Once a new shoot becomes visible (white arrows), the "Initial growth" phase has begun. The shoot remains in this phenophase until it is about 2 inches high (Image 2). If new shoots are hidden under leaf litter, you may never see and be able to report "yes" for this phenophase.

LEAVES

Once the shoot reaches about 2 inches in height (white arrow), it has left the "Initial growth" phase and entered the "Leaves" phenophase.

LEAVES





Stems remain in the "Leaves" phenophase until their leaves are dried and dead and they have lost all green color. Saltmeadow rush often grows as a dense mat of stems which stand upright in the beginning of the growing season (Images 3-4), and gradually fall over as the season progresses (Image 5), eventually lying flat on the ground. Leaves and stems turn yellow and then brown as they senesce (Image 5).

Dried and dead leaves and stems have no green color left in them.

Juncus gerardii

(saltmeadow rush)

Flower phenophases

Saltmeadow rush has small, inconspicuous flowers arranged in an inflorescence that emerges from the side of a stem. Once you see an inflorescence begin to emerge (Image 7, white arrow), 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. Each rush flower has three tiny petals and three tiny sepals, collectively called tepals, that are green-brown and remain intact after flowering, while the fruit develops. Therefore, it is the withering of the reproductive parts that signals an end to the "Open flowers" and "Flowers or flower buds" phenophases.

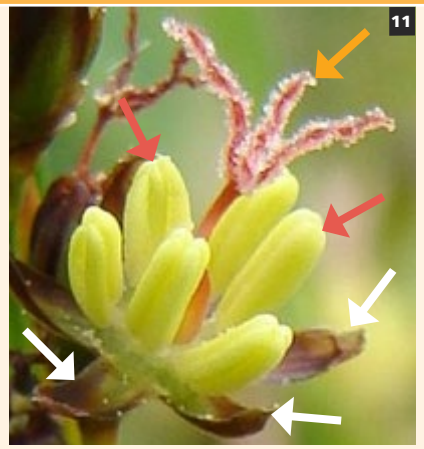
For an overview of floral characteristics of the rushes, see page 58 in Section 1 of this *Primer*.

FLOWERS OR FLOWER BUDS

The inflorescence will emerge from the side of the stem (Image 7, white arrow). As the flower stalk lengths, the individual flower buds become apparent (Image 9, white arrows).

FLOWERS OR FLOWER BUDS

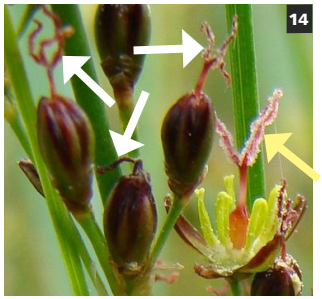
OPEN FLOWERS



Green-brown tepals (white arrows) fold back to expose male (red arrows) and female (orange arrows) reproductive parts. Reddish female stigmas appear first (Image 10), followed by yellow male anthers (Image 11). The anthers in Image 12 (red arrows) have released most of their pollen grains and are begining to shrivel, but the female style (orange arrow) is still fresh.

POLLEN RELEASE

Pollen grains (white arrow) are visible when released by male anthers.



Spent flowers. Tepals have folded back up over the ovary and the female stigmas have withered (white arrows). See the fresh stigma (yellow arrow) of an open flower for comparison.

Juncus gerardii

(saltmeadow rush)

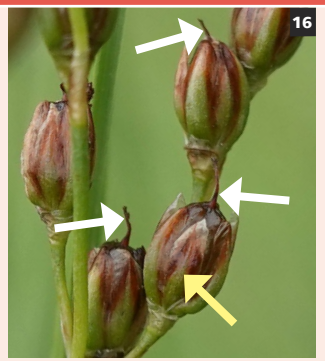
Fruit phenophases

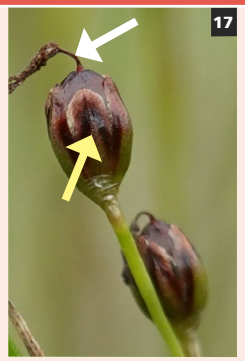
When a saltmeadow rush flower has been fertilized, the ovary will develop into a fruit capsule soon afterwards. The green-brown tepals of the flower fold back up and partially cover the developing capsule (Image 16, yellow arrow).

The *Nature's Notebook* fruit definition reads "For *Juncus gerardii*, the fruit is a small capsule and is clustered with several others at the ends of many short branches on stems that arise near the base of the seed head. The capsule changes from green to rusty brown or brown and splits open to expose the seeds. A fruit is considered ripe when it has turned rusty brown or brown and has split open to expose the seeds. Do not include empty capsules that have already dropped all of their seeds."

Open female flower. The style (white arrow) extends from the ovary (black arrow) that will develop into a fruit after fertilization.

FRUITS





Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger (Image 16). Tepals (yellow arrows) partially cover the fruits and change from green-brown (Image 16) to brown (Image 17) as fruits develop. Dried styles (white arrows) remain attached to the fruits while they develop.

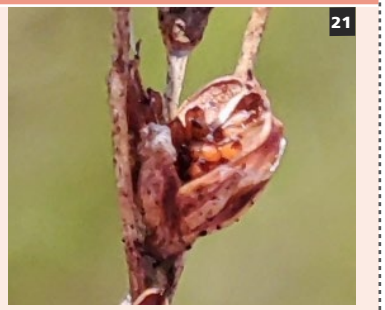
FRUITS

As fruits develop, they gradually get larger and rounder before they split open (Image 20).

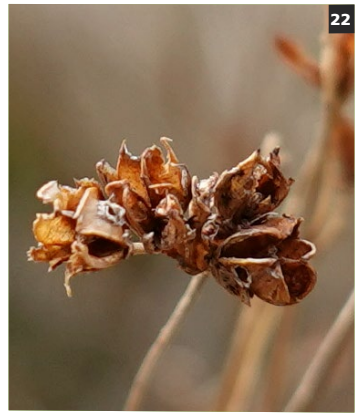
RIPE FRUITS

A fruit is ripe when it has turned rusty brown or brown and starts to split open along the seams to expose the brown seeds inside (white arrow).

RECENT FRUIT OR SEED DROP



Once a capsule has opened far enough, seeds will start to shake out as the wind blows. Report "yes" for "Recent fruit or seed drop" if you see an open capsule that is likely to have lost some or all of its tiny seeds since your last visit.



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

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 viginiana* (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.

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

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

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.

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.

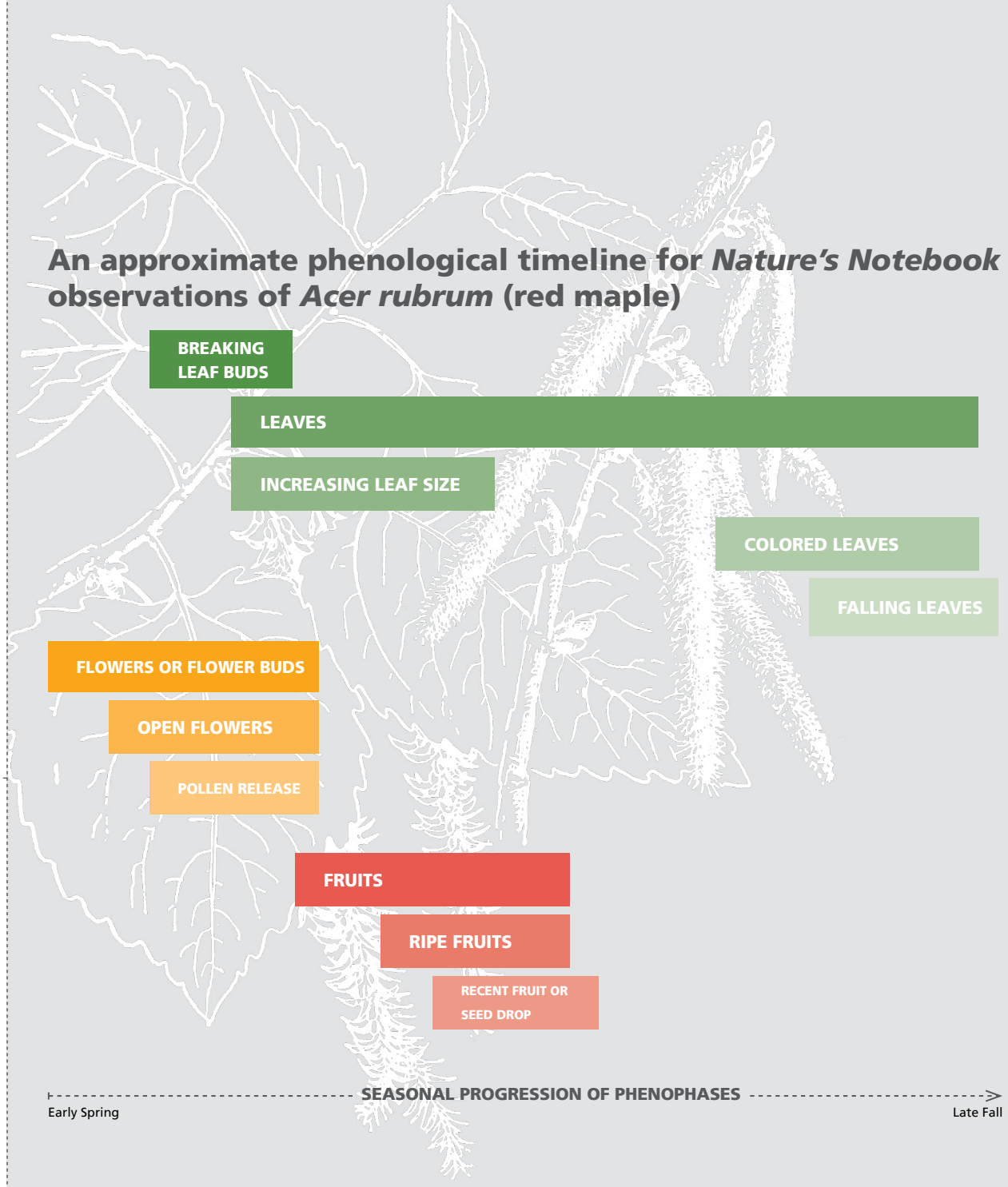
How many mature fruits have dropped seeds or have completely dropped or been removed from the plant since your last visit? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

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 later in spring or 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
- flowers emerge before leaves
- fruit ripeness indicated by color change

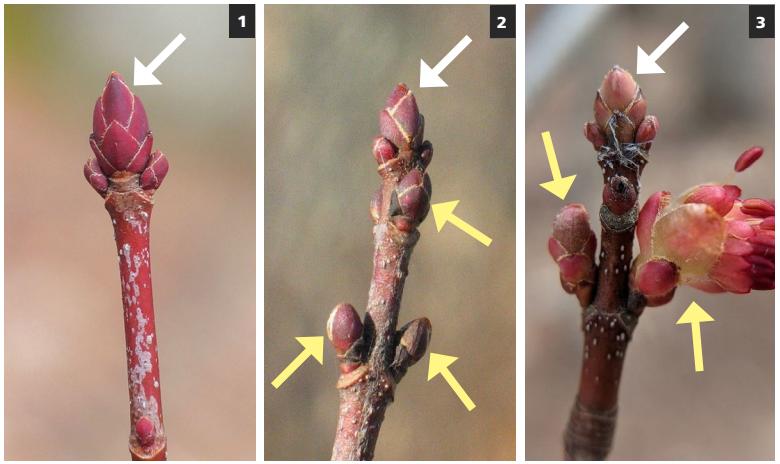
An approximate phenological timeline for *Nature's Notebook* observations of *Acer rubrum* (red maple)



Acer rubrum

(red maple)

Activity begins very early 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".



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.

Leaf phenophases

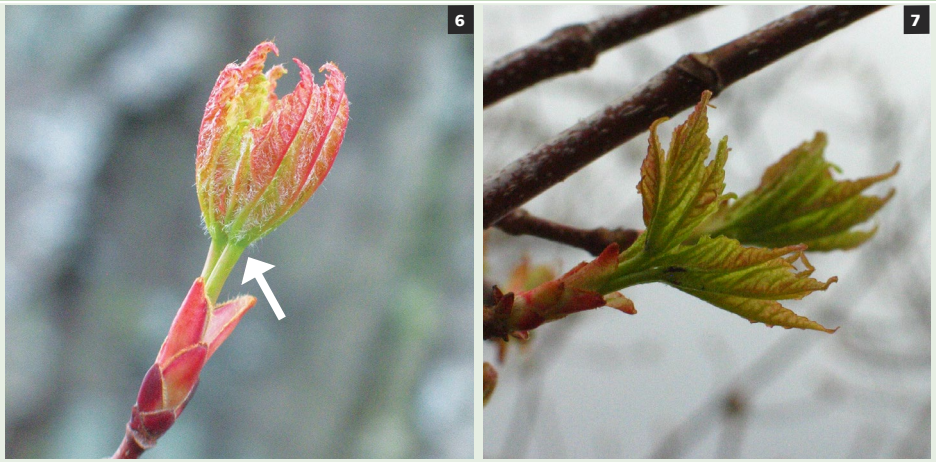
"Breaking leaf buds" begins when leaf tips emerge (Image 4). Then, when at least one breaking leaf bud's first leaf has unfolded (Image 6), begin reporting "yes" for the "Leaves" phenophase, and continue reporting "yes" until the last leaf has dropped from the plant in fall. You will also be reporting "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.

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 (Image 6, white arrow), 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


8


9


10

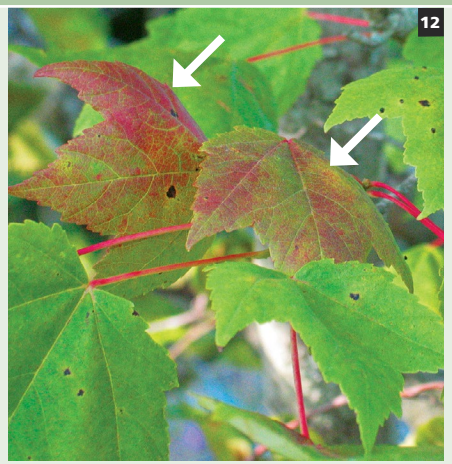
A plant remains in the "Increasing leaf size" phase as new spring leaves grow larger. During this period, leaves are lighter in color, and thinner in texture than they will become when they are full size and mature (Image 11). Although new leaves continue to grow from branch tips all summer, report "no"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


11

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


12


13


14

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


15

Fallen leaves under the plant.

Acer rubrum

(red maple)

Flower phenophases

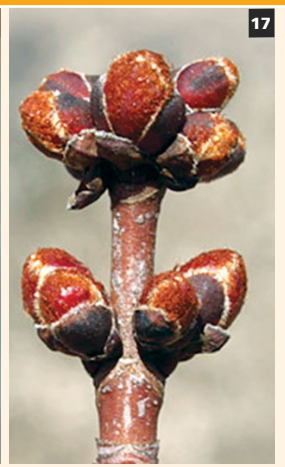
Once the floral buds begin swelling, bud scales start to slide apart and the "Flowers or flower buds" phase has begun. Report "yes" for this phenophase when floral buds begin swelling and continue reporting "yes" until the last flower is withered or dried. If you are unsure whether you see swelling floral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


16


17

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

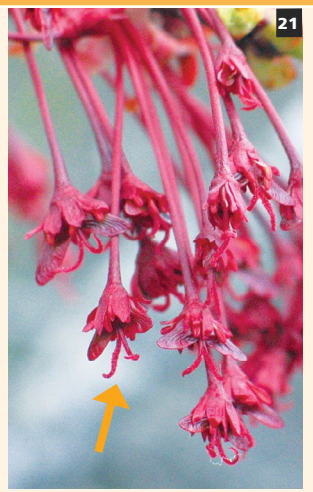
FLOWERS OR FLOWER BUDS

OPEN FLOWERS


18


19


20


21

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

POLLEN RELEASE


22

Report on "Pollen release" only if you can get close enough to male flowers to see whether pollen grains are being released (white arrow).

Acer rubrum

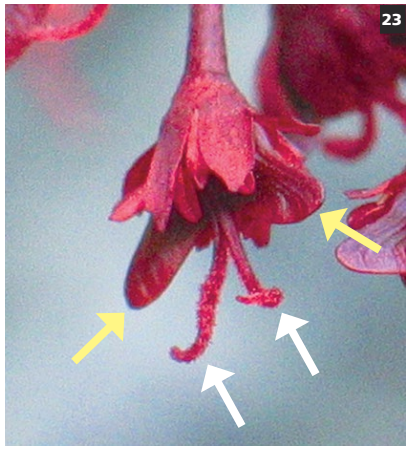
(red maple)

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).

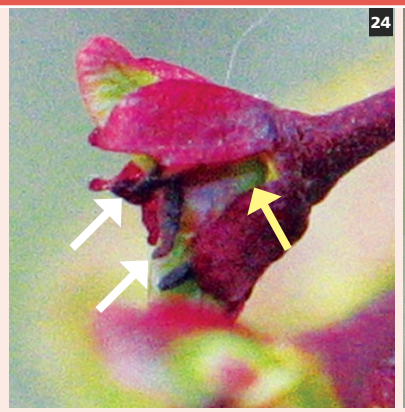
The *Nature's Notebook* fruit definition reads "For *Acer rubrum*, the fruit is two joined seeds in a 'V' shape, each seed having a wing, that changes from green or red to tan or brownish and drops from the plant. A fruit is considered ripe when it has turned tan or brownish and readily drops from the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

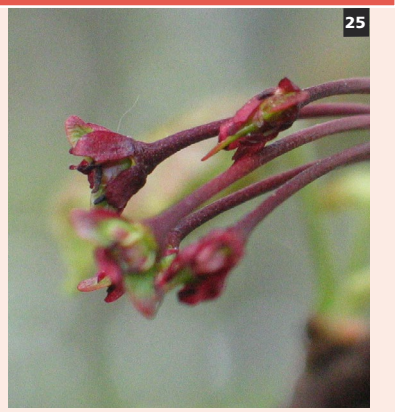
Remember that if your red maple has only male flowers, it will not produce any fruit.



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

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.

RIPE FRUITS

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

RECENT FRUIT OR SEED DROP

Seeds missing (white arrows) since the last visit in Image 30 indicate recent drop.

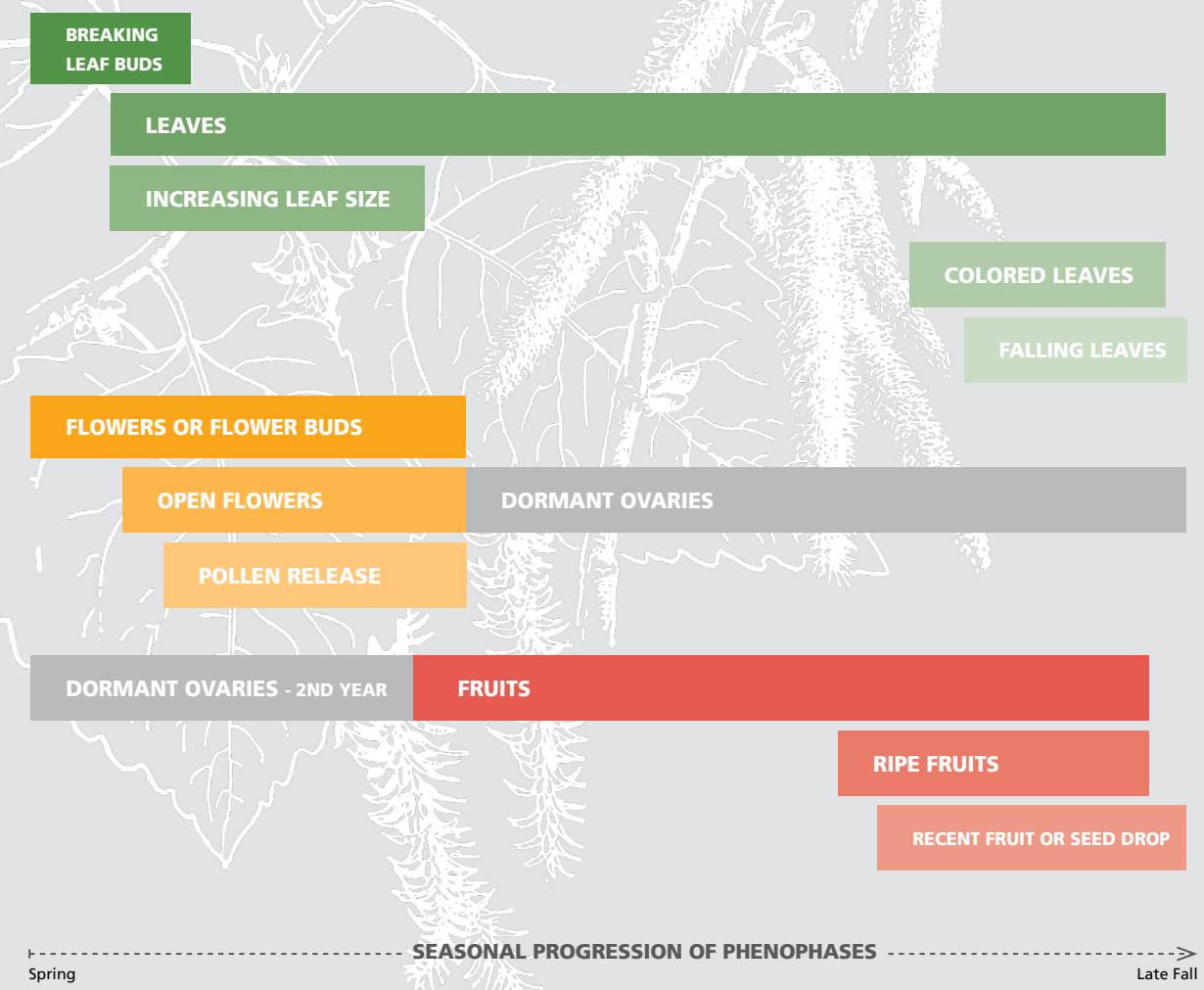
Northern red oak is a dominant tree of forests in the northeastern US. It is monoecious—that is, the male and female flowers are separate on the same plant. Flowers are wind-pollinated and arranged in catkins, typically emerging just after leaf out. Every few years, it produces a massive crop of acorns 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 buds may contain leaves only, or leaves and flowers in a mixed bud
- male and female parts are in separate flowers arranged in catkins
- leaves emerge just before flowers
- 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 scaled 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 and any leaves remaining on the plant are dried and dead. 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.

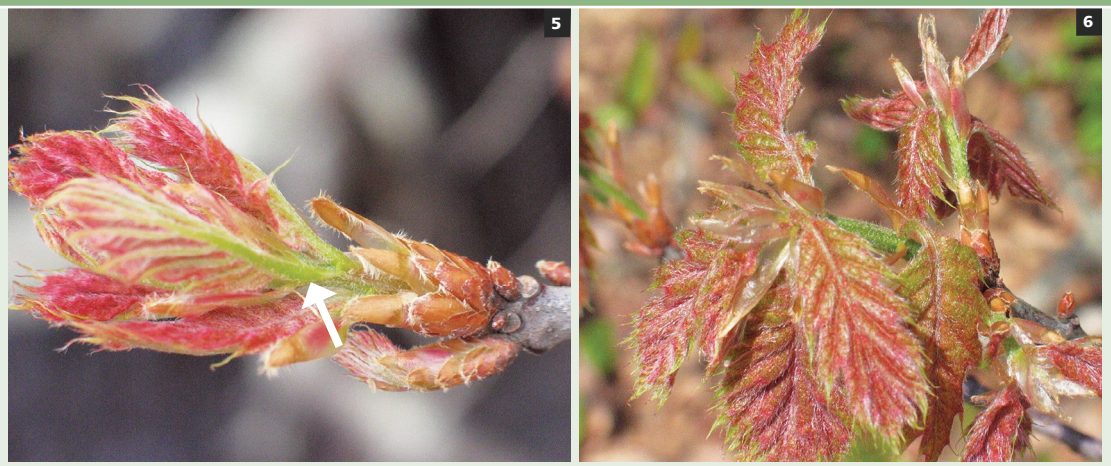
Dormant and swelling buds. While the buds are dormant (Image 1), or newly active and swelling (Images 2-3), report "no" for "Breaking leaf buds" until the bud scales slide apart enough that a green or reddish leaf tip emerges at the tip of the bud (Image 4, white arrow).

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 (Image 5, white arrow), 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


7


8


9

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.


10


11

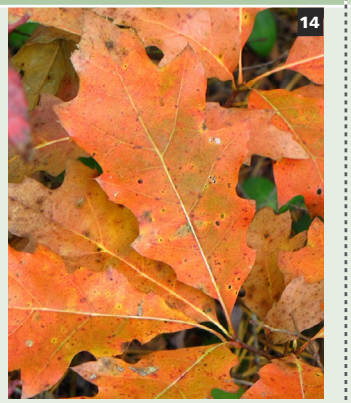
Full-size, mature leaves in shade (Image 10) and in sun (Image 11). Note that at maturity, shade leaves in the lower part of the tree canopy will be larger, lighter in color and thinner in texture than any sun leaves growing in the treetop.

LEAVES

COLORED LEAVES


12


13


14

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


15

Fallen leaves under the plant.


16

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

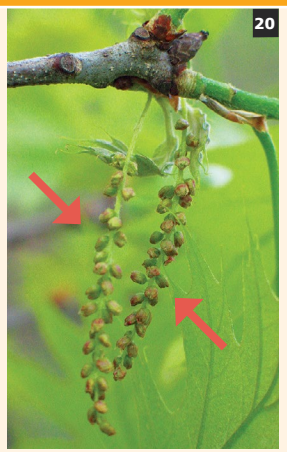

17


18

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

FLOWERS OR FLOWER BUDS


19


20

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


21


22

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

POLLEN RELEASE


23

Report on "Pollen release" only if you can get close enough to male flowers to see whether pollen grains are being released (white arrow).

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.

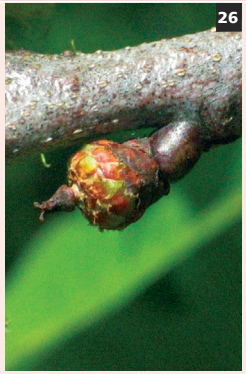
The *Nature's Notebook* fruit definition reads "For *Quercus rubra*, the fruit is a nut (acorn), partially covered with a 'cap', that changes from green to green-brown to brown, red-brown or dark brown. A fruit is considered ripe when it has turned brown, red-brown or dark brown."

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

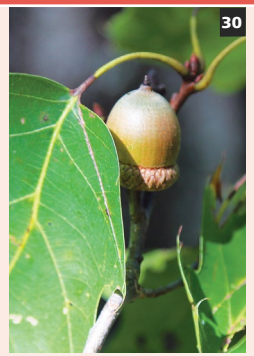
Once pollinated, female flower stigmas dry out (white arrows) and the tiny ovaries sit dormant on the plant for many months. The ovaries will not be fertilized and begin fruit development until the following spring.

FRUITS



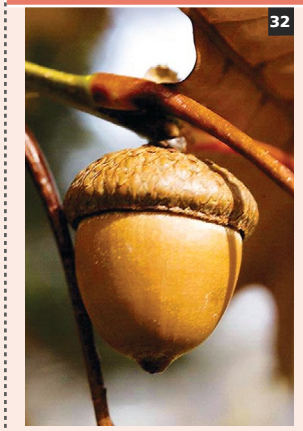
Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger after its year-long dormancy (Image 26). If these small fruits are out of reach, you may not be able to see them at all until they grow a little larger.

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



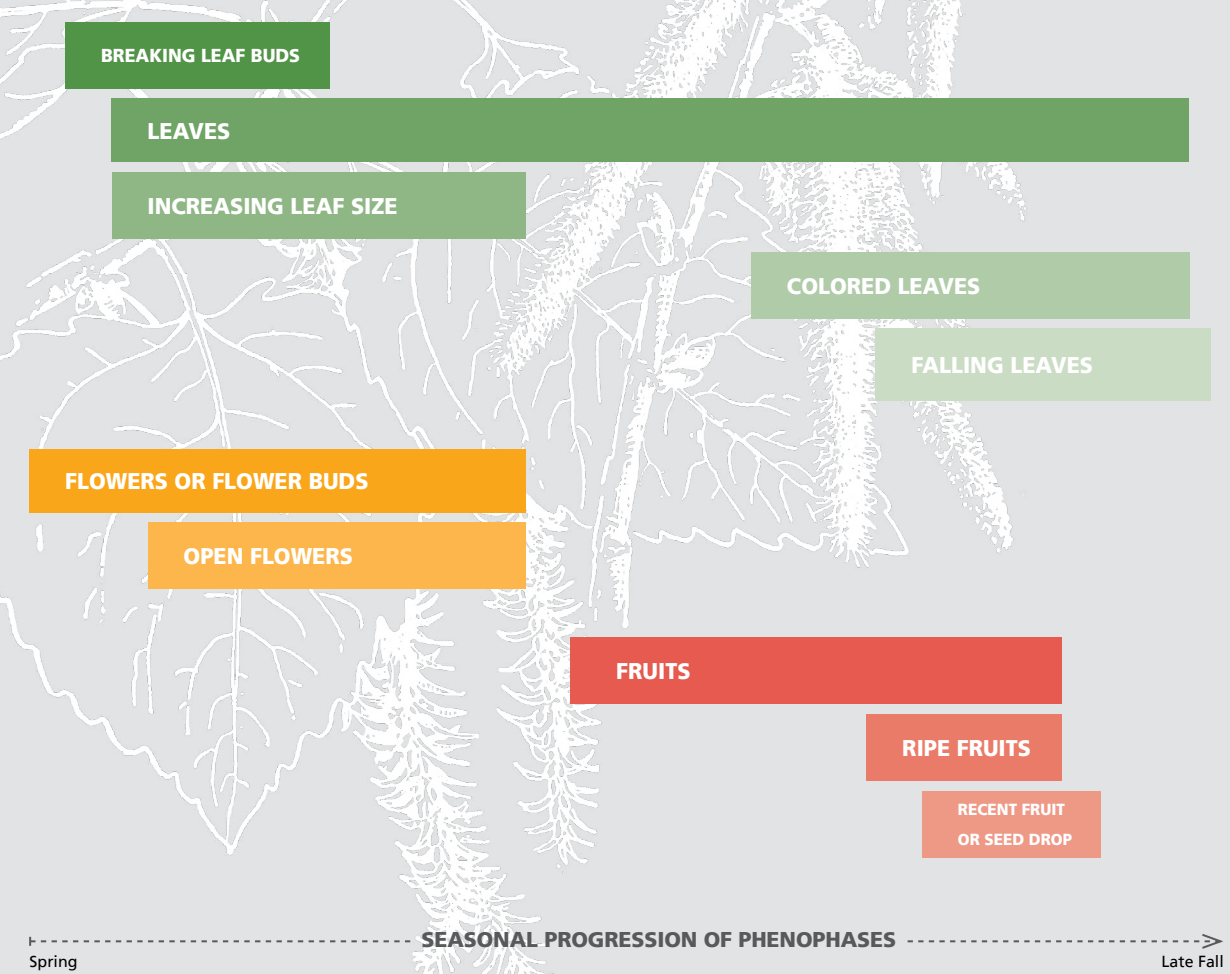
A fruit is ripe when it has turned brown, red-brown or dark brown.

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.

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



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 indistinguishable 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 buds may contain leaves or flowers or both in a mixed bud
- single large flower has male and female parts
- flowers emerge before leaves
- individual fruits arranged in unusual cone-like clusters
- "dehiscent" capsule-like fruits split open when ripe

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.

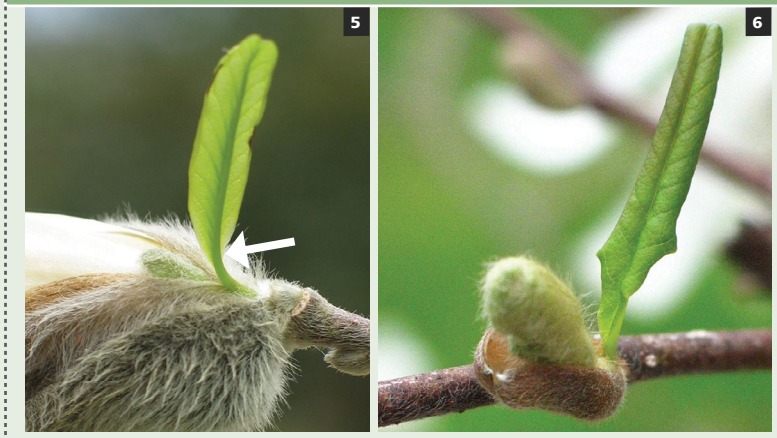
Dormant and swelling buds. While the buds are dormant (Image 1), or newly active and swelling (Image 2), report "no" for "Breaking leaf buds" until the fuzzy bud scale breaks open enough that a green leaf tip emerges alongside the developing flower in a mixed bud (Image 3) or at the tip of a leaf bud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

BREAKING LEAF BUDS

Once a green leaf tip (white arrows) 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

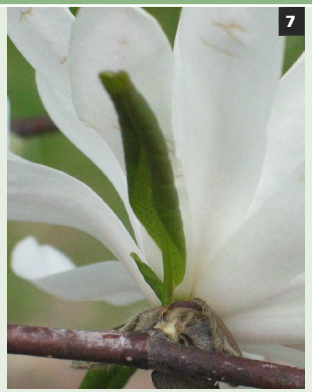
INCREASING LEAF SIZE



Once the leaf base becomes visible (Image 5, white arrow), 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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8


9

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.


10

Full-size, mature leaves.

LEAVES

COLORED LEAVES


11


12

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

FALLING LEAVES


13

Fallen leaves under the plant.

Magnolia stellata

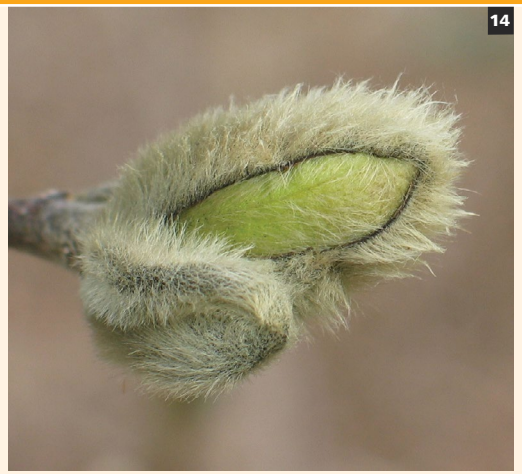
(star magnolia)

Flower phenophases

Once the floral or mixed buds begin swelling, the "Flowers or flower buds" phase has begun and the fuzzy bud scale will start to split open. 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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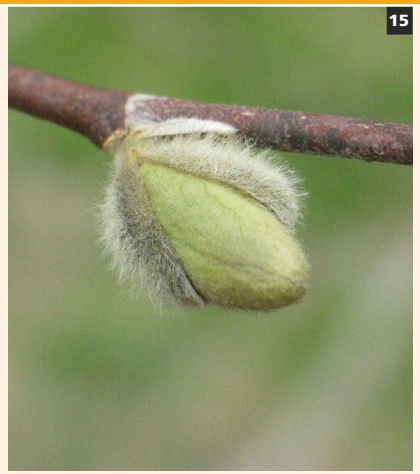
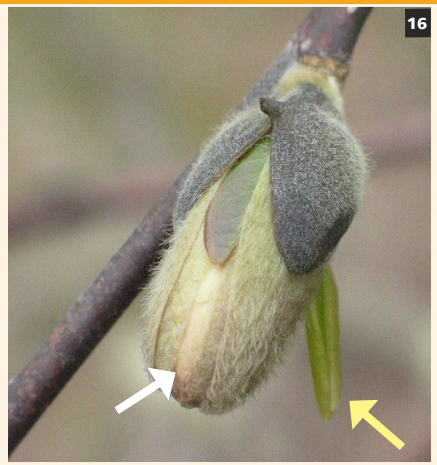
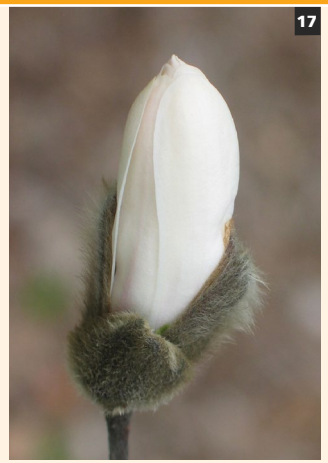

15

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."

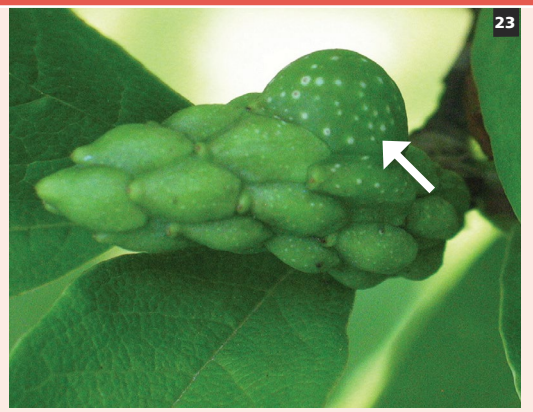

20


21


22

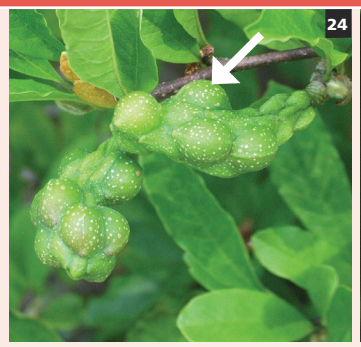
A fruit cluster develops from the center of a spent flower and begins to elongate and grow plumper as the individual ovaries swell (Images 20-21). Often development of the entire cluster ceases and the cluster withers, turns gray (Image 22) and eventually drops from the plant. For this reason, in star 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).

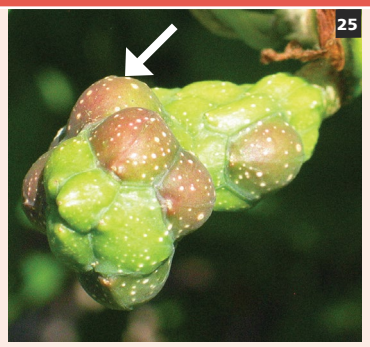
FRUITS


23

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


24


25

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 (white arrow) 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

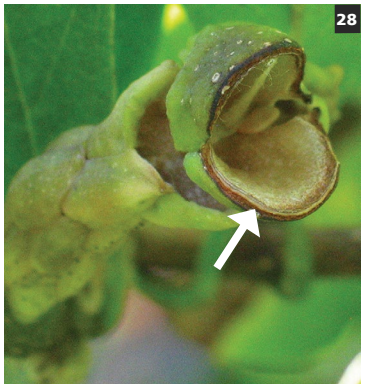

26

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

RECENT FRUIT OR SEED DROP


27

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


28

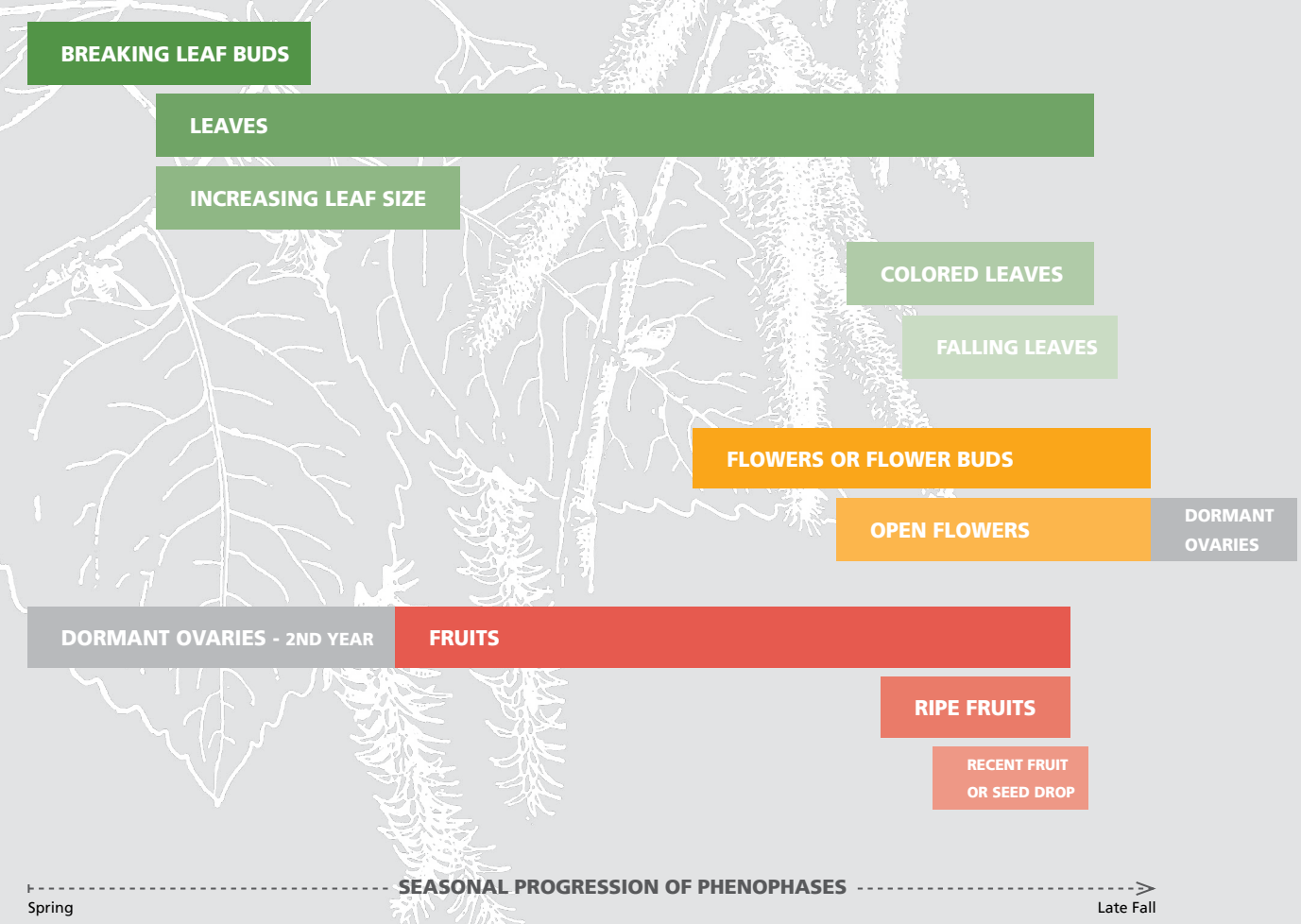
Empty capsule-like fruits that have dropped their seed (white arrow) should not be included in the "Fruits" or "Ripe fruits" phenophases.

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
- flower buds appear in summer and open in fall
- unfertilized ovaries in spent flowers remain dormant over winter
- "dehiscent" fruit capsules split open, sometimes explosively, when ripe

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



Hamamelis virginiana

(American witchhazel)

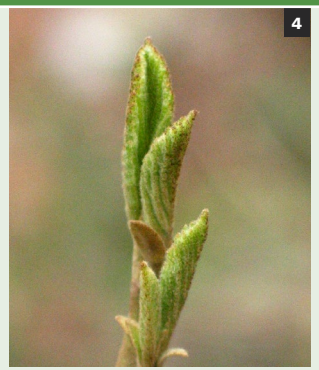
Activity begins in spring as dormant buds come to life. American witchhazel has overwintering leaf buds, but they differ from many deciduous plants in that the buds are "naked". That is, they don't have hard scales that cover and obscure its new leaves. Instead they have tiny leaves tightly folded together (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 (Image 5, white arrow), 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


8


9

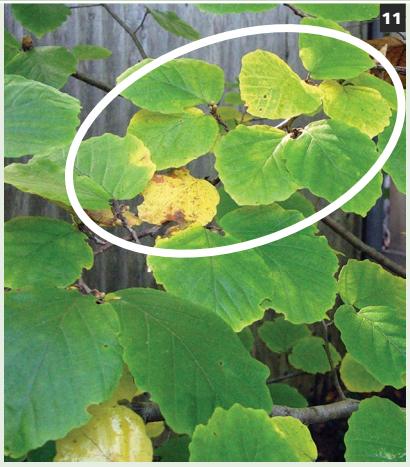
A plant remains in the "Increasing leaf size" phase as new spring leaves grow larger. During this period, leaves are lighter in color, and thinner in texture than they will become when they are full size and mature (Image 10). Although new leaves continue to grow from branch tips all summer, report "no"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


10

Full-size, mature leaves.

LEAVES

COLORED LEAVES


11


12

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

FALLING LEAVES


13

Fallen leaves under the plant.

Hamamelis virginiana

(American witchhazel)

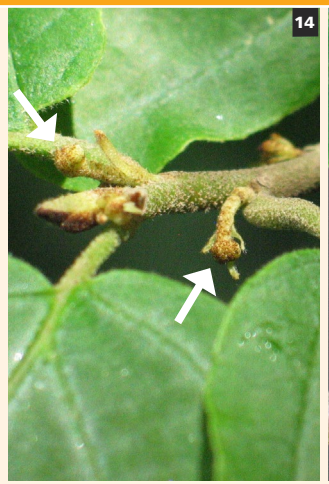
Flower phenophases

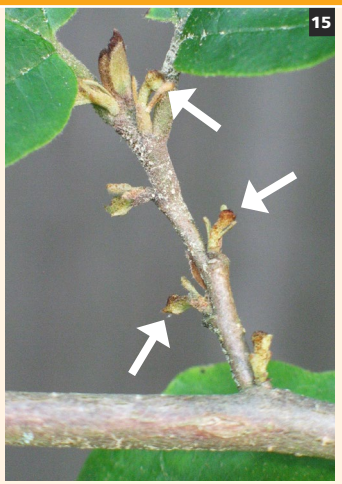
American witchhazel has a rather unique flowering strategy. Flower buds form in summer after the leaves are full-sized, and flowers open in the fall as the leaves are changing color or after leaf fall. Flowers are pollinated, but fertilization is delayed. As flowers wilt, their ovaries enter a dormant 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. Ribbon-like yellow petals emerge from the flower buds (Image 18, white arrow) before reproductive parts are visibile.

OPEN FLOWERS

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

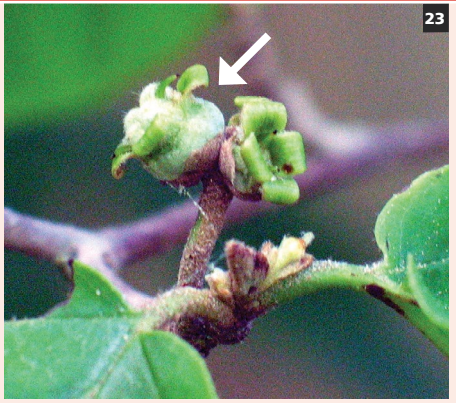
The *Nature's Notebook* fruit definition reads "For *Hamamelis virginiana*, the fruit is a fuzzy capsule that changes from green to brown and splits open, sometimes explosively, to expose the seeds. A fruit is considered ripe when it has turned brown and has split open to expose the seeds. Do not include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

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

DORMANT OVARIES

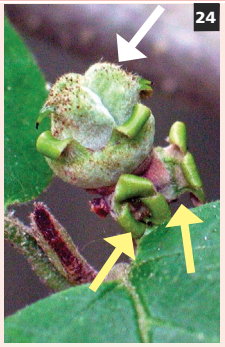
Once flowers have wilted, the cup-like calyx containing the ovary sits dormant on the plant over the winter (Image 21) and into the spring or early summer (Image 22).

FRUITS



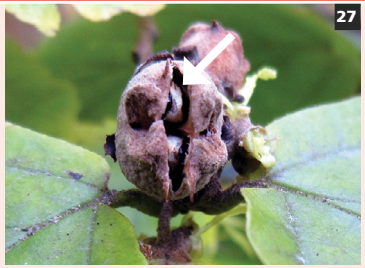
Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger after its long dormancy (white arrow).

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 starts to 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 one or both of its seeds since your last visit.

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

TREE/ SHRUB— DROUGHT DECIDUOUS

This functional group includes desert- and dryland-adapted woody plant species with leaves that will drop during periods of stress. Leaves may or may not be present year-round, depending on rainfall and temperature conditions. A plant may be evergreen in most years, or leaves may regularly senesce and fall from the plant during dry periods. Leaves develop sporadically—growth starts and stops with water availability—so that identifying a typical "full-sized" leaf may be difficult. Dormant leaf buds are either not present or too small to observe the process of bud break.

Representative species:

- *Prosopis velutina* (velvet mesquite)
- *Ceanothus greggii* (desert ceanothus)

Young leaves

One or more young, unfolded leaves are visible on the plant. A leaf is considered "young" and "unfolded" once its entire length has emerged from the 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, but before the leaf has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

How many young leaves are present? 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

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.

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

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

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.

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.

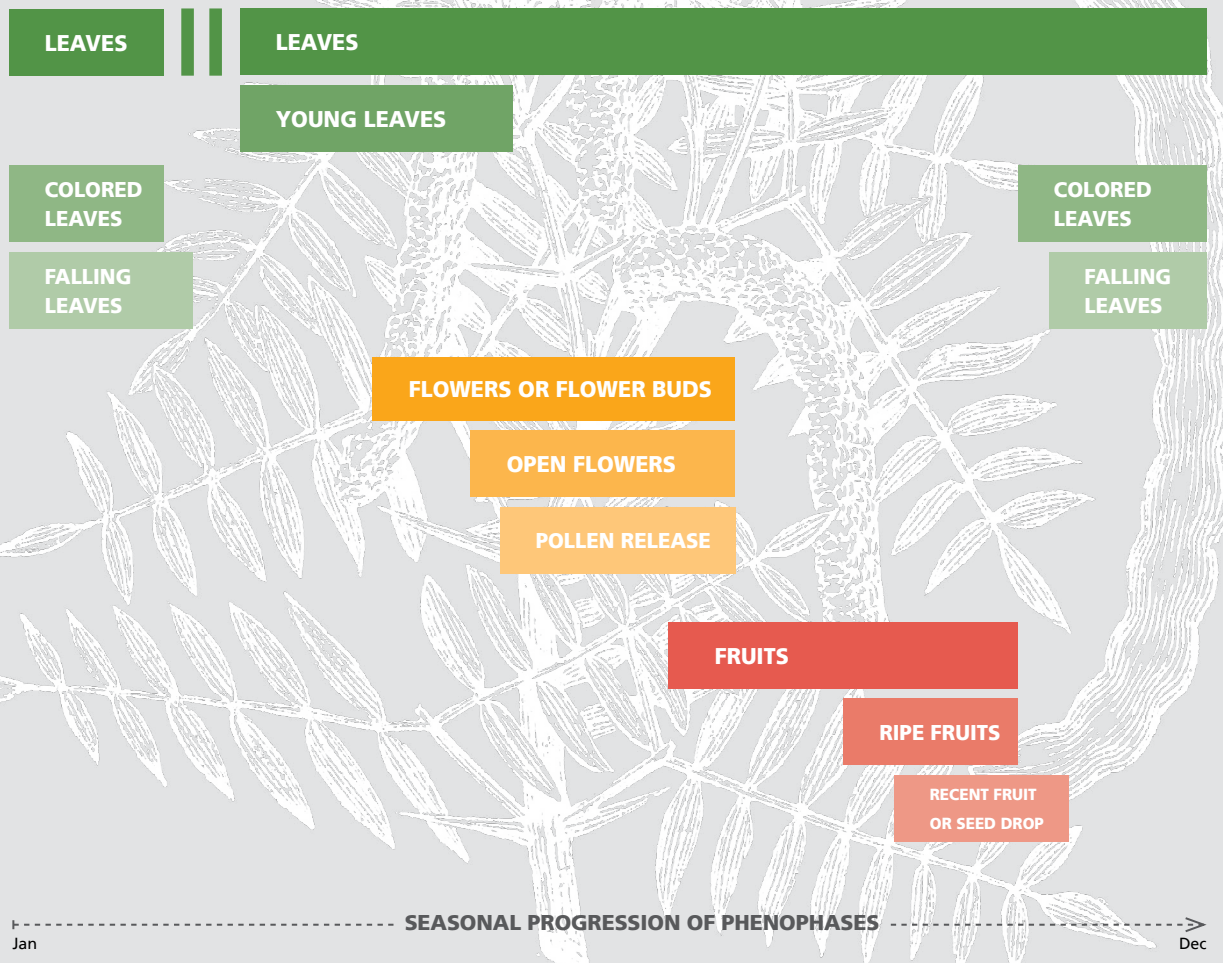
How many mature fruits have dropped seeds or have completely dropped or been removed from the plant since your last visit? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

Velvet mesquite is a small tree of dry-land habitats in the southwestern US. It is typically deciduous but, depending on temperature and other environmental factors, its leaves can be retained year-round (represented by the hashed section of the "Leaves" phenophase bar on the timeline). The yellow flowers that emerge in spring are insect-pollinated and arranged in catkins. Usually only a few of the flowers in a catkin are fertilized, then develop into long fruit pods that ripen later in the year.

Phenological characteristics of note:

- leaves and flowers emerge from short shoots
- a leaf is composed of many leaflets
- male and female parts are in same flowers arranged in catkins
- new leaves emerge before flowering
- individual fruit pods emerge from catkins
- fruit ripeness indicated by color change
- leaf color change may be absent

An approximate phenological timeline for *Nature's Notebook* observations of *Prosopis velutina* (velvet mesquite)



Prosopis velutina

(velvet mesquite)

Activity often begins in spring when leaf tissue emerges from stems, but sometimes there are waves of new growth that start and stop several times throughout the year. Velvet mesquites have no discernible buds—buds are tiny and deeply hidden in stem tissue—so new leaf growth will appear at branch tips and on the many hard, bumpy "short shoots" along the branches.

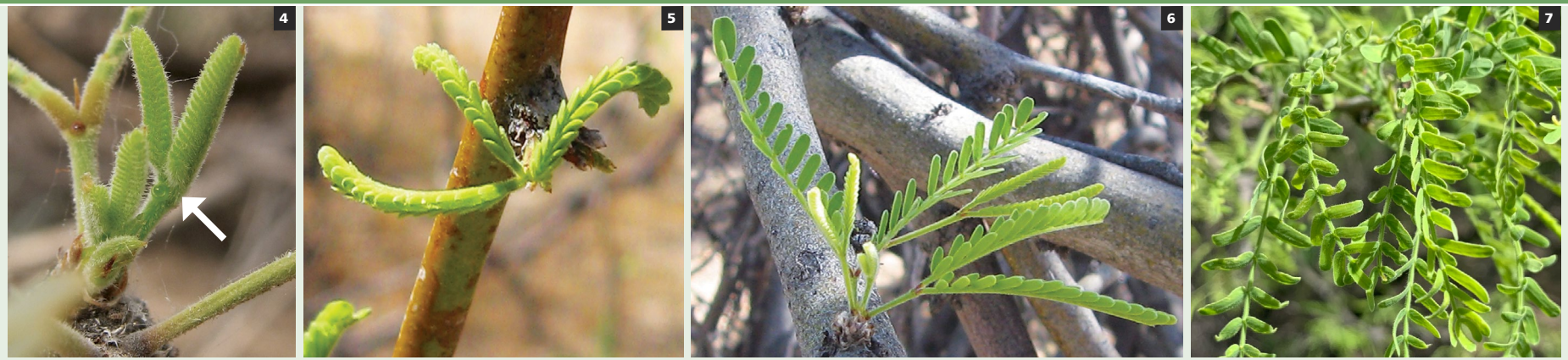
Leaf phenophases

"Young leaves" begins when at least one new leaf has unfolded (Image 4), and ends when all leaves have become the color and texture of mature leaves on the plant. Begin reporting "yes" for the "Leaves" phenophase with the first unfolded leaf, and continue reporting "yes" until the last leaf has dropped from the plant. You will also be reporting "yes" for "Colored leaves" when leaves senesce in fall or in dry periods.

Dormant and newly active short shoots. While the short shoots are dormant (Image 1, white circle) or newly active with leaf tissue just starting to emerge (Images 2-3), report no for "Young leaves" until the first leaf base is visible where it attaches to the petiole (Image 4).

LEAVES

YOUNG LEAVES



Once the base of a leaf is visible where it attaches to the petiole (Image 4, white arrow), it is considered "unfolded" and the "Young leaves" and "Leaves" phenophases have begun. Velvet mesquite has compound leaves with many leaflets attached to a central leaf stem. In Image 4, the developing leaflets resemble the teeth of a comb. A plant remains in the "Young leaves" phase as new leaves grow larger and are lighter in color and thinner in texture than they will become when they are mature. Mature leaf and leaflet size can vary—they may stop getting larger if water availability is low during growth—so look for mature color and texture rather than size.

LEAVES

YOUNG LEAVES


8


9

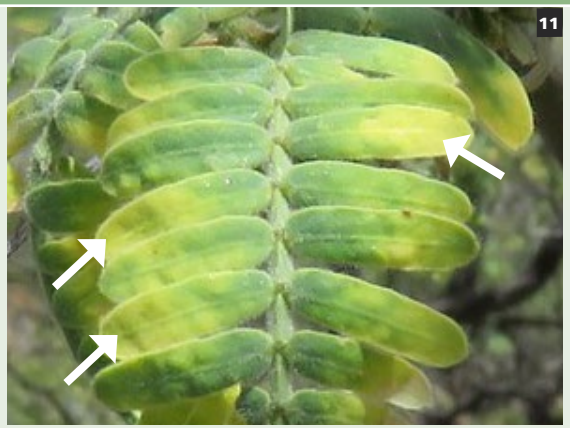
New leaf growth can occur throughout the year in response to rainfall. In Image 9, young leaves (white arrows) are a lighter shade of green than the older, mature leaves on the plant (yellow arrows).


10

Mature leaves. Mature leaves are dark green, sometimes bluish-green, and thicker in texture than young leaves.

LEAVES

COLORED LEAVES


11


12


13

When leaves start to senesce at the end of the season or during dry periods, yellow color begins to appear in leaflets and the "Colored leaves" phase has begun (Image 11). In velvet mesquite, leaflets may change from yellow to brownish-yellow before they fall from the plant. Sometimes leaflets might not change color at all and remain green as they dry up and fall from the plant. If this is the case, you will not see and report "yes" for "Colored leaves".

FALLING LEAVES


14

Leaflets missing from the leaf stem (white arrow) indicate recent fall.

Prosopis velutina

(velvet mesquite)

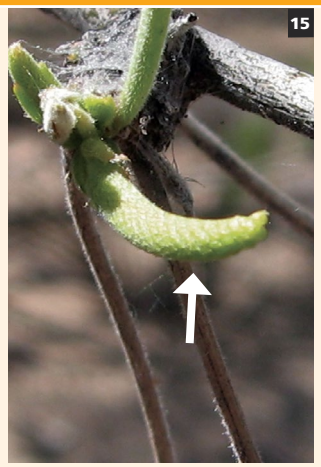
Flower phenophases

Velvet mesquite flowers are arranged in long catkins that emerge from short shoots after leaf growth has begun. Once you see a catkin begin to emerge (Image 15, white arrow), 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. Each tiny flower in the catkin has both male and female reproductive parts. Female stigmas emerge (Image 17) before the floral parts open up fully to expose male anthers and give the catkin a fluffy appearance (Image 19). Where flowers are out of reach, the initial appearance of female stigmas is hard to see, so begin reporting "yes" for "Open flowers" when catkins begin to appear fluffy.

Because velvet mesquite pollen is an allergen, the "Pollen release" phenophase is also included for observation.

FLOWERS OR FLOWER BUDS

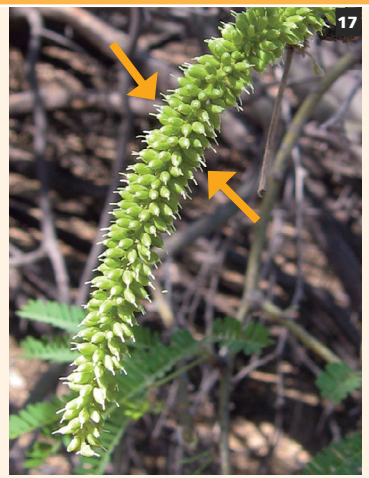

15


16

Catkins will emerge from short shoots after the leaves emerge (Image 15, white arrow). They are initially short and compact, then lengthen and hang more loosely as they develop.

FLOWERS OR FLOWER BUDS

OPEN FLOWERS


17


18


19

Female stigmas emerge from each tiny flower bud, resembling white bristles (Images 17 and 18, orange arrows). Then floral parts open up fully to expose the yellow, male anthers (Image 18, red arrows), giving the catkin a fluffy appearance (Image 19, white arrows).

POLLEN RELEASE


20

Report on "Pollen release" only if you can get close enough to male flowers to see whether pollen grains are being released (white oval).

Prosopis velutina

(velvet mesquite)

Fruit phenophases

After velvet mesquite flowers have been pollinated, the ovaries are fertilized very soon afterwards and fruit pods begin to develop immediately. Usually only a few flowers in a catkin will be fertilzed and develop into fruits.

The *Nature's Notebook* fruit definition reads "For *Prosopis velutina*, the fruit is a pod that changes from green to tan, often mottled or flecked with maroon. A fruit is considered ripe when it has turned tan, often mottled or flecked with maroon."

FRUITS


21


22

Begin reporting "yes" for "Fruits" once you notice at least one small, green pod emerge from a catkin (Image 20, black arrows), often while flowers are still present. Pods lengthen as they grow (Image 21, white arrows).

FRUITS


23


24


25

As the pods develop, they gradually get longer and become lumpy, changing from dark green to a lighter green before reaching their ripened color of tan, often with maroon flecks.

RIPE FRUITS


26

A fruit is ripe when it has turned tan, often mottled or flecked with maroon.

RECENT FRUIT OR SEED DROP


27

Ripe fruit will eventually drop from the plant.

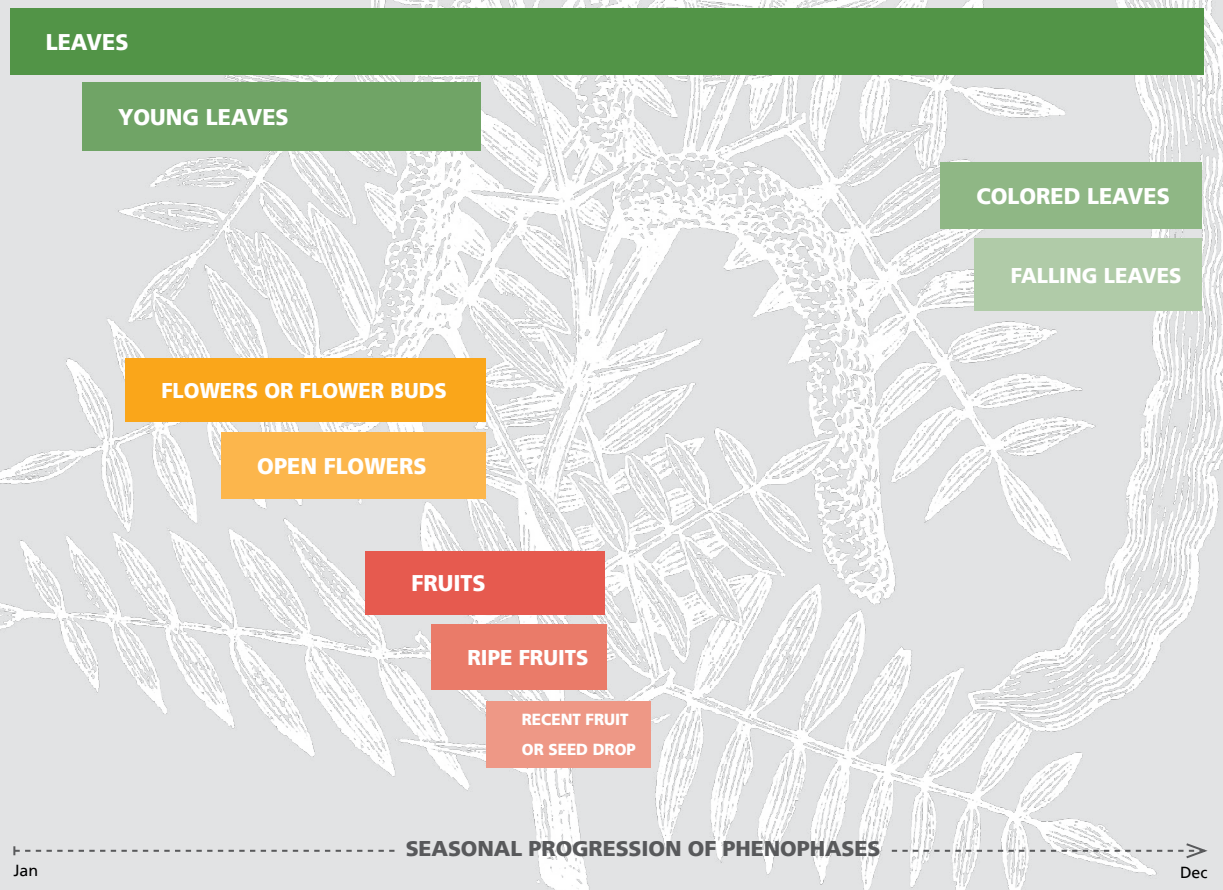
Desert ceanothus is a shrub of dryland habitats in the southwestern US. It is typically evergreen, but in cases of extreme drought, it may drop all its leaves at once. Clusters of white flowers are insect-pollinated and emerge from scaled buds in spring, not long after new leaf growth begins. The fruits are round capsules that ripen and break open later in the year to release their seeds.

Taxonomy of this species has recently changed and some sources use a new scientific name, *Ceanothus pauciflorus.*

Phenological characteristics of note:

- leaves emerge from stems and flowers from scaled buds
- small flowers are arranged in a cluster-like inflorescence
- new leaves emerge before flowering
- "dehiscent" fruit capsules split open, sometimes explosively, when ripe
- leaf color change may be absent

An approximate phenological timeline for *Nature's Notebook* observations of *Ceanothus greggii* (desert ceanothus)



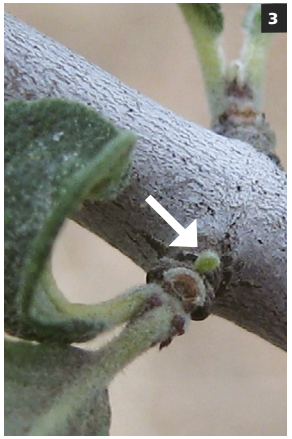
Ceanothus greggii

(desert ceanothus)

Activity typically begins in early spring when tiny leaves begin to appear. Desert ceanothuses do not have discernible leaf buds—they are naked, very tiny and hidden—so new leaf growth will appear at stem tips, from the base of dormant floral buds, and from "short shoots" along the branches.

Leaf phenophases

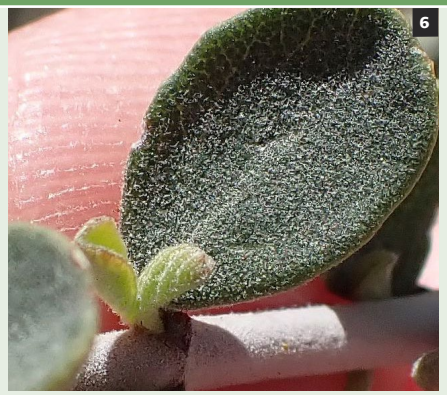
"Young leaves" begins when at least one new leaf has unfolded (Image 4), and ends when all leaves have become the color and texture of mature leaves on the plant. "Leaves" begins with the first unfolded leaf, and continues until the last leaf has dropped from the plant. However, desert ceanothus is often evergreen—it only rarely drops all of its leaves at once—so you will most likely be reporting "yes" to "Leaves" all year round. You will also be reporting "yes" for "Colored leaves" when leaves senesce in fall or in dry periods.



Dormant and newly active leaf buds. Tiny, dormant leaf buds are hidden in stem tips under leathery, brown stipules (Image 1, white arrows). While the leaf buds are dormant or newly active—with tiny, fuzzy leaves just starting to emerge from between the stipules (Image 2, white arrow) or from short shoots (Image 3, white arrow)—report no for "Young leaves" until the first leaf base is visible where it attaches to the petiole (Image 4). If mature leaves are present during this time, as they are in these images, you should be reporting "yes" for the "Leaves" phenophase.

LEAVES

YOUNG LEAVES



Once the base of a leaf is visible where it attaches to the petiole (Image 4, white arrows), it is considered "unfolded" and the "Young leaves" phenophase has begun. Newly emerging leaves of desert ceanothus are very small, so you may need to look very closely to see where the leaf base meets the petiole. Image 5 shows new leaves (white arrows) emerging from the base of dormant flower buds. A plant remains in the "Young leaves" phase as new leaves grow larger and are lighter in color and thinner in texture than they will become when they are mature. Mature leaf size can vary—they may stop getting larger if water availability is low during growth—so look for mature color and texture rather than size.

LEAVES

YOUNG LEAVES


8


9


10

Young leaves (white arrows) are a lighter shade of green than the older, mature leaves on the plant (yellow arrows), but the difference becomes hard to discern as young leaves reach maturity.


11

Mature leaves. Mature leaves are dark green and thick in texture.

LEAVES

COLORED LEAVES


12


13


14

When leaves start to senesce at the end of the season or during dry periods, yellow color begins to appear and the "Colored leaves" phase has begun. Color change in some leaves may be obvious in contrast to dark green leaves on the plant (Image 12, white circles), or it may be more subtle and gradual, with all leaves on the plant developing a yellow-green color (Images 13-14). Sometimes leaves might not change color at all before they dry up and fall from the plant. If this is the case, you will not see and report "yes" for "Colored leaves".

FALLING LEAVES


15

Fallen leaves under the plant.

Ceanothus greggii

(desert ceanothus)

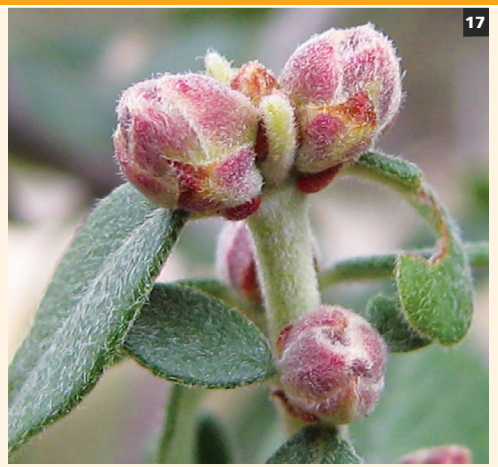
Flower phenophases

Desert ceanothus has small, white flowers arranged in inflorescences. Scaled flower buds form late in the year and generally remain dormant until after leaf growth has begun in the spring. Once floral buds begin swelling (Image 17) 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, you can wait until you see white flower petals begin to emerge from the bud (Image 18, white arrows) 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 can be in different phases on the plant, so it is not unusual to see buds, open flowers, and fruits within a single inflorescence.

Dormant flower buds (white arrows).

FLOWERS OR FLOWER BUDS



As flower buds swell, they get larger and scales slide apart until they break open to reveal white flower petals (Image 18, white arrows).

FLOWERS OR FLOWER BUDS

Each flower bud develops into an inflorescence with several individual flowers. White petals emerge (Image 18, white arrows) before reproductive parts are visible.

OPEN FLOWERS

Each flower has both male (red arrows) and female (orange arrow) reproductive parts.

Spent flowers. The petals have withered and the flowers are no longer fresh. Some ovaries have already become green fruits.

Ceanothus greggii

(desert ceanothus)

Fruit phenophases

When a desert ceanothus flower has been fertilized, the ovary will develop into a fruit soon afterwards.

The *Nature's Notebook* fruit definition reads "For *Ceanothus greggii*, the fruit is a three-lobed capsule that changes from green to red-green to maroon 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."

FRUITS

Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger (Image 23). As fruits develop, they begin to turn reddish in color (Image 24). Styles (white arrows) remain attached to the fruits while they develop.

FRUITS

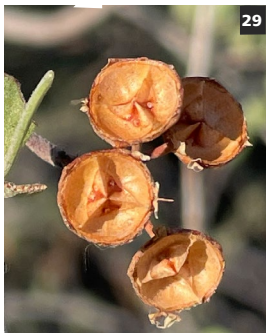
As the fruits continue to develop, they change through shades of maroon and red-brown before reaching their ripened color of brown (Image 27).

RIPE FRUITS

A fruit is ripe (white circle) when it has turned brown and starts to split open to expose seeds inside. Often the capsule opens explosively and falls apart immediately, 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

Capsules often fall apart as they open. Report "yes" to "Recent fruit or seed drop" if you see a capsule base that has lost its seeds and sides since your last visit (white circle).



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

TREE/ SHRUB— SEMI-EVERGREEN

This functional group includes woody plant species with leaves that remain on the plant for only one growing season, but that senesce and fall from the plant only after the large flush of new leaves—thus leaves are present year-round. It also includes species with leaves that remain on the plant for multiple growing seasons in some locations or years (typically milder climates and weather conditions), but that may senesce and fall from the plant as they enter a leafless dormant season in other locations or years (in more extreme conditions). Dormant leaf buds are generally large enough to observe the process of bud break.

The similar phenophases, "Young leaves" and "Increasing leaf size", are both included for this group. Observers may choose to report on both or only the one that seems most appropriate for their individual plant.

Representative species:

- *Quercus douglasii* (blue oak)

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

Young leaves

One or more young, unfolded leaves are visible on the plant. A leaf is considered "young" and "unfolded" once its entire length has emerged from the 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, but before the leaf has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

How many young leaves are present? 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 die-back 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.

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

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

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.

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

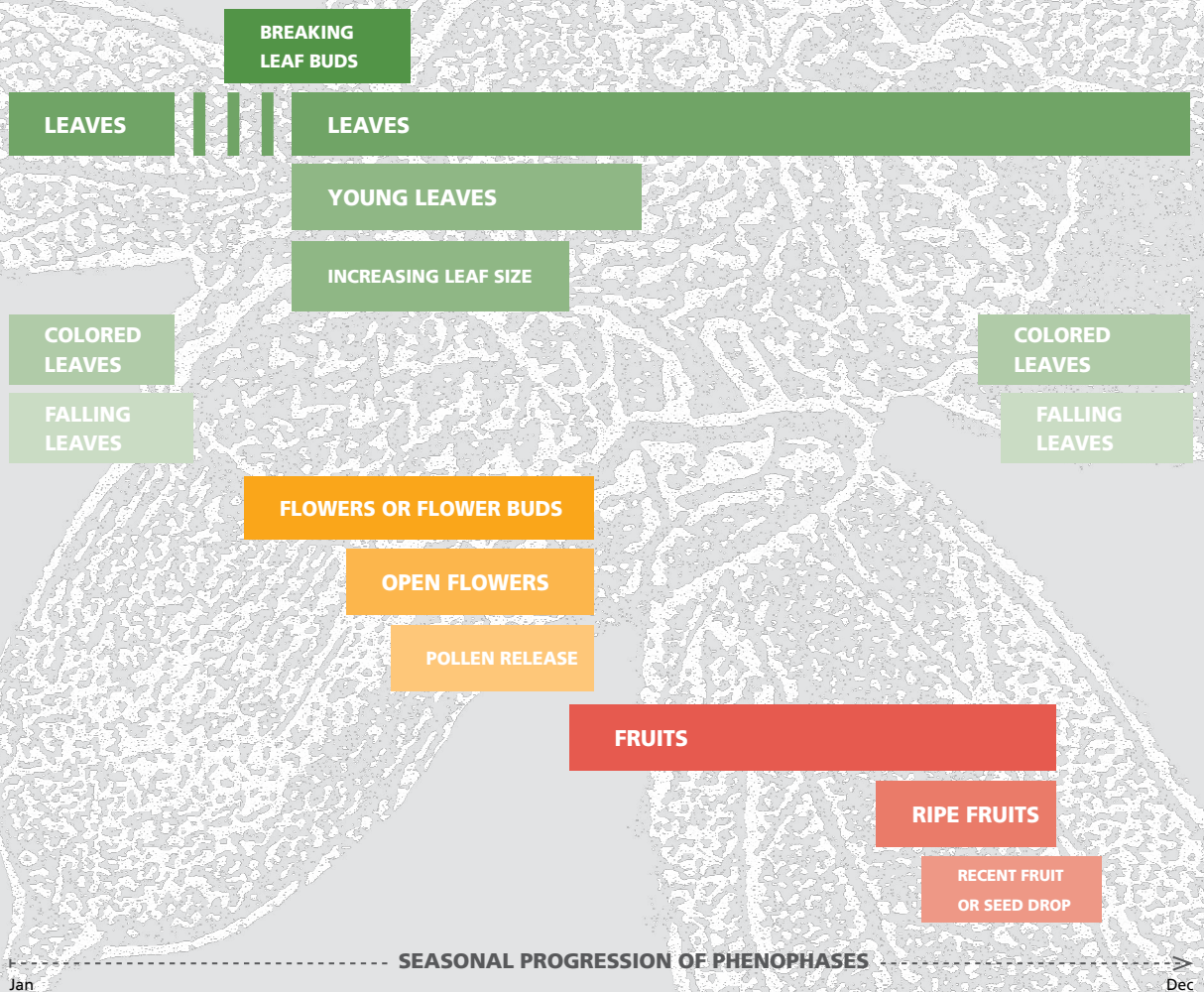
Blue oak is found in California and most of the time is a winter deciduous species. Occasionally—in wetter and milder habitats—it can behave as a evergreen and retain leaves year-round (represented by the hashed section of the "Leaves" phenophase bar on the timeline). It can also be drought deciduous, dropping its leaves during periods of low water availability.

Blue oak is monoecious (separate male and female flowers on the same plant), and 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".

Phenological characteristics of note:

- scaled buds may contain leaves or flowers or both in a mixed bud
- male and female parts are in separate flowers arranged in catkins
- new leaves emerge just before flowering
- fruit abortion is common
- fruit ripeness indicated by color change

An approximate phenological timeline for *Nature's Notebook* observations of *Quercus douglasii* (blue oak)



Quercus douglasii

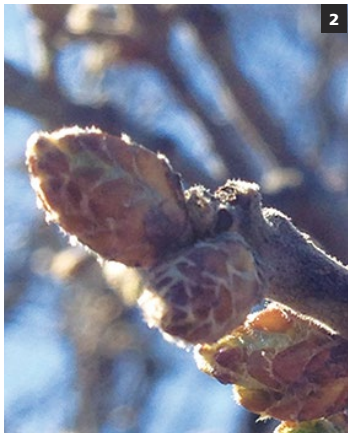
(blue oak)

Blue oak is primarily a deciduous species, but in some locales leaves may be present year-round. Regardless, there is a distinct period of growth in spring as dormant buds come to life to produce a new leaf canopy or replenish an evergreen one. In dry climates, it can also develop a new flush of leaves following a heavy rainfall. Blue oak typically has three types of scaled buds—vegetative (leaf), reproductive (floral) and mixed buds that produce both leaves and flowers. The buds look very similar and it is not always possible to tell what they contain until they open. 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 "Young leaves" and/or "Increasing leaf size" in the spring, and "Colored leaves" in fall.


1


2

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 bud scales slide apart enough that a green or reddish leaf tip emerges at the tip of the bud (Image 3).

BREAKING LEAF BUDS

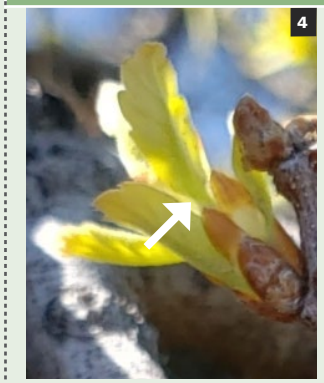

3

Once a leaf tip (white arrow) 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 4, white arrow). Report "yes" for this phenophase until all broken buds have a visible leaf base.

LEAVES

YOUNG LEAVES

INCREASING LEAF SIZE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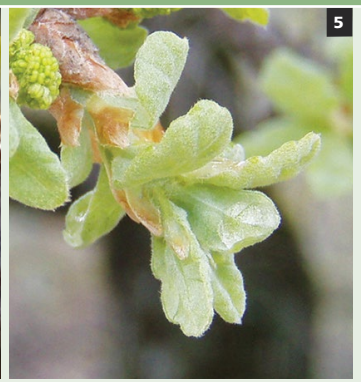

5


6


7

Once the leaf base becomes visible (Image 4, white arrow), the first leaf from the bud is considered "unfolded". At this point, the bud has left the breaking stage and entered the "Leaves", "Young leaves" and "Increasing leaf size" phenophases. A plant remains in the "Young leaves" and "Increasing leaf size" phenophases as new leaves grow larger and are lighter in color and thinner in texture than they will become when they are full size and mature.

LEAVES

YOUNG LEAVES

INCREASING LEAF SIZE


8


9

"Young leaves" and "Increasing leaf size" both capture essentially the same thing—the period of time it takes new leaves to mature. You could choose to report on both or only one of these—"Increasing leaf size" where there is a single large flush every spring and it is clear when leaves reach full size, or "Young leaves" in dry climates where full leaf size may vary year to year and new leaves may appear sporadically following rainfall events.


10

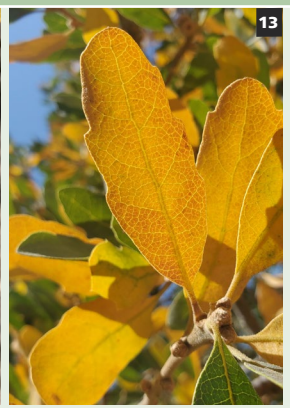

11

Full-size, mature leaves. Mature leaves are dark green and thick in texture. Leaf size at maturity will vary by location and conditions, so you will need to get to know what to expect on your individual plant.

LEAVES

COLORED LEAVES


12


13


14

When leaves start to senesce, yellow or brown color begins to appear and the "Colored leaves" phase has begun (Image 12). In blue oak, leaves turn various shades of yellow and brown, and sometimes dead, brittle leaves 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


15

Fallen leaves under the plant.


16

Dead brittle "marcescent" leaves might remain on the plant for long periods of time.

Quercus douglasii

(blue oak)

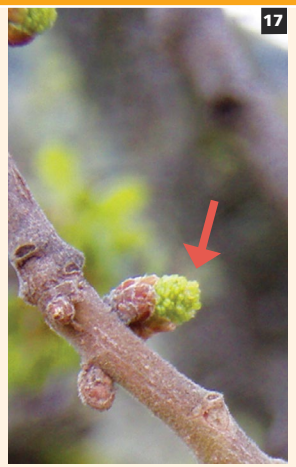
Flower phenophases

Blue 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 floral buds (Image 17) or from mixed buds just after leaves emerge from the same bud (Image 18). 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 21, orange arrow). 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 22).

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

FLOWERS OR FLOWER BUDS


17


18

Male catkins (red arrows) will emerge from floral buds (Image 17) or from mixed buds shortly after the leaves (Image 18). They are initially compact and stiff.

FLOWERS OR FLOWER BUDS


19


20


21

Male catkins eventually unfold to become longer (Images 19-20, red arrows). Tiny female flowers developing in leaf axils will be very difficult to see (Image 21, orange arrow). If they are out of reach, do not worry about reporting on them.

OPEN FLOWERS


22


23

Once male catkins are hanging loosely (Image 22), the individual flowers are (or will soon be) open with anthers exposed. Female flowers are open when pistils are exposed (Image 23), but these will be hard to see.

POLLEN RELEASE


24

Report on "Pollen release" only if you can get close enough to male flowers to see whether pollen grains are being released (white arrow).

Quercus douglasii

(blue oak)

Fruit phenophases

After female blue oak flowers have been pollinated, the ovaries are fertilized one to two months later and the fruits—acorns—begin to develop and will mature in the fall.

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

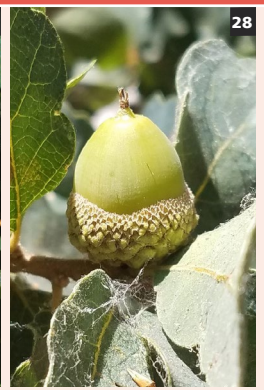
Blue oak commonly discontinues the growth of some fruits, aborting them before they mature. These will appear as tiny acorns on the plant that stopped getting larger (Image 30, white arrow), or small immature fruits dropped from the plant.

Open female flowers. Stigmas (white arrows) extend from ovaries (yellow arrows) that will develop into fruits after fertilization.

FRUITS

Begin reporting "yes" for "Fruits" once stigmas have dried out (white arrow) and you notice at least one ovary starting to swell and get larger (yellow arrow). If these small fruits are out of reach, you may not be able to see them until they grow larger.

FRUITS



As the fruit develops and gets larger, a green acorn emerges from the cap (Image 27). Acorns will gradually change color from green to yellowish-green before reaching their ripened color of brown or dark brown. Small, underdeveloped fruits are most likely aborted fruits that will never mature (Image 30, 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 or dark brown.

RECENT FRUIT OR SEED DROP

Mature, fully developed fruit will drop not long after they become ripe. Caps on the plant that are missing acorns since your last visit (Image 32, white arrow) indicate recent drop.

TREE/ SHRUB— EVERGREEN

This functional group includes woody plant species with leaves that remain on the plant for multiple growing seasons. Leaves are present year-round and there is no distinct dormant period, although there are periods of new leaf growth. Dormant leaf buds are large enough to observe the process of bud break in some species, but not in others.

Representative species:

- *Kalmia latifolia* (mountain laurel)
- *Gaultheria shallon* (salal)

Breaking leaf buds *

excluded for some species

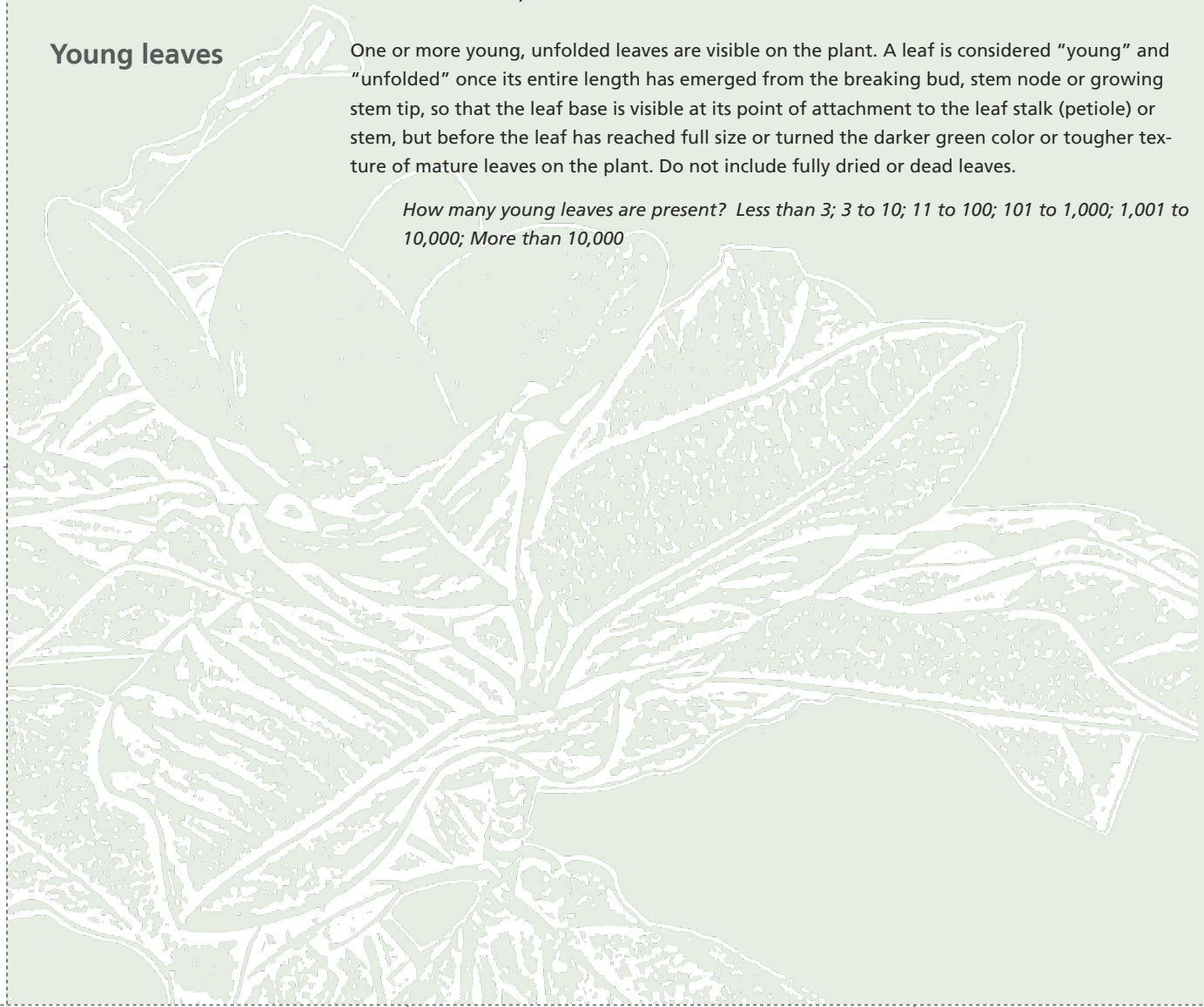
One or more breaking leaf buds are visible on the plant. A leaf bud is considered "breaking" once a green leaf tip is visible at the end of the bud, but before the first leaf from the bud has unfolded to expose the leaf base at its point of attachment to the leaf stalk (petiole) or stem.

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

Young leaves

One or more young, unfolded leaves are visible on the plant. A leaf is considered "young" and "unfolded" once its entire length has emerged from the 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, but before the leaf has reached full size or turned the darker green color or tougher texture of mature leaves on the plant. Do not include fully dried or dead leaves.

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



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

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

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.

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.

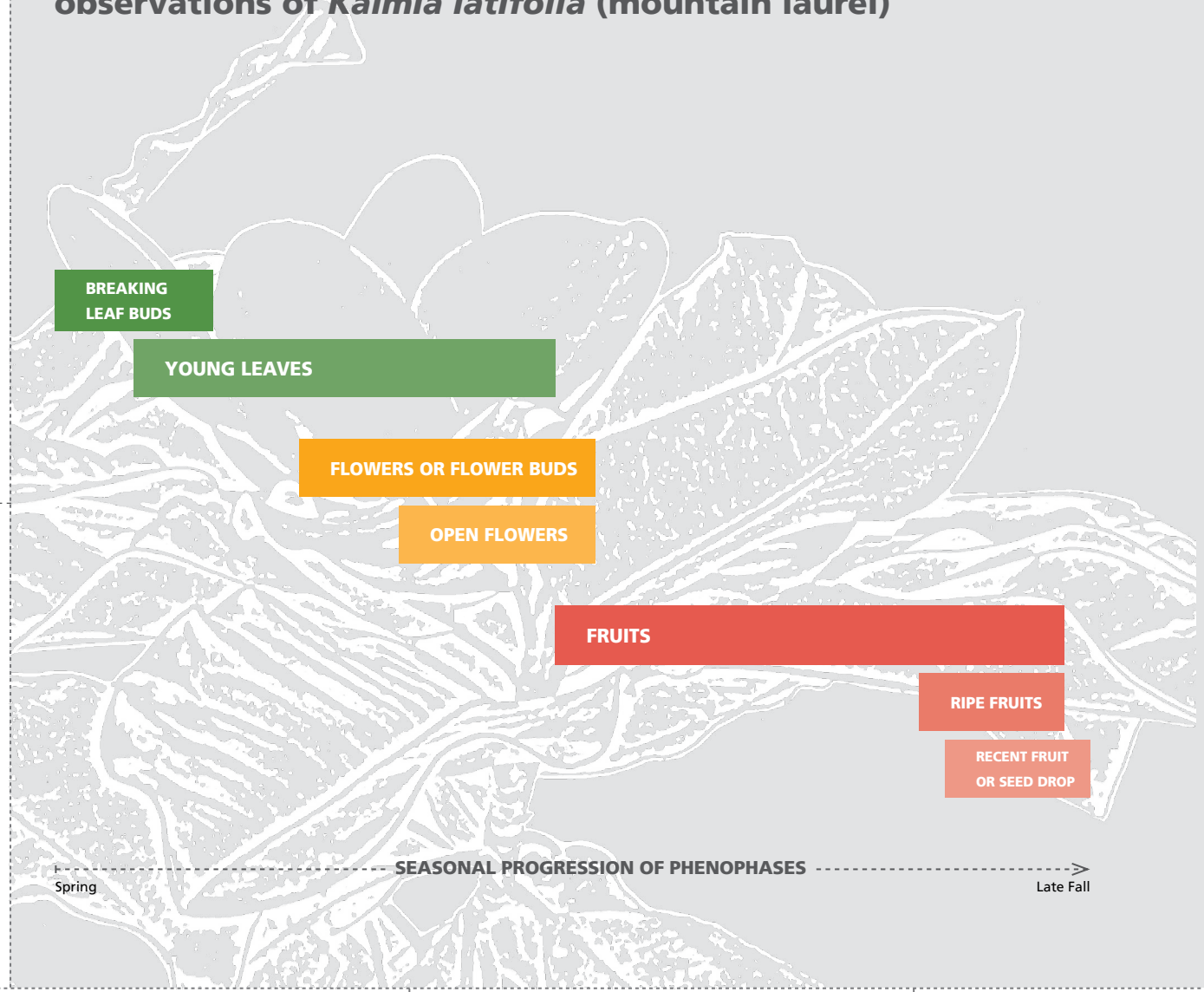
How many mature fruits have dropped seeds or have completely dropped or been removed from the plant since your last visit? Less than 3; 3 to 10; 11 to 100; 101 to 1,000; 1,001 to 10,000; More than 10,000

An approximate phenological timeline for *Nature's Notebook* observations of *Kalmia latifolia* (mountain laurel)

Mountain laurel is an evergreen shrub of the eastern US, occurring naturally in the forest understory as well as planted ornamentally in gardens. Many people expectantly await its beautiful floral displays each year—is was chosen as the state flower in both Connecticut and Pennsylvania. New leaves emerge in spring, followed by the showy, insect-pollinated flowers. Fruits are inconspicuous capsules that develop over the summer and ripen in late fall when they split open to release seeds.

Phenological characteristics of note:

- hidden leaf buds emerge from the leaf axils of older leaves
- flowers develop from overwintering dormant inflorescences
- new leaves emerge before flowering
- tiny "dehiscent" fruit capsules split open when ripe



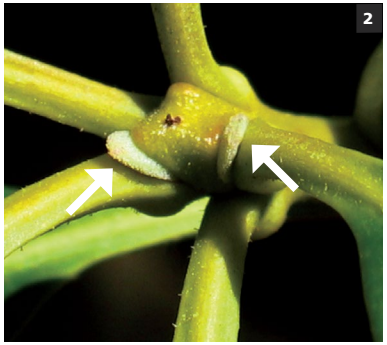
Kalmia latifolia

(mountain laurel)

Although leaves are present on the plant year-round, there is a distinct period of growth in spring as dormant buds come to life. Mountain laurel has two types of buds—vegetative (leaf) and reproductive (floral). Leaf buds are hidden in leaf axils at branch tips and emerge when swelling begins (Image 2, white arrows). Floral buds wait in inflorescences all winter (Image 13) and become active after leaf growth has begun.

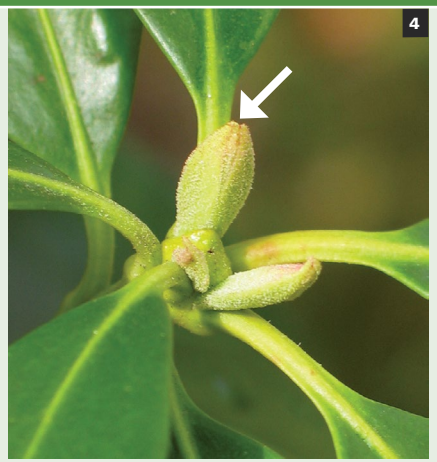
Leaf phenophases

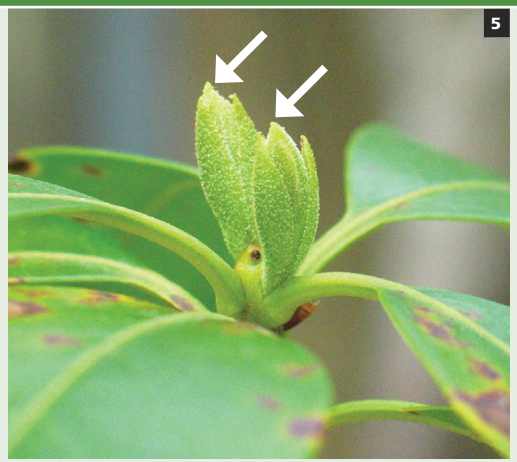
"Breaking leaf buds" begins when leaf tips emerge (Image 4). Then, when at least one breaking leaf bud's first leaf has unfolded (Image 6), begin reporting "yes" for the "Young leaves" phenophase, and continue reporting "yes" until all leaves have become the color and texture of mature leaves on the plant.



Dormant and swelling leaf buds. Mountain laurel has unusual leaf buds that are hidden in the axils of evergreen leaves at the tip of a stem (Image 1, white circle). When the plant renews activity in the spring, the leaf buds emerge from the edges of the stem tip, looking like tiny green tongues (Image 2, white arrows). The bud has two scales with a seam that meets in the middle (Image 3, white arrow). The scales look like leaves, but they will split along the seam to reveal the tips of the true leaves (Image 4, white arrow). 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 split apart enough that a green leaf tip emerges at the tip of the bud (Image 4).

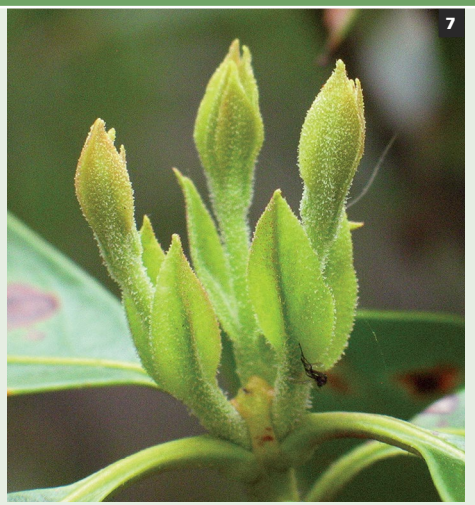
BREAKING LEAF BUDS





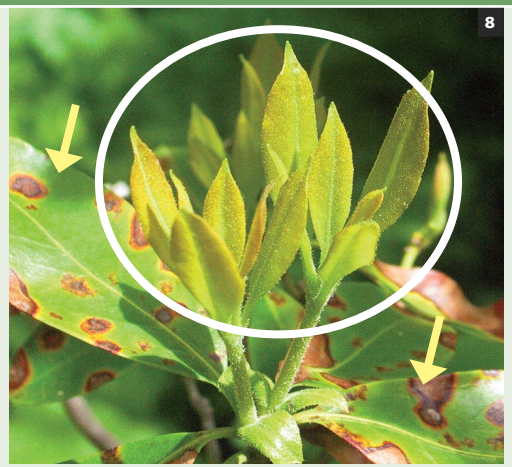
Once a leaf tip (white arrows) is visible at the end of the broken bud, the "Breaking leaf buds" phase has begun. The bud remains in this phenophase until the base of its first leaf is visible where it attaches to the petiole (Image 6, white arrow). Report "yes" for this phenophase until all broken buds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

YOUNG LEAVES



Once the leaf base becomes visible (Image 6, white arrow), the first leaf from the bud is considered "unfolded". At this point, the bud has left the breaking stage and entered the "Young leaves" phenophase.

YOUNG LEAVES


8


9


10

A plant remains in the "Young leaves" phase as new leaves grow larger. During this period, the young leaves (white ovals) are lighter in color, and thinner in texture than the dark green, leathery, mature leaves on the plant (yellow arrows).

YOUNG LEAVES


11

New leaves (white oval) grow at the ends of branches above the mature leaves (yellow oval) lower on the same branch.


12

New leaves have become the same size, color and texture as the older, brown-spotted leaves on the plant. The "Young leaves" phase has ended.

Kalmia latifolia

(mountain laurel)

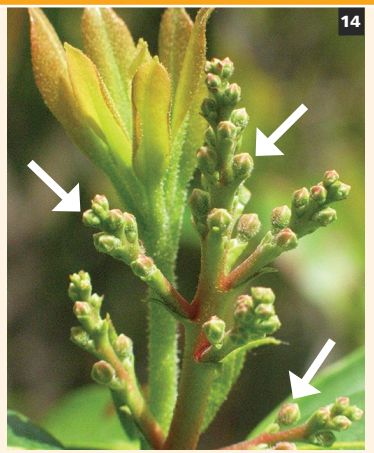
Flower phenophases

Mountain laurel flower buds are organized in inflorescences that form in late summer or fall (Image 13) and generally remain dormant until spring after leaf growth has begun. Once the tiny flower buds in the inflorescence begin swelling (Image 14, white arrows), the "Flowers or flower buds" phase has begun. Report "yes" for this phenophase when flower buds begin swelling and continue reporting "yes" until the last flower is withered or dried. If you are unsure whether you see swelling flower buds, you can wait until you see a white or pink flower petal begin to 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. If you look closely, you might catch the unique pollination engineering of this species' flowers. As the flower opens, the anthers are tucked into tiny pockets of the flower. When an insect alights, the anthers are released and spring loose to ensure the pollinator gets covered with pollen.

Dormant flower buds in an inflorescence sit inactive on the plant over the winter.

FLOWERS OR FLOWER BUDS



Tiny flower buds begin swelling after new leaves start to emerge.

FLOWERS OR FLOWER BUDS

As flower buds grow larger, the white or pink flower petals look somewhat like pleated ballons inflating (Image 16). Eventually they split open to expose reproductive parts (Image 17).

OPEN FLOWERS

Male and female reproductive parts emerge from the center of a cup-like flower. Male anthers are initially tucked into pockets (Image 18, black arrow) around the inside of the flower until they spring loose when touched by an insect pollinator.

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

Kalmia latifolia

(mountain laurel)

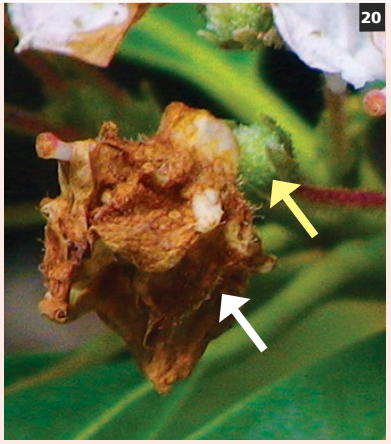
Fruit phenophases

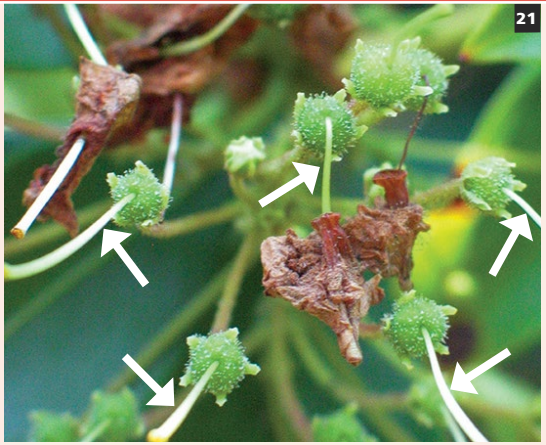
When a mountain laurel flower has been fertilized and the wilted and dried petals fall off, a round, green, fuzzy ovary—with the flower style still attached—becomes apparent (Image 20). This fruit capsule does not get much larger, but the style eventually dries and falls off as the fruit develops.

The *Nature's Notebook* fruit definition reads "For *Kalmia latifolia*, the fruit is a small capsule that changes from green to reddish to brown and splits open 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."

When out of reach, it can be very difficult to determine whether mountain laurel fruit capsules still contain seeds once they have split open. In this case you may need to report "?" for the fruit phenophases.

FRUITS


20


21

The flower's petals have dried (Image 20, white arrow) a round, green ovary is now visible (Image 20, yellow arrow). The ovary has entered the "Fruits" phenophase. Styles remain attached to the fruits while they develop (Image 21, white arrows).

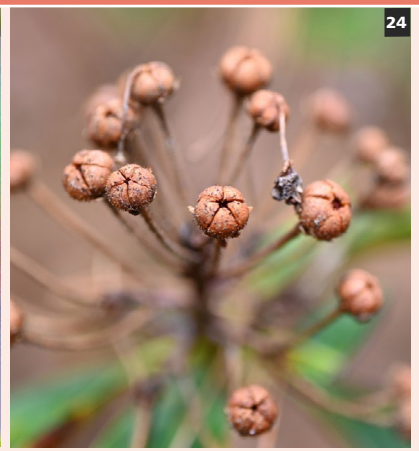
FRUITS


22

Fruits change from green to reddish and the styles dry out (white arrows). A fruit is not considered ripe until the capsule dries enough to split open.

RIPE FRUITS


23


24

A fruit is ripe when it has dried to a brown color and starts to split open along the seams of the five valves in the capsule, creating a star pattern.

RECENT FRUIT OR SEED DROP


25

Once a capsule has opened far enough, seeds will start to shake out as the wind blows. Report "yes" to "Recent fruit or seed drop" if you see an open capsule that is likely to have lost some or all of its tiny seeds since your last visit.


26

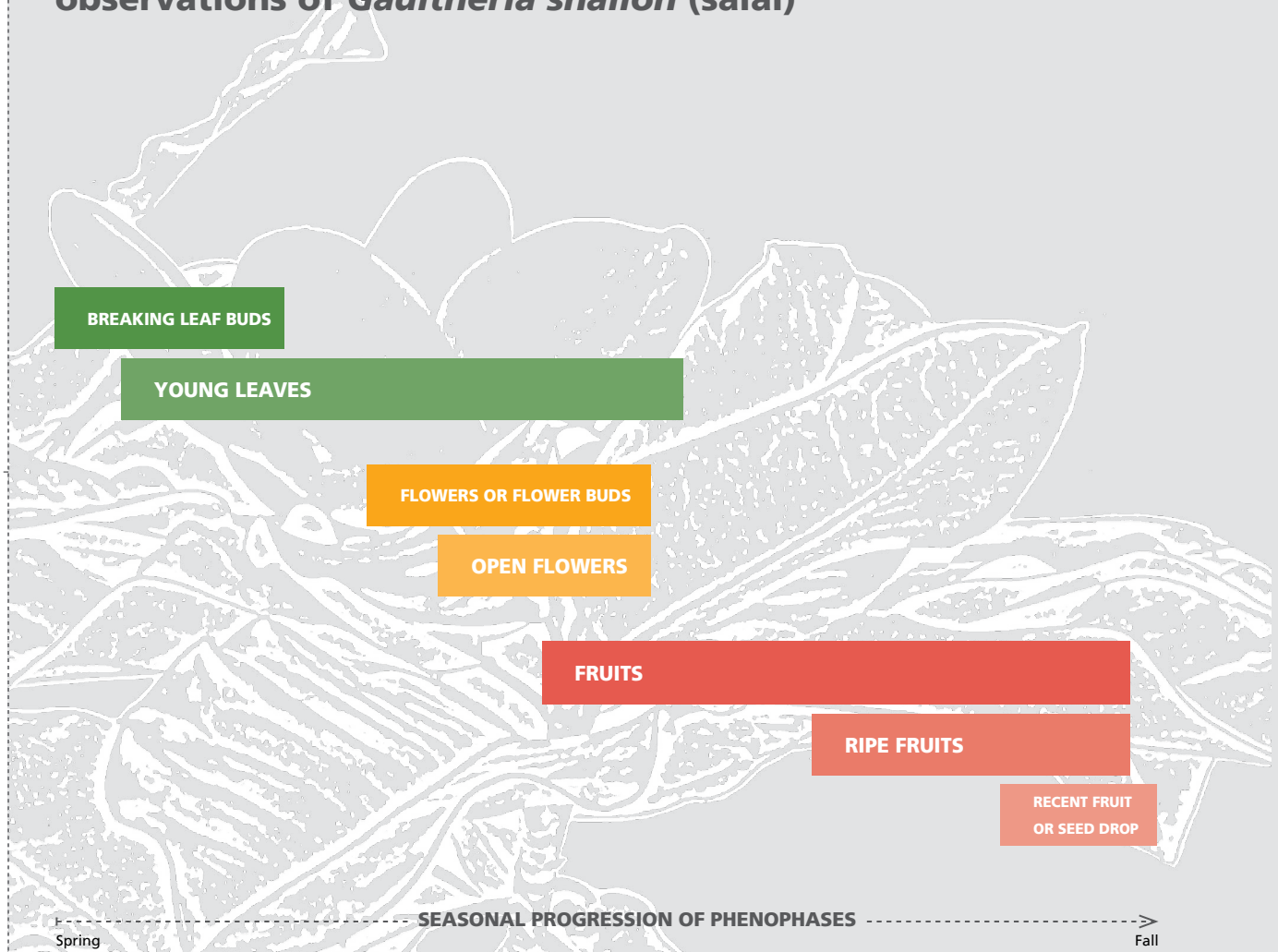
Empty capsules that have dropped all their seeds should not be included in the "Fruits" or "Ripe fruits" phenophases.

An approximate phenological timeline for *Nature's Notebook* observations of *Gaultheria shallon* (salal)

Salal is a creeping to upright evergreen subshrub to shrub found in the Pacific Northwest that can form dense, impenetrable thickets. New leaves emerge in spring, followed inflorescences that display a string of showy, bell-like, white or pink flowers that are insect-pollinated. Fruits are fleshy and berry-like, ripening to purple-black during the summer and remaining on the plant until they drop on their own or are found and eaten by wildlife.

Phenological characteristics of note:

- scaled leaf and floral buds are separate
- bracts appear from leaf buds before the first true leaf
- bell-like flowers are arranged on a stem-like inflorescence
- new leaves emerge before flowering
- flowers have only a small opening to allow pollinators inside
- fruit ripeness indicated by color change



Gaultheria shallon

(salal)

Although leaves are present on the plant year-round, there is a distinct period of growth in spring as dormant buds come to life. Salal has two types of buds—vegetative (leaf) and reproductive (floral). The buds look very similar and it is not always possible to tell what they contain until they open. When leaf buds open, a new stem with bracts and then new leaves emerges. When floral buds open, the stem of an inflorescence with bracts and individual flower buds emerges. Usually new leaves begin to emerge before floral buds become active.

Leaf phenophases

"Breaking leaf buds" begins when leaf-like bract tips emerge (Image 3). Several bracts will appear on the elongating stem before the first true leaf—distinguished by its midvein—becomes visible. When at least one breaking leaf bud's first true leaf has unfolded (Image 4), begin reporting "yes" for the "Young leaves" phenophase, and continue reporting "yes" until all leaves have become the color and texture of mature leaves on the plant.


1


2

Dormant and swelling buds. While leaf buds are dormant (Image 1) or newly active and swelling (Image 2), report "no" for "Breaking leaf buds" until the bud scales split apart enough that a green leaf-like tip (technically a bract) emerges at the tip of the bud (Image 3).

BREAKING LEAF BUDS


3

Once a leaf-like bract tip (Image 3, white arrow) 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 true leaf is visible where it attaches to the petiole (Image 4, white arrow). Report "yes" for this phenophase until all broken buds have a visible leaf base.

YOUNG LEAVES

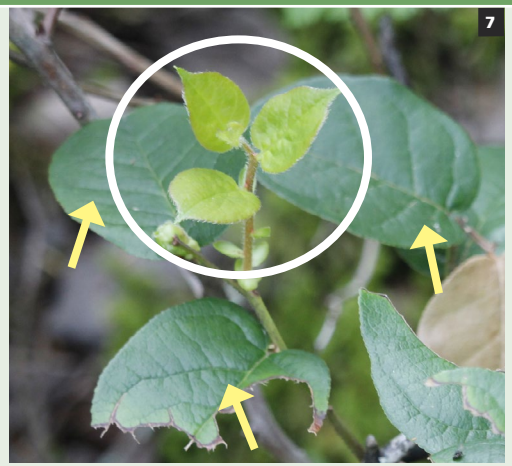

4


5


6

Once the leaf base of the first true leaf becomes visible (Image 4, white arrow), the first leaf from the bud is considered "unfolded". At this point, the bud has left the breaking stage and entered the "Young leaves" phenophase. In Image 5, a true leaf (white arrow) can be distinquished from bracts (yellow arrows) by its prominent midrib.

YOUNG LEAVES


7


8


9


10

A plant remains in the "Young leaves" phase as new leaves grow larger. During this period, the young leaves (white ovals) are lighter in color than the dark green, mature leaves on the plant (yellow arrows).

YOUNG LEAVES


11

Young leaves (white oval) are now only slightly lighter in color and are almost indistinquishable from the darker green mature leaves (yellow oval) on the plant.


12

Full-size, mature leaves. The evergreen salal leaves live two to four years, occationally more, before dying.

Gaultheria shallon

(salal)

Flower phenophases

Salal has small, urn or bell-shaped flowers that are arranged in a line and hang downwards along an inflorescence stem (raceme). The inflorescences emerge from dormant floral buds (Image 13) after new leaves have emerged. Once floral buds begin swelling 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 white or pink flower buds develop along the raceme (Images 14-15) before reporting "yes" for "Flowers or flower buds".

The "Open flowers" phenophase begins when reproductive parts become accessible to pollinators through a small opening at the tip of the flower and ends when the last flower is withered or dried.


13

Dormant flower buds.

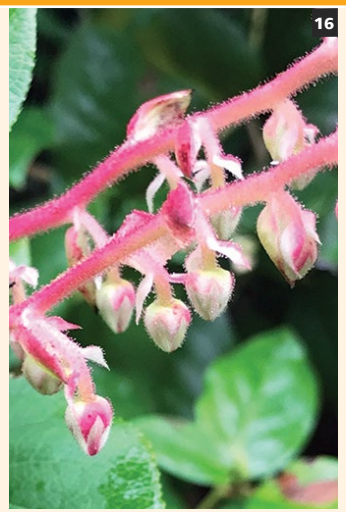
FLOWERS OR FLOWER BUDS


14


15

As the inflorescence emerges from a floral bud, tiny individual flower buds are cover by bracts. Flower buds (white arrows) become apparent as bracts (yellow arrows) fold away from the growing raceme.

FLOWERS OR FLOWER BUDS


16

Individual flowers hanging from the raceme have not yet opened.

OPEN FLOWERS


17


18


19

Flowers open when the fused petals that comprise the flower "bell" curl back at the tip to make an opening large enough for insect pollinators to enter (Image 17, white arrow). Viewing from underneath, the male and female reproductive parts are visible (Image 18, black arrow).


20

Spent flower. The fused petals (the "bell") have withered and dropped.

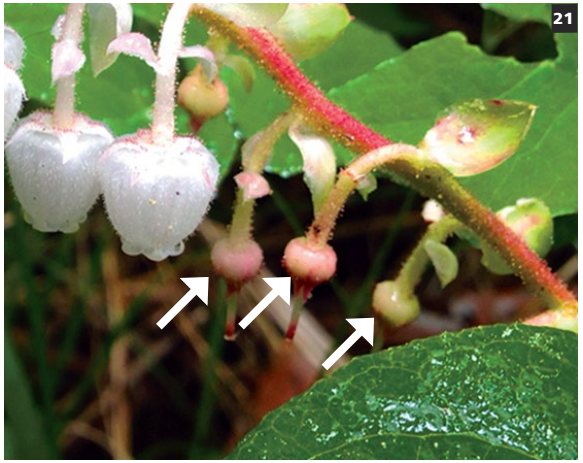
Gaultheria shallon

(salal)

Fruit phenophases

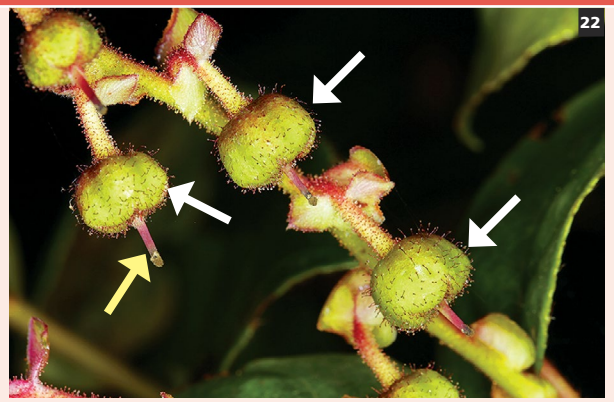
When a salal flower drops its bell-like, fused petals, the round, white, pink or greenish ovary—with the flower style still attached—becomes apparent (Image 21, white arrows). The ovary begins to develop into a fruit soon afterwards.

The *Nature's Notebook* fruit definition reads "For *Gaultheria shallon*, the fruit is a berry-like, fleshy capsule that changes from green to red to bluish-black or black-purple. A fruit is considered ripe when it has turned bluish-black or black-purple."



Ovaries become visible (white arrows) after the flower petals drop off.

FRUITS



Begin reporting "yes" for "Fruits" once you notice at least one ovary starting to swell and get larger (white arrows). The initally white or pink ovary starts to turn green when fruit development begins. Styles remain attached to the fruits while they develop (yellow arrow).

FRUITS

As the fruits develop and get larger, they will change from green to red and other intermediary colors before reaching their ripened color of bluish-black or black-purple.

RIPE FRUITS

A fruit is ripe when it has turned bluish-black or black-purple. Ripe fruits may remain on the plant for an extended period of time before dropping or being eaten by wildlife.

RECENT FRUIT OR SEED DROP

Short stems that are missing fruits (white arrows) since the last visit indicate recent fruit drop.

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Ellen Denny (USA-NPN Monitoring Design and Data Coordinator) and Patty Guertin (USA-NPN Botanist) defined the structure and content of this Primer. Patty developed the written and photographic content for Section 1 and preliminary content for Section 2. Ellen reviewed and edited Section 1, and completed the written and photographic content for Section 2. LoriAnne Barnett Warren (former USA-NPN Education Coordinator) managed the project in its early years. Graphic design was conceptualized by Terry Moody and implemented by Sara Schaffer and Yash Sihag.

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We gratefully acknowledge our observers and Local Phenology Leaders who participate in the *Nature's Notebook* phenology monitoring program. Their active contributions and support create a framework for the broader understanding of how our planet's species are responding to environmental change.

IN MEMORIAM

In May 2018 we lost Patty Guertin to cancer. She had been the staff botanist for the USA-NPN since the start in 2007.

Patty saw the beauty in every environment she visited or had called home, from the deciduous forests of the Northeast to the lush rainforests of the Pacific Northwest to the ever-changing Sonoran Desert. In addition to an exceptional eye for detail, Patty possessed genuine wonderment at the natural world and a deep knowledge of its plants and animals. And she loved to paint, capturing the vibrant red of a desert flower, the softly illuminated spines of a cactus at sunset, or reflected light dancing on a water surface.

Patty was caring, humble, generous, and a devoted member of the USA-NPN team. She kept meticulous, detailed records as she conducted her botanical research, and she always made time to write a carefully detailed response to an observer question or a help a fellow staff member puzzle out a species identification.

We will remember Patty as she lived, in a beautiful, quiet spot of nature with a paintbrush in her hand and love in her heart for the people and places surrounding her. In our efforts at the USA-NPN and among you, our observers, we will carry on her legacy in the careful and loving study of our local plants and places.

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PAGES 5-9: PHENOPHASE PRIMER INTRODUCTION

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2 *Fragaria virginiana*—Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

3 *Typha latifolia*—broadleaf cattail (Patty Guertin; CC BY-NC 4.0)

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7 *Ceratonia* sp.—carob tree (© Sara N. Schaffer; CC BY-NC 4.0)

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11 *Agave* sp. *& Echinocereus* sp.—agave and hedgehog cactus (© Sara N. Schaffer; CC BY-NC 4.0)

12 *Scirpus* sp.—bullrush (© Sara N. Schaffer; CC BY-NC 4.0)

13 *Spartina patens*—saltmeadow cordgrass (Ellen G. Denny; CC BY-NC 4.0)

14 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

15 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

16 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

17 *Scirpus cyperinus*—woolgrass (Ellen G. Denny; CC BY-NC 4.0)

18 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

19 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

20 *Betula papyrifera*—paper birch (Ellen G. Denny; CC BY-NC 4.0)

21 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

22 *Juncus geradii*—saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

PAGES 13-15: SECTION ONE INTRODUCTION

1 *Cornus canadensis*—bunchberry dogwood (Ellen G. Denny; CC BY-NC 4.0)

2 *Oenothera speciosa*—pinkladies (Patty Guertin; CC BY-NC 4.0)

3 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

4 *Rhododendron* sp.—rhododendron (Ellen G. Denny; CC BY-NC 4.0)

5 *Prunus* sp.—cherry (Ellen G. Denny; CC BY-NC 4.0)

6 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

7 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

8 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

9 *Ilex verticillata*—common winterberry (Ellen G. Denny; CC BY-NC 4.0)

10 *Sambucus racemosa*—red elderberry (Ellen G. Denny; CC BY-NC 4.0)

11 *Rubus* sp.—blackberry (Ellen G. Denny; CC BY-NC 4.0)

12 *Typha latifolia*—broadleaf cattail (Ellen G. Denny; CC BY-NC 4.0)

13 *Rosa* sp.—rose (Patty Guertin; CC BY-NC 4.0)

14 *Carnegiea gigantea*—saguaro (© Sara N. Schaffer; CC BY-NC 4.0)

15 *Rudbeckia hirta*—black-eyed susan (© Sara N. Schaffer; CC BY-NC 4.0)

PAGES 16-17: AN OVERVIEW OF VEGETATIVE (LEAF) PHENOPHASES

1 *Rhaphanus* sp.—radish sprout (Patty Guertin; CC BY-NC 4.0)

2 Deciduous Tree/Shrub Leaf Phenophases Timeline (Ellen G. Denny; CC BY-NC 4.0)

3 *Amelanchier arborea*—common serviceberry (Ellen G. Denny; CC BY-NC 4.0)

4 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

5 *Rhus typhina*—staghorn sumac (Ellen G. Denny; CC BY-NC 4.0)

PAGES 18-19: THE PHENOPHASE FOR INITIAL GROWTH

1 *Podophyllum peltatum*—mayapple (Ellen G. Denny; CC BY-NC 4.0)

2 *Fragaria virginiana*—Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

3 *Symplocarpus foetidus* — skunk cabbage (© Annkatrin Rose via iNaturalist.org; CC BY-NC 4.0)

4 *Rhaphanus* sp.—radish sprout (Patty Guertin; CC BY-NC 4.0)

5 *Proboscidea parviflora*—devil's claw (Patty Guertin; CC BY-NC 4.0)

6 *Lactuca sativa*—lettuce (Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org, CC BY-NC 3.0 US)

7 *Sorghum halepense*—Johnson grass (Ohio State Weed Lab, The Ohio State University, Bugwood.org; CC BY-NC 3.0 US)

8 Summer annual Poaceae sprout (Patty Guertin; CC BY-NC 4.0)

9 Summer annual Poaceae sprout (Patty Guertin; CC BY-NC 4.0)

10 *Eragrostis lehmanniana*—Lehmann lovegrass (Saguaro National Park via Wikimedia Commons; CC BY 2.0)

11 *Digitaria californica*—Arizona cottontop (Patty Guertin; CC BY-NC 4.0)

12 *Setaria macrostachya*—plains bristlegrass (Patty Guertin; CC BY-NC 4.0)

13 *Carex* sp.—sedge sprout (Patty Guertin; CC BY-NC 4.0)

14 *Juncus gerardii*—saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

15 *Juncus balticus*—mountain rush (© bendingtree via iNaturalist.org; CC BY-NC 4.0)

PAGES 20-21: AN OVERVIEW OF DORMANT AND SWELLING BUDS

1 *Liquidambar styraciflua*—sweetgum (JonRichfield via Wikimedia Commons; CC BY-SA 3.0)

2 *Acer pseudoplatanus*—sycamore maple (André Karwath aka Aka via Wikimedia Commons; CC BY-SA 2.5)

3 *Quercus alba*—white oak (© Hahn, Marlene via EOL; CC BY-NC-SA 3.0)

4 *Acer saccharinum*—silver maple (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

5 *Alnus viridis*—green alder (Robert Vidéki, Doronicum Kft., Bugwood.org; CC BY-NC 3.0 US)

6 *Fagus grandifolia*—American beech (© 2002 Steven J. Baskauf via EOL; CC BY-NC-SA 3.0)

7 *Amelanchier utahensis*—Utah serviceberry (Russ Kleinman, Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium; for permission of image usage, see http://www.wnmu.edu/academic/nspages/gilaflora/index.html)

8 *Salix irrorata*—dewystem willow (Russ Kleinman, Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium; for permission of image usage, see http://www.wnmu.edu/academic/nspages/gilaflora/index.html)

9 *Salix sitchensis*—Sitka willow (©2008 Keir Morse; CC BY-NC-SA 3.0)

10 *Salix* sp.—willow (Mary Ellen (Mel) Harte, Bugwood.org; CC BY-NC 3.0 US)

11 *Viburnum lentago*—nannyberry (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

12 *Liriodendron tulipifera*—tuliptree (© 2003 Steven J. Baskauf via EOL; CC BY-NC-SA 3.0)

13 *Fraxinus nigra*—black ash (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

14 *Carya cordiformis*—bitternut hickory (© Daniel Carter via EOL; CC BY-NC 3.0)

15 *Viburnum lantanoides*—hobblebush (© Susan Elliott via EOL; CC BY-NC-SA 3.0)

16 *Callicarpus americana*—American beauty-berry (Tubifex via Wikimedia Commons; CC BY-SA 3.0)

17 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

18 *Leucophyllum frutescens*—Texas barometer bush (Frank Vincentz via Wikimedia Commons; CC BY-SA 3.0)

19 *Buddleja marrubiifolia*—woolly butterflybush (Ellen G. Denny; CC BY-NC 4.0)

20 *Ficus citrifolia*—wIld banyantree (© Reinaldo Aguilar via Flickr; CC BY-SA 3.0)

21 *Ficus carica*—edible fig (4028mdk09 via Wikimedia Commons; CC BY-SA 3.0)

22 *Ficus carica*—edible fig (Philmarin via Wikimedia Commons; CC BY-SA 3.0)

23 *Platanus racemosa*—western sycamore (Eugene Zelenko via Wikimedia Commons; CC BY-SA 3.0)

24 *Platanus wrightii*—Arizona sycamore (Russ Kleinman, Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium; for permission of image usage, see http://www.wnmu.edu/academic/nspages/gilaflora/index.html)

25 *Ailanthus altissima*—tree of heaven (Paul Wray, Iowa State University, Bugwood.org; CC BY-NC 3.0 US)

PAGES 22-23: THE PHENOPHASE FOR BREAKING LEAF BUDS

1 *Amelanchier arborea*—common serviceberry (Ellen G. Denny; CC BY-NC 4.0)

2 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

3 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

4 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

5 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

6 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

7 *Acer saccharum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

8 *Rhododendron* sp.—rhododendron (Ellen G. Denny; CC BY-NC 4.0)

9 *Arctostaphylos* sp.—manzanita (Patty Guertin; CC BY-NC 4.0)

10 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

11 *Toxicodendron radicans*—eastern poison ivy (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

12 *Asimina triloba*—pawpaw (Robert Gummi via Wikimedia Commons; Public domain)

13 *Rhus glabra*—smooth sumac (Rob Routledge, Sault College, Bugwood.org; CC

BY 3.0 US)

14 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

15 *Rhus typhina*—staghorn sumac (Ellen G. Denny; CC BY-NC 4.0)

PAGES 24-29: AN OVERVIEW OF UNFOLDED LEAVES

1 - 3 *Proboscidea parviflora*—doubleclaw (Patty Guertin; CC BY-NC 4.0)

4 - 7 *Podophyllum peltatum*—mayapple (Ellen G. Denny; CC BY-NC 4.0)

8 - 9 *Cornus canadensis*—bunchberry dogwood (Ellen G. Denny; CC BY-NC 4.0)

10 - 12 *Erythronium americanum*—dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

13 - 16 *Fragaria virginiana*—Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

17 *Chimaphila umbellata*—pipsissewa (© Joe Walewski via iNaturalist.org; CC BY-NC 4.0)

18 *Chimaphila umbellata*—pipsissewa (Bjoertvedt via Wikimedia Commons; CC BY-SA 3.0)

19 *Chimaphila umbellata*—pipsissewa (© owenclarkin via iNaturalist.org; CC BY-NC 4.0)

20 *Chimaphila umbellata*—pipsissewa (Patty Guertin; CC BY-NC 4.0)

21 *Zea mays*—corn (Kembangraps via Wikimedia Commons; CC BY-SA 3.0)

22 *Zea mays*—corn (Howard F. Schwartz, Colorado State University, Bugwood.org; CC BY 3.0 US)

23 *Zea mays*—corn (Amada44 via Wikimedia Commons; CC BY-SA 3.0)

24 *Carex pilosa*—hairy greenweed (©2007 Dr. Amadej Trnkoczy; CC BY-NC-SA 3.0)

25 *Carex pilosa*—hairy greenweed (©2007 Dr. Amadej Trnkoczy; CC BY-NC-SA 3.0)

26 - 27 *Carex pensylvanica*—Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

28 - 29 *Juncus gerardii*—saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

30 - 33 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

34 - 35 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

36 - 37 *Fraxinus americana*—white ash (Ellen G. Denny; CC BY-NC 4.0)

38 - 41 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

42 - 43 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

44 - 45 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

46 - 49 *Rhododendron* sp.—rhododendron (Patty Guertin; CC BY-NC 4.0)

50 - 54 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

55 - 58 *Larrea tridentata*—creosote bush (Patty Guertin; CC BY-NC 4.0)

59 - 61 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

62 - 64 *Parkinsonia microphylla*—yellow paloverde (Patty Guertin; CC BY-NC 4.0)

65 - 66 *Acacia greggii*—catclaw acacia (Patty Guertin; CC BY-NC 4.0)

67 - 69 *Prosopis velutina*—velvet mesquite (Patty Guertin; CC BY-NC 4.0)

75 *Fouquieria splendens*—ocotillo (© Sara N. Schaffer; CC BY-NC 4.0)

76 *Fouquieria splendens*—ocotillo (Frank Vincentz via Wikimedia Commons; CC BY-SA 3.0)

77 *Fouquieria splendens*—ocotillo (© Sara N. Schaffer; CC BY-NC 4.0)

78 *Fouquieria splendens*—ocotillo (© Sara N. Schaffer; CC BY-NC 4.0)

79 *Fouquieria splendens*—ocotillo (Leslie Seaton via Wikimedia Commons; CC BY 2.0)

80 *Fouquieria splendens*—ocotillo (Patty Guertin; CC BY-NC 4.0)

81 *Fouquieria splendens*—ocotillo (© Sara N. Schaffer; CC BY-NC 4.0)

82 *Fouquieria splendens*—Ocotillo (© Jesse Rorabaugh via iNaturalist; CC BY 3.0)

83 - 86 *Ceanothus greggii*—Desert ceanothus (Patty Guertin; CC BY-NC 4.0)

PAGES 30-33: THE PHENOPHASE FOR LEAVES

1 *Helianthus annuum*—Common sunflowers (Amada44 via EOL; Public domain)

2 *Maianthemum canadense*—Canada mayflowers (Fungus Guy via Wikimedia Commons; CC BY-SA 3.0)

3 *Penstemon* sp.—penstemon (Patty Guertin; CC BY-NC 4.0)

4 *Penstemon palmeri*—Palmer's penstemon (Patty Guertin; CC BY-NC 4.0)

5 *Penstemon* sp.—penstemon (Patty Guertin; CC BY-NC 4.0)

6 *Penstemon superbus*—superb penstemon (Russ Kleinman, Western New Mexico University Department of Natural Sciences and the Dale A. Zimmerman Herbarium; for permission of image usage, see http://www.wnmu.edu/academic/nspages/gilaflora/index.html)

7 *Paspalum dilatatum*—dallisgrass (Joseph M. DiTomaso, University of California—Davis, Bugwood.org; CC BY-NC 3.0 US)

8 *Setaria macrostachya*—plains bristlegrass (Patty Guertin; CC BY-NC 4.0)

9 *Carex obnupta*—slough sedge (© Diana Lukinuk via iNaturalist.org; CC BY-NC-SA 4.0)

10 *Carex leptopoda*—taperfruit shortscale sedge (©2008 Keir Morse; CC BY-NC-SA 3.0)

11 *Carex pensylvanica*—Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

12 - 14 *Juncus gerardii*—saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

15 - 17 *Acer rubrum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

18 *Acer rubrum*—red maple (Gaoyuan via Wikimedia Commons, CC BY-SA 3.0)

19 - 23 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

24 - 25 *Prosopis velutina*—velvet mesquite (Patty Guertin; CC BY-NC 4.0)

26 *Prosopis velutina*—velvet mesquite (© Sara N. Schaffer; CC BY-NC 4.0)

27 *Prosopis velutina*—velvet mesquite (Patty Guertin; CC BY-NC 4.0)

28 - 31 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

32 *Quercus laurifolia*—laurel oak (© Mike Ostrowski via iNaturalist.org; CC BY-SA 4.0)

33 *Quercus laurifolia*—laurel oak (© Bruce Kirchoff via Flickr; CC BY 2.0)

34 *Quercus laurifolia*—laurel oak (© Mary Keim, via EOL; CC BY-NC-SA 2.0)

35 *Quercus laurifolia*—laurel oak (© Tom Palmer via iNaturalist.org; CC BY-NC 4.0)

PAGES 34-35: THE PHENOPHASE FOR YOUNG LEAVES

1 *Chimaphila umbellata*—pipsissewa (Superior National Forest via Wikimedia Commons; CC BY 2.0)

2 *Goodyera oblongifolia*—western rattlesnake plantain (© seakay via iNaturalist; CC BY-NC-SA 3.0)

3 *Sarracenia purpurea*—purple pitcherplant (Copyright Daniel Carter via EOL; CC BY-NC 3.0)

4 *Croton argyranthemus*—healing croton (© Adam Arendell via iNaturalist.org; CC BY-NC 4.0)

5 *Fragaria virginiana*—Virginia strawberry (© magpax via iNaturalist.org; CC BY-NC 4.0)

6 *Asclepias subulata*—rush milkweed (Patty Guertin; CC BY-NC 4.0)

7 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

8 *Larrea tridentata*—creosote bush (Patty Guertin; CC BY-NC 4.0)

9 *Quercus laurifolia* (young leaves)—laurel oak (© Mary Keim; CC BY-NC-SA 2.0)

10 *Quercus laurifolia* (mature leaves)—laurel oak—common name (© Rolling Meadows Farm; CC BY-NC 4.0)

11 *Ligustrum sinense*—Chinese privet (©2005 Luigi Rignanese; CC BY-NC 3.0)

12 *Chilopsis linearis*—desert willow (© maggiegabq via iNaturalist.org; CC BY-NC 4.0)

13 *Acacia greggii*—catclaw acacia (©Sara N. Schaffer; CC BY-NC 4.0)

PAGES 36-37: THE PHENOPHASE FOR INCREASING LEAF SIZE

1 - 6 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

7 - 10 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

11 - 15 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

16 *Hydrangea paniculata*—panicled hydrangea (Ellen G. Denny; CC BY-NC 4.0)

17 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

PAGES 38-39: THE PHENOPHASE FOR COLORED LEAVES

1 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

2 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

3 *Prunus serotina*—black cherry (Ellen G. Denny; CC BY-NC 4.0)

4 *Rubus* sp.—blackberry (Ellen G. Denny; CC BY-NC 4.0)

5 - 7 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

8 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

9 - 13 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

14 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

15 *Fagus grandifolia*—American beech (Famartin via Wikimedia Commons; CC BY-SA 4.0)

16 *Acer rubrum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

PAGES 40-41: THE PHENOPHASE FOR FALLING LEAVES

1 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

2 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

3 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

4 *Cornus alternifolia*—alternateleaf dogwood (Ellen G. Denny; CC BY-NC 4.0)

5 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

6 - 10 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

11 *Acer saccharum*—sugar maple (Ellen G. Denny; CC BY-NC 4.0)

12 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

PAGES 42-43: AN OVERVIEW OF REPRODUCTIVE (FLOWER AND FRUIT) PHENOPHASES

1 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

2 Flower and Fruit Phenophases Timeline (Ellen G. Denny; CC BY-NC 4.0)

3 - 5 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

PAGE 44: AN OVERVIEW OF DORMANT FLOWER BUDS

1 *Forsythia* x *intermedia*—showy forsythia (Ellen G. Denny; CC BY-NC 4.0)

2 *Forsythia* x *intermedia*—showy forsythia (AnRo0002 via Wikimedia Commons; CC0 1.0)

3 *Forsythia* x *intermedia*—showy forsythia (Ellen G. Denny; CC BY-NC 4.0)

4 - 7 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

8 - 12 *Acer rubrum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

13 - 17 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

PAGE 45: AN OVERVIEW OF MIXED BUDS

1 *Oemleria cerasiformis*—Indian plum (Jennifer Wheeler, BLM, Arcata Field Office; Public domain)

2 *Acer rubrum*—red maple (©2016 Keir Morse; CC BY-NC-SA 3.0)

3 *Sambucus racemosa*—red elderberry (© Sarah Carline via iNaturalist.org; CC BY-NC 4.0)

4 *Magnolia stellata*—star magnolia (Alpsdake via Wikimedia Commons; CC BY-SA 3.0)

5 *Acer negundo*—boxelder (©2016 Keir Morse; CC BY-NC-SA 3.0)

6 *Viburnum lantanoides*—hobblebush (© Kent McFarland via Flickr; CC BY-NC 2.0)

PAGES 46-47: AN OVERVIEW OF FLOWERS AND INFLORESCENCES

1 Flower illustration (Patty Guertin; CC BY-NC 4.0)

2 Inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

3 *Kallstroemia grandiflora*—Arizona poppy (Patty Guertin; CC BY-NC 4.0)

4 *Magnolia* x *soulangiana*—Chinese magnolia (Ellen G. Denny; CC BY-NC 4.0)

5 *Verbascum thapsis*—wooly mullein (Patty Guertin; CC BY-NC 4.0)

6 *Lupinus* sp.—lupine (Patty Guertin; CC BY-NC 4.0)

7 *Prosopis velutina*—velvet mesquite (Patty Guertin; CC BY-NC 4.0)

8 *Yucca baccata*—banana yucca (Patty Guertin; CC BY-NC 4.0)

9 *Sambucus racemosa*—red elderberry (Ellen G. Denny; CC BY-NC 4.0)

10 thistle (Patty Guertin; CC BY-NC 4.0)

11 *Achillea millefolium*—common yarrow (Patty Guertin; CC BY-NC 4.0)

PAGES 48-51: THE PHENOPHASE FOR FLOWERS OR FLOWER BUDS

1 - 6 *Opuntia santa-rita*—Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

7 - 8 *Eschscholzia californica*—California poppy (Patty Guertin; CC BY-NC 4.0)

9 *Eschscholzia californica*—California poppy (H. Zell via Wikimedia Commons; CC BY-SA 3.0)

10 *Eschscholzia californica*—California poppy (Eugene Zelenko via Wikimedia Commons; CC BY-SA 4.0)

11 - 12 *Eschscholzia californica*—California poppy (Patty Guertin; CC BY-NC 4.0)

13 - 18 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

19 - 25 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

26 - 30 *Alnus incana*—grey alder (Ellen G. Denny; CC BY-NC 4.0)

31 *Alnus incana* ssp. *rugosa*—speckled alder (Kenneth Dritz. USDA NRCS. 1995. Northeast wetland flora: Field office guide to plant species. Northeast National

Technical Center, Chester, PA. Courtesy of USDA NRCS Wetland Science Institute; Public domain)

32 - 34 *Alnus incana*—grey alder (Ellen G. Denny; CC BY-NC 4.0)

35 - 41 *Prosopis velutina*—velvet mesquite (Patty Guertin; CC BY-NC 4.0)

42 *Quercus pacifica*—Channel Island scrub oak (©2014 Steve Matson; CC BY-NC 3.0)

43 *Quercus rubra*—northern red oak (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

44 *Quercus imbricaria*—shingle oak (© Gerrit Davidse, Tropicos.org. Missouri Botanical Garden. 22 Aug 2016 <http://www.tropicos.org/Image/100194018>; CC BY-NC-SA 3.0)

45 *Arisaema triphyllum*—jack in the pulpit (Meneerke bloem via Wikimedia Commons; CC BY-SA 3.0)

46 *Arisaema triphyllum*—jack in the pulpit (© Yuri Huta via Finding Species; CC BY-NC-SA 3.0)

47 *Arisaema triphyllum*—jack in the pulpit (© 2005 Steven J. Baskauf, http://bio-images.vanderbilt.edu/; CC BY-NC-SA 4.0)

48 *Celtis pallida*—desert hackberry (Patty Guertin; CC BY-NC 4.0)

49 *Celtis pallida*—desert hackberry; male flowers (Patty Guertin; CC BY-NC 4.0)

50 *Celtis pallida*—desert hackberry; female flowers (Patty Guertin; CC BY-NC 4.0)

PAGES 52-53: AN OVERVIEW OF GRASS FLOWERS AND FLOWER HEADS

1 Grass inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

2 *Sorghum halepense*—Johnson grass (Tau'olunga via Wikimedia Commons; CC BY-SA 3.0)

3 *Setaria ambigua*—barbed bristlegrass (©2008 Luigi Rignanese; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

4 *Achnatherum hymenoides*—Indian ricegrass (Dave Powell, USDA Forest Service, Bugwood.org; CC BY 3.0 US)

5 *Bothriochloa ischaemum*—yellow bluestem (Petr Filippov via Wikimedia Commons; CC BY 3.0)

6 *Hordeum* sp.—barley (Alina Zienowicz via Wikimedia Commons; CC BY-SA 3.0)

7 *Bromus tectorum*—cheatgrass (©2008 Gary A. Monroe; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

8 *Bouteloua gracilis*—blue grama (©2008 Robert Sivinski; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

9 *Setaria neglecta*—African bristlegrass (©2011 Zoya Akulova; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

10 *Hordeum murinum*—mouse barley (D. Walters and C. Southwick, CPHST, Bugwood.org; CC BY-NC 3.0 US)

11 *Eragrostis pilosa*—Indian lovegrass (D. Walters and C. Southwick, CPHST, Bugwood.org; CC BY-NC 3.0 US)

12 *Setaria faberi*—Japanese bristlegrass (D. Walters and C. Southwick, CPHST, Bugwood.org; CC BY-NC 3.0 US)

PAGES 54-57: AN OVERVIEW OF SEDGE FLOWERS AND FLOWER HEADS

1 *Carex* inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

2 *Cyperus* inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

3 *Scirpus* inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

4 *Eriophorum* inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

5 *Carex barbarae*—Santa Barbara sedge (Russell Huddleston; Public domain)

6 *Carex concinna*—low northern sedge (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

7 *Scirpus pendulus*—rufous bulrush (©2008 Keir Morse; CC BY-NC-SA 3.0)

8 *Scirpus microcarpus*—panicled bulrush (©2003 Steve Matson; CC BY-NC 3.0)

9 *Cladium mariscoides*—smooth sawgrass (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

10 *Cyperus esculentus*—yellow nutsedge (© Kenneth Bader; CC BY-NC 4.0)

11 *Eriophorum virginicum*—tawny cottongrass (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

12 *Eriophorum crinigerum*—fringed cottongrass (© Chloe and Trevor Van Loon via iNaturalist.org; CC BY 4.0)

13 *Carex luzulina* var. *ablata*—woodrush sedge (©2010 Keir Morse; CC BY-NC-SA 3.0)

14 *Carex pendula*—drooping sedge (Franz Xaver via Wikimedia Commons; CC BY-SA 3.0)

15 *Carex concinna*—low northern sedge (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

16 *Carex sprengelii*—long--beaked sedge (©2016 Keir Morse; CC BY-NC-SA 3.0)

17 *Carex stipata* var. *stipata*—owlfruit sedge (©2008 Keir Morse; CC BY-NC-SA 3.0)

18 *Carex scabrata*—eastern rough sedge (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

19 *Carex breweri*—Brewer's sedge (©2010 Keir Morse; CC BY-NC-SA 3.0)

20 *Schoenoplectus lacustris*—lakeshore bulrush (Fabelfroh via Wikimedia Commons; CC BY-SA 3.0)

21 *Schoenoplectus americanus*—chairmaker's bulrush (©2009 Robert Sivinski; CC BY-NC 3.0)

22 *Schoenoplectus pungens*—common threesquare (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

23 *Schoenoplectus acutus*—hardstem bulrush (R. C. Brody; Public Domain)

24 *Scirpus pendulus*—rufous bulrush (©2008 Keir Morse; CC BY-NC-SA 3.0)

25 *Cladium mariscoides*—smooth sawgrass (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

26 *Cladium californicum*—California sawgrass (USDI Bureau of Land Management, United States, NV, Clark Co.; Public domain)

27 *Cyperus esculentus*—yellow nutsedge (© Kenneth Bader via iNaturalist.org; CC BY-NC 4.0)

28 *Cyperus eragrostis*—tall flatsedge (©2008 Keir Morse; CC BY-NC-SA 3.0)

29 *Eriophorum vaginatum*—tussock cottongrass (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

30 *Eriophorum vaginatum* in flower—tussock cottongrass (Krzysztof Ziarnek via Wikimedia Commons; CC BY-SA 3.0)

31 *Eriophorum vaginatum* in fruit—tussock cottongrass (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

PAGES 58-59: AN OVERVIEW OF RUSH FLOWERS AND FLOWER HEADS

1 Rush inflorescence illustration (Patty Guertin; CC BY-NC 4.0)

2 *Juncus xiphioides*—Iris-leaved rush (©2009 Keir Morse; CC BY-NC-SA 3.0)

3 *Juncus laccatus*—shiny rush (©2007 Steve Matson; CC BY-NC 3.0)

4 *Juncus ensifolius*—swordleaf rush (©2008 Keir Morse; CC BY-NC-SA 3.0)

5 *Juncus dubius*—mariposa rush (©2015 Keir Morse; CC BY-NC-SA 3.0)

6 *Juncus bufonius*—toad rush (©2011 Jorg & Mimi Fleige; CC BY-NC 3.0)

7 *Juncus bolanderi*—Bolander's rush (©2003 Steve Matson; CC BY-NC 3.0)

8 *Juncus longistylis*—long-styled rush (©2015 Keir Morse; CC BY-NC-SA 3.0)

9 *Juncus chlorocephalus*—greenhead rush (©2003 Steve Matson; CC BY-NC 3.0)

10 *Juncus balticus*—Baltic rush (©2008 Keir Morse; CC BY-NC-SA 3.0)

11 *Juncus chlorocephalus*—greenhead rush (©2012 Thomas Reyes; CC BY-NC-SA 3.0)

12 *Juncus ensifolius*—swordleaf rush (©2015 Steve Matson; CC BY-NC 3.0)

13 *Juncus howellii*—Howell's rush (©2015 Steve Matson; CC BY-NC 3.0)

14 *Juncus mertensianus*—Mertens' rush (©2007 Steve Matson;CC BY-NC 3.0)

15 *Juncus nevadensis*—Nevada rush (©2003 Steve Matson; CC BY-NC 3.0)

16 *Juncus orthophyllus*—straightleaf rush (©2008 Keir Morse; CC BY-NC-SA 3.0)

PAGE 60: THE PHENOPHASE FOR FLOWER HEADS (FOR GRASSES AND SEDGES)

1 *Phalaris arundinacea*—reed canarygrass (James Lindsey at Ecology of Commanster via Wikimedia Commons; CC BY-SA 3.0)

2 *Phalaris arundinacea*—reed canarygrass (Maja Dumat via Flickr; CC BY 2.0)

3 *Phalaris arundinacea*—reed canarygrass (Kristian Peters via Wikimedia Commons; CC BY-SA 3.0)

4 *Phalaris arundinacea*—reed canarygrass (©2008 Keir Morse; CC BY-NC-SA 3.0)

5 *Phalaris arundinacea*—reed canarygrass (James Lindsey at Ecology of Commanster via Wikimedia Commons; CC BY-SA 3.0)

6 *Phalaris arundinacea*—reed canarygrass (Leslie J. Mehrhoff, University of Connecticut, Bugwood.org; CC BY 3.0 US)

7 - 11 *Carex pensylvanica* - Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

PAGE 61: THE PHENOPHASE FOR FLOWERS OR FLOWER BUDS (FOR RUSHES)

1 *Juncus interior*—inland rush (© 2010, Craig Althen; for permission of image usage, see http://biology.burke.washington.edu/herbarium/imagecollection/imageinfo.php?imageNumber=31066&TaxonID=2289&SourcePage=taxon)

2 *Juncus confusus*—Colorado rush (©2015 Steve Matson; CC BY-NC 3.0)

3 *Juncus torreyi*—Torrey's rush (© John Hilty; for permission of image usage, see http://www.illinoiswildflowers.info/files/photo_use.html)

4 *Juncus chlorocephalus*—greenhead rush (©2010 Barry Breckling; CC BY-NC-SA 3.0)

5 *Juncus pallidus*—pale rush (© Tony Wills; CC BY-SA 4.0)

6 *Juncus torreyi*—Torrey's rush (© schock1 via iNaturalist.org; CC BY-NC 4.0)

7 *Juncus tenuis*—poverty rush (©2008 Keir Morse; CC BY-NC-SA 3.0)

PAGES 62-65: THE PHENOPHASE FOR OPEN FLOWERS

1 *Carnegiea gigantea*—saguaro (Patty Guertin; CC BY-NC 4.0)

2 *Opuntia santa-rita*—Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

3 *Penstemon superbus*—superb beardtongue (Patty Guertin; CC BY-NC 4.0)

4 *Ceanothus greggii*—desert ceanothus (Patty Guertin; CC BY-NC 4.0)

5 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

6 *Sambucus racemosa*—red elderberry (Ellen G. Denny; CC BY-NC 4.0)

7 *Yucca baccata*—banana yucca (Patty Guertin; CC BY-NC 4.0)

8 *Magnolia* x *soulangiana*—Chinese magnolia (Ellen G. Denny; CC BY-NC 4.0)

9 *Parkinsonia microphylla*—yellow paloverde (Patty Guertin; CC BY-NC 4.0)

10 *Cornus florida*—flowering dogwood (Vern Wilkins, Indiana University, Bugwood.org; CC BY-NC 3.0 US)

11 *Passiflora* sp.—passionflower (Patty Guertin; CC BY-NC 4.0)

12 *Asclepias subulata*—rush milkweed (Patty Guertin; CC BY-NC 4.0)

13 *Plantago* sp.—plantain (Patty Guertin; CC BY-NC 4.0)

14 *Platanus racemosa*—California sycamore (Eugene Zelenko via Wikimedia Commons; CC BY-SA 4.0)

15 *Alnus incana*—gray alder (Ellen G. Denny; CC BY-NC 4.0)

16a *Quercus rubra*—northern red oak (DAVID LEE, Bugwood.org; CC BY-NC 3.0 US)

16b *Quercus rubra*—northern red oak (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

17a *Simmondsia chinensis*—jojoba (©2012 Keir Morse; CC BY-NC-SA 3.0)

17b *Simmondsia chinensis*—jojoba (Stan Shebs via Wikimedia Commons; CC BY-SA 3.0)

18a *Atriplex canescens*—fourwing saltbush (Patty Guertin; CC BY-NC 4.0)

18b *Atriplex canescens*—fourwing saltbush (©2010 Steve Matson; CC BY-NC 3.0)

19 *Typha* sp.—cattail (Patty Guertin; CC BY-NC 4.0)

20 *Helianthus annuus*—common sunflower (©2015 Richard Spellenberg; CC BY-NC-SA 3.0)

21 *Helianthus niveus* ssp. *tephrodes*—Algodones sunflower (©2014 Keir Morse; CC BY-NC-SA 3.0)

22 *Zinnia grandiflora*—Rocky Mountain zinnia (Patty Guertin; CC BY-NC 4.0)

23 *Liatris punctata*—blazingstar (USFWS Mountain-Prairie; CC BY 2.0)

24 *Taraxacum offincinale*—common dandelion (Uoaei1 via Wikimedia Commons; CC BY-SA 3.0)

25 *Cirsium occidentale* var. *californicum*—California thistle (©2015 Keir Morse; CC BY-NC-SA 3.0)

26 *Pseudognaphalium* sp.—everlasting (Patty Guertin; CC BY-NC 4.0)

27 *Ericameria nauseosus*—rubber rabbitbush (Stan Shebs via Wikimedia Commons; CC BY-SA 3.0)

28a *Baccharis sarothroides*—broom baccharis (©2015 Keir Morse; CC BY-NC-SA 3.0)

28b *Baccharis sarothroides*—broom baccharis (©2015 Keir Morse; CC BY-NC-SA 3.0)

29 *Artemisia californica*—California sagebrush (©2008 Jorg Fleige; CC BY-NC 3.0)

30 *Ambrosia psilostachya*—western ragweed (©2014 Richard Spellenberg; CC BY-NC-SA 3.0)

31 *Ambrosia monogyra*—single-whorl burrobrush (©2014 Keir Morse; CC BY-NC-SA 3.0)

32 *Bromus inermis*—smooth brome (Fabelfroh via Wikimedia Commons; CC BY-SA 3.0)

33 *Pennisetum setaceum*—crimson fountaingrass (©2011 Zoya Akulova; CC BY-NC 3.0)

34 *Tripsacum* sp.—gamagrass (Patty Guertin; CC BY-NC 4.0)

35 *Carex concinna*—low northern sedge (Rob Routledge, Sault College, Bugwood.org ; CC BY 3.0 US)

36 *Carex aurea*—golden sedge (©2003 Steve Matson; Creative Commons Attri-

bution-NonCommercial 3.0 (CC BY-NC 3.0)

37 *Scirpus microcarpus*—panicled bulrush (©2003 Steve Matson; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

38 *Juncus balticus*—baltic rush (©2008 Keir Morse; CC BY-NC-SA 3.0)

39 *Juncus howellii*—Howell's rush (©2015 Steve Matson; Creative Commons Attribution-NonCommercial 3.0 (CC BY-NC 3.0)

40 *Luzula hitchcockii*—Hitchcock's wood rush (©2010 Keir Morse; CC BY-NC-SA 3.0)

PAGES 66-67: THE PHENOPHASE FOR POLLEN RELEASE

1 *Opuntia versicolor*—staghorn cholla (Patty Guertin; CC BY-NC 4.0)

2 *Kallstroemia grandiflora*—Arizona poppy (Patty Guertin; CC BY-NC 4.0)

3 *Typha* sp.—fourwing saltbush (Patty Guertin; CC BY-NC 4.0)

4 *Pinus* sp.—Pine (Tangopaso via Wikimedia Commons; Public domain)

5 *Atriplex canescens*—fourwing saltbush (Patty Guertin; CC BY-NC 4.0)

6 *Aegilops cylindrica*—jointed goatgrass (©2014 Al Keuter; CC BY-NC-SA 3.0)

7 Poaceae species—grass (David Cappaert, Bugwood.org; CC BY-NC 3.0 US)

8 *Saccharum spontaneum*—wild sugarcane (Scott Bauer via Wikimedia Commons; Public domain)

9 *Paspalum quadrifarium*—tussock paspalum (Chris Evans, University of Illinois, Bugwood.org; CC BY-NC 3.0 US)

10 *Tripsacum dactyloides*—eastern gamagrass (Patty Guertin; CC BY-NC 4.0)

11 *Anthoxanthum odoratum*—sweet vernal grass (©2008 Zoya Akulova; CC BY-NC 3.0)

12 *Gilia tricolor*—bird's-eye gilia (©2015 Steve Matson; CC BY-NC 3.0)

13 *Calochorus* sp.—mariposa lily (Patty Guertin; CC BY-NC 4.0)

14 *Calochorus kennedyi*—desert mariposa lily (Patty Guertin; CC BY-NC 4.0)

15 *Oenothera speciosa*—pinkladies (Patty Guertin; CC BY-NC 4.0)

16 *Asclepias asperula*—antelope horn milkweed (LevyRat via Wikimedia Commons; CC0 1.0)

PAGES 68-69: AN OVERVIEW OF "SPENT" FLOWERS

1 - 6 *Citrus* sp.—orange (Patty Guertin; CC BY-NC 4.0)

7 *Opuntia engelmannii*—cactus apple (Patty Guertin; CC BY-NC 4.0)

8 *Eriogonum fasciculatum*—eastern Mojave buckwheat (Patty Guertin; CC BY-NC 4.0)

9 *Anaphalis* sp.—everlasting (Patty Guertin; CC BY-NC 4.0)

10 *Ferocactus wislizeni*—candy barrelcactus (Patty Guertin; CC BY-NC 4.0)

11 *Eschscholzia californica*—California poppy (Patty Guertin; CC BY-NC 4.0)

12 *Fouquieria splendens*—ocotillo (Ciar via Wikimedia Commons; Public domain)

13 *Penstemon superbus*—superb beardtongue (Patty Guertin; CC BY-NC 4.0)

14 *Punica granatum*—pomegranate (© Sara N. Schaffer; CC BY-NC 4.0)

15 *Acacia berlandieri*—guajillo (© Sara N. Schaffer; CC BY-NC 4.0)

16 *Grindellia* sp.—gumweed (Patty Guertin; CC BY-NC 4.0)

17 unknown Asteraceae (Patty Guertin; CC BY-NC 4.0)

18 *Eriogonum fasciculatum*—eastern Mojave buckwheat (Patty Guertin; CC BY-NC 4.0)

19 *Chysothamnus* sp.—rabbitbrush (Patty Guertin; CC BY-NC 4.0)

20 *Schoenoplectus americanus*—bulrush (Patty Guertin; CC BY-NC 4.0)

PAGES 70-71: AN OVERVIEW OF NEW FRUITS

1 *Oenothera elata* ssp. *hirsutissima*—hairy evening-primrose (©2013 Keir Morse; CC BY-NC-SA 3.0)

2 *Ranunculus uncinatus*—woodland buttercup (©2011 Jean Pawek; for permission of image usage, see http://calphotos.berkeley.edu/cgi/img_query?enlarge=0000+0000+0811+2603)

3 *Acacia greggii*—catclaw acacia (Patty Guertin; CC BY-NC 4.0)

4 *Eriogonum fasciculatum*—Eastern Mojave buckwheat (© Kyle Eaton via iNaturalist.org; CC BY-NC 4.0)

5 *Solanum lycopersicum*—tomato (Slick via Wikimedia Commons; CC0 1.0)

6 *Penstemon albomarginatus*—whitemargin beardtongue (©2014 John Game; CC BY-SA 3.0)

7 *Cucumis melo*—cantelope (Patty Guertin; CC BY-NC 4.0)

8 *Lepidium lasiocarpum* var. *lasiocarpum*—shaggyfruit pepperweed (Stan Shebs via Wikimedia Commons; CC BY-SA 3.0)

9 *Sambucus racemosa*—red elderberry (Ellen G. Denny; CC BY-NC 4.0)

10 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

11 *Quercus rubra*—northern red oak (DAVID LEE, Bugwood.org; CC BY-NC 3.0 US)

12 *Corylus cornuta* ssp. *californica*—California hazelnut (©2010 Barry Breckling; CC BY-NC-SA 3.0)

13 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

PAGES 72-74: THE PHENOPHASE FOR FRUITS

1 *Opuntia santa-rita*—Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

2 *Opuntia santa-rita*—Santa Rita pricklypear (© Sara N. Schaffer; CC BY-NC 4.0)

3 - 4 *Opuntia santa-rita*—Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

5 - 8 *Fragaria virginiana*—Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

9 - 11 *Spartina patens* - saltmeadow cordgrass (Ellen G. Denny; CC BY-NC 4.0)

12 - 15 *Scirpus cyperinus*—woolgrass (Ellen G. Denny; CC BY-NC 4.0)

16 - 19 *Juncus gerardii* - saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

20 - 23 *Kalmia latifolia*—mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

24 - 27 *Betula nigra*—river birch (Ellen G. Denny; CC BY-NC 4.0)

28 - 32 *Acer rubrum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

33 - 36 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

37 *Quercus rubra*—northern red oak (Tom DeGomez, University of Arizona, Bugwood.org; CC BY 3.0 US)

PAGE 75: AN OVERVIEW OF ABORTED FRUITS

1 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

2 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

3 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

4 *Citrus* sp.—orange (Patty Guertin; CC BY-NC 4.0)

5 *Quercus emoryi*—Emory oak (Patty Guertin; CC BY-NC 4.0)

6 *Cucumis melo*—cantalope (Patty Guertin; CC BY-NC 4.0)

7 *Quercus rubra*—northern red oak (Ellen G. Denny; CC BY-NC 4.0)

PAGES 76-77: THE PHENOPHASE FOR RIPE FRUITS

1 - 5 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

6 - 10 *Vaccinium corymbosum*—highbush blueberry (Ellen G. Denny; CC BY-NC 4.0)

11 - 12 *Ceanothus* sp.—ceanothus (Patty Guertin; CC BY-NC 4.0)

13 - 14 *Penstemon superbus*—superb beardtongue (Patty Guertin; CC BY-NC 4.0)

15 - 16 *Asclepias subulata*—rush milkweed (© Sara N. Schaffer; CC BY-NC 4.0)

17 - 18 *Xanthium strumarium*—rough cocklebur (Jan Samanek, Phytosanitary Administration, Bugwood.org; CC BY 3.0 US)

19 - 20 *Baileya multiradiata*—desert marigold (Patty Guertin; CC BY-NC 4.0)

21 - 22 *Prosopis velutina*—velvet mesquite (© Sara N. Schaffer; CC BY-NC 4.0)

23 - 24 *Cornus canadensis*—bunchberry dogwood (Patty Guertin; CC BY-NC 4.0)

25 - 26 *Cucumis melo*—cantalope (Patty Guertin; CC BY-NC 4.0)

27 - 28 *Setaria* sp.—bristlegrass (Patty Guertin; CC BY-NC 4.0)

29 *Juncus confusus*—Colorado rush (©2012 Gary A. Monroe; CC BY-NC 3.0)

30 *Juncus confusus*—Colorado rush (©2012 Steve Matson; CC BY-NC 3.0)

PAGE 78: AN OVERVIEW OF RIPENED, PERSISTENT FRUITS

1 *Ilex verticillata*—common winterberry (Ellen G. Denny; CC BY-NC 4.0)

2 *Chimaphila umbellata* ssp. *umbellata*—common pipsissewa (©2016 Keir Morse; CC BY-NC-SA 3.0)

3 *Chimaphila umbellata*—pipsissewa (Patty Guertin; CC BY-NC 4.0)

4 *Chimaphila umbellata*—prince's pine (©2010 Jean Pawek; for permission of image usage, see http://calphotos.berkeley.edu/cgi/img_query?enlarge=0000+0000+0910+1820)

5 *Chimaphila umbellata*—pipsissewa (©2012 Barry Rice; CC BY-NC-SA 3.0)

6 - 8 *Hamamelis virginiana*—American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

9 - 11 *Ilex verticillata*—common winterberry (Ellen G. Denny; CC BY-NC 4.0)

PAGE 79: THE PHENOPHASE FOR RECENT FRUIT OR SEED DROP

1 *Acer rubrum*—red maple (Ellen G. Denny; CC BY-NC 4.0)

2 *Olneya tesota*—desert ironwood (Patty Guertin; CC BY-NC 4.0)

3 *Erythronium americanum*—dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

4 *Salix discolor*—pussy willow (Ellen G. Denny; CC BY-NC 4.0)

5 *Typha* sp.—cattail (Patty Guertin; CC BY-NC 4.0)

6 *Asclepias subulata*—rush milkweed (© Sara N. Schaffer; CC BY-NC 4.0)

7 *Betula nigra*—river birch (Ellen G. Denny; CC BY-NC 4.0)

8 *Ilex verticillata*—common winterberry (Ellen G. Denny; CC BY-NC 4.0)

9 *Betula papyrifera*—paper birch (Ellen G. Denny; CC BY-NC 4.0)

10 *Magnolia stellata*—star magnolia (Ellen G. Denny; CC BY-NC 4.0)

11 *Ilex verticillata*—common winterberry (Ellen G. Denny; CC BY-NC 4.0)

12 *Quercus emoryi*—Emory oak (Patty Guertin; CC BY-NC 4.0)

PAGES 84-87: SECTION TWO INTRODUCTION

1 - 8 *Hamamelis virginiana* - American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

9 *Acer rubrum* - red maple (Ellen G. Denny; CC BY-NC 4.0)

10 *Acer rubrum* - red maple (© Claire O'Neill via iNaturalist.org; CC BY-NC 4.0)

11 *Acer rubrum* - red maple (© Joshua Harkness via iNaturalist.org; CC BY-NC 4.0)

12 - 20 *Acer rubrum* - red maple (Ellen G. Denny; CC BY-NC 4.0)

PAGES 88-89: CACTUS *(FUNCTIONAL GROUP)*

1 *Carnegiea gigantea* - saguaro (Patty Guertin; CC BY-NC 4.0)

2 *Carnegiea gigantea* - saguaro (© srrgr16 via iNaturalist.org; CC BY-NC 4.0)

3 *Carnegiea gigantea* - saguaro (© Sara Schaffer; CC BY-NC 4.0)

4 *Carnegiea gigantea* - saguaro (© ob1963 via iNaturalist.org; CC BY-NC 4.0)

PAGES 90-93: CACTUS *(OPUNTIA SANTA-RITA)*

1 - 9 *Opuntia santa-rita* - Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

10 *Opuntia santa-rita* - Santa Rita pricklypear (© Sara Schaffer; CC BY-NC 4.0)

11 - 12 *Opuntia santa-rita* - Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

13 *Opuntia santa-rita* - Santa Rita pricklypear (© Sara Schaffer; CC BY-NC 4.0)

14 - 17 *Opuntia santa-rita* - Santa Rita pricklypear (Patty Guertin; CC BY-NC 4.0)

PAGES 94-97: CACTUS *(CARNEGIEA GIGANTEA)*

1 - 2 *Carnegiea gigantea* - saguaro (Patty Guertin; CC BY-NC 4.0)

3 - 4 *Carnegiea gigantea* - saguaro (© Jess White via iNaturalist.org; CC BY-NC 4.0)

5 *Carnegiea gigantea* - saguaro (© srrgr16 via iNaturalist.org; CC BY-NC 4.0)

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11 *Carnegiea gigantea* - saguaro (© Laurens R Halsey via iNaturalist.org; CC BY-NC 4.0)

12 *Carnegiea gigantea* - saguaro (© Mike Plagens via iNaturalist.org; CC BY-NC 4.0)

13 *Carnegiea gigantea* - saguaro (© ob1963 via iNaturalist.org; CC BY-NC 4.0)

14 *Carnegiea gigantea* - saguaro (© Susan Dingwell via iNaturalist.org; CC BY-NC 4.0)

15 *Carnegiea gigantea* - saguaro (© dbond via iNaturalist.org; CC BY-NC 4.0)

PAGES 98-99: FORB *(FUNCTIONAL GROUP)*

1 - 4 *Erythronium americanum* - dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

PAGES 100-103: FORB *(ERYTHRONIUM AMERICANUM)*

1 - 3 *Erythronium americanum* - dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

4 *Erythronium americanum* - dogtooth violet (© Mentor Naturalists via iNaturalist.org; CC BY-NC 4.0)

5 *Erythronium americanum* - dogtooth violet (Bonnie Isaac via iNaturalist.org; Public domain)

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13 *Erythronium americanum* - dogtooth violet (© Erika Mitchell via iNaturalist.org; CC BY-NC 4.0)

14 *Erythronium americanum* - dogtooth violet (© tallpaultheforester via iNaturalist.org; CC BY-NC 4.0)

15 - 16 *Erythronium americanum* - dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

18 *Erythronium americanum* - dogtooth violet (© Tom Scavo via iNaturalist.org; CC BY 4.0)

19 - 22 *Erythronium americanum* - dogtooth violet (Ellen G. Denny; CC BY-NC 4.0)

PAGES 104-109: FORB *(PODOPHYLLUM PELTATUM)*

1 *Podophyllum peltatum* - mayapple (© samwilhelm via iNaturalist.org; CC BY-NC 4.0)

2 *Podophyllum peltatum* - mayapple (© Thomas Koffel via iNaturalist.org; CC BY 4.0)

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30 *Podophyllum peltatum* - mayapple (Ellen G. Denny; CC BY-NC 4.0)

PAGES 110-113: FORB *(HELIANTHUS ANNUUS)*

1 *Helianthus annuus* - common sunflower (Emoke Dénes via Wikimedia Commons; CC BY-SA 4.0)

2 *Helianthus annuus* - common sunflower (Forest and Kim Starr via Flickr; CC BY 3.0)

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14 *Helianthus annuus* - common sunflower (© explorer2023 via iNaturalist.org; CC BY-NC 4.0)

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24 *Helianthus annuus* - common sunflower(© Alexander Baransky via iNaturalist.org; CC BY-NC 4.0)

PAGES 114-115: FORB—SEMI-EVERGREEN *(FUNCTIONAL GROUP)*

1 *Fragaria virginiana* - Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

2 *Fragaria virginiana* - Virginia strawberry (© Erin Faulkner via iNaturalist.org; CC BY-NC 4.0)

3 - 4 *Fragaria virginiana* - Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

PAGES 116-121: FORB—SEMI-EVERGREEN *(FRAGARIA VIRGINIANA)*

1 - 4 *Fragaria virginiana* - Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

5 *Fragaria virginiana* - Virginia strawberry (© Senna Bryce Robeson via iNaturalist.org; CC BY-NC 4.0)

6 *Fragaria virginiana* - Virginia strawberry (© Eric Keith via iNaturalist.org; CC BY-NC 6.0)

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8 *Fragaria virginiana* - Virginia strawberry (© Michelle Paleczny via iNaturalist.org; CC BY-NC 4.0)

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21 - 27 *Fragaria virginiana* - Virginia strawberry (Ellen G. Denny; CC BY-NC 4.0)

PAGES 122-123: FORB—EVERGREEN *(FUNCTIONAL GROUP)*

1 *Sarracenia purpurea* - purple pitcherplant (© claudie_b via iNaturalist.org; CC BY-NC 4.0)

2 - 3 *Sarracenia purpurea* - purple pitcherplant (©2016 Keir Morse; CC BY-NC-SA 3.0)

4 *Sarracenia purpurea* - purple pitcherplant (dogtooth77 via Flickr; CC BY-NC-SA 2.0)

PAGES 124-127: FORB—EVERGREEN *(CHIMAPHILA UMBELLATA)*

1 *Chimaphila umbellata* - pipsissewa (© Erika Mitchell via iNaturalist.org; CC BY-NC 4.0)

2 *Chimaphila umbellata* - pipsissewa (Bjoertvedt via Wikimedia Commons; CC BY-SA 3.0)

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21 *Chimaphila umbellata* - pipsissewa (© Susan Elliott via iNaturalist.org; CC BY-NC 4.0)

PAGES 128-131: FORB—EVERGREEN *(SARRACENIA PURPUREA)*

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2 *Sarracenia purpurea* - purple pitcherplant (© stonehorton via iNaturalist.org; CC BY-NC 4.0)

3 *Sarracenia purpurea* - purple pitcherplant (© Frank Ziegler via iNaturalist.org; CC BY-NC 4.0)

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19 *Sarracenia purpurea* - purple pitcherplant (© Ben Freeman via iNaturalist.org; CC BY-NC 4.0)

20 *Sarracenia purpurea* - purple pitcherplant (© Jeremy Collison via iNaturalist.org; CC BY-NC 4.0)

PAGES 132-133: GRAMINOID—GRASS *(FUNCTIONAL GROUP)*

1 *Echinochloa crus-galli* - barnyardgrass (Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org; CC BY 3.0 US)

2 *Echinochloa crus-galli* - barnyardgrass (© aseeger via iNaturalist.org; CC BY-NC 4.0)

3 *Echinochloa crus-galli* - barnyardgrass (Rasbak via Wikimedia Commons; CC BY-SA 3.0)

4 *Echinochloa crus-galli* - barnyardgrass (© mobbini via iNaturalist.org; CC BY-NC 4.0)

PAGES 134-137: GRAMINOID—GRASS *(ECHINOCHLOA CRUS-GALLI)*

1 *Echinochloa crus-galli* - barnyardgrass (Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org; CC BY 3.0 US)

2 *Echinochloa crus-galli* - barnyardgrass (Gilles Ayotte via Wikimedia Commons; CC BY-SA 4.0)

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7 *Echinochloa crus-galli* - barnyardgrass (© Vadim Prokhorov via iNaturalist.org; CC BY-NC 4.0)

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21 *Echinochloa crus-galli* - barnyardgrass (Stephen James McWilliam via iNaturalist.org; Public domain)

PAGES 138-141: GRAMINOID—GRASS *(SPARTINA PATENS)*

1 - 11 *Spartina patens* - saltmeadow cordgrass (Ellen G. Denny; CC BY-NC 4.0)

12 *Spartina patens* - saltmeadow cordgrass (© wanderingeden via iNaturalist.org; CC BY-NC 4.0)

13 - 19 *Spartina patens* - saltmeadow cordgrass (Ellen G. Denny; CC BY-NC 4.0)

PAGES 142-143: GRAMINOID—SEDGE *(FUNCTIONAL GROUP)*

1 - 4 *Carex pensylvanica* - Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

PAGES 144-147: GRAMINOID—SEDGE *(CAREX PENSYLVANICA)*

1 - 14 *Carex pensylvanica* - Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

15 *Carex pensylvanica* - Pennsylvania sedge (© jim_keesling via iNaturalist.org;

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14 - 20 *Carex pensylvanica* - Pennsylvania sedge (Ellen G. Denny; CC BY-NC 4.0)

PAGES 148-149: GRAMINOID—RUSH *(FUNCTIONAL GROUP)*

1 - 2 *Juncus gerardii* - saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

3 *Juncus gerardii* - saltmeadow rush (© Maria via iNaturalist.org; CC BY 4.0)

4 *Juncus gerardii* - saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

PAGES 150-153: GRAMINOID—RUSH *(JUNCUS GERARDII)*

1 - 9 *Juncus gerardii* - saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

10 *Juncus gerardii* - saltmeadow rush (© Ian Bryson via iNaturalist.org; CC BY-NC 4.0)

11 - 12 *Juncus gerardii* - saltmeadow rush (© Maria via iNaturalist.org; CC BY 4.0)

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22 *Juncus gerardii* - saltmeadow rush (Ellen G. Denny; CC BY-NC 4.0)

PAGES 154-155: TREE/SHRUB—DECIDUOUS *(FUNCTIONAL GROUP)*

1 - 4 *Acer rubrum* - red maple (Ellen G. Denny; CC BY-NC 4.0)

PAGES 156-161: TREE/SHRUB—DECIDUOUS *(ACER RUBRUM)*

1 - 2 *Acer rubrum* - red maple (Ellen G. Denny; CC BY-NC 4.0)

3 *Acer rubrum* - red maple (© Claire O'Neill via iNaturalist.org; CC BY-NC 4.0)

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22 *Acer rubrum* - red maple (© Abby Darrah via iNaturalist.org; CC BY 4.0)

23 - 31 *Acer rubrum* - red maple (Ellen G. Denny; CC BY-NC 4.0)

PAGES 162-167: TREE/SHRUB—DECIDUOUS *(QUERCUS RUBRA)*

1 - 2 *Quercus rubra* - northern red oak (Ellen G. Denny; CC BY-NC 4.0)

3 *Quercus rubra* - northern red oak (Paul Bolstad, University of Minnesota, Bugwood.org; CC BY 3.0 US)

4 - 13 *Quercus rubra* - northern red oak (Ellen G. Denny; CC BY-NC 4.0)

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22 *Quercus rubra* - northern red oak (Rob Routledge, Sault College, Bugwood.org; CC BY 3.0 US)

23 *Quercus rubra* - northern red oak (Ellen G. Denny; CC BY-NC 4.0)

24 - 25 *Quercus rubra* - northern red oak (David Lee, Bugwood.org; CC BY-NC 3.0 US)

26 - 29 *Quercus rubra* - northern red oak (Ellen G. Denny; CC BY-NC 4.0)

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33 - 34 *Quercus rubra* - northern red oak (Ellen G. Denny; CC BY-NC 4.0)

PAGES 168-173: TREE/SHRUB—DECIDUOUS *(MAGNOLIA STELLATA)*

1 - 28 *Magnolia stellata* - star magnolia (Ellen G. Denny; CC BY-NC 4.0)

PAGES 174-179: TREE/SHRUB—DECIDUOUS *(HAMAMELIS VIRGINIANA)*

1 - 11 *Hamamelis virginiana* - American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

12 *Hamamelis virginiana* - American witchhazel (© Ramonde G Chartier via iNaturalist.org; CC BY-NC 4.0)

13 - 27 *Hamamelis virginiana* - American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

28 *Hamamelis virginiana* - American witchhazel (@ Angus Mossman via iNaturalist.org; CC BY-NC 4.0)

29 *Hamamelis virginiana* - American witchhazel (Ellen G. Denny; CC BY-NC 4.0)

PAGES 180-181: TREE/SHRUB—DROUGHT DECIDUOUS *(FUNCTIONAL GROUP)*

1 - 3 *Prosopis velutina* - velvet mesquite (Patty Guertin; CC BY-NC 4.0)

4 *Prosopis velutina* - velvet mesquite (© Sara Schaffer; CC BY-NC 4.0)

PAGES 182-187: TREE/SHRUB—DROUGHT DECIDUOUS *(PROSOPIS VELUTINA)*

1-2 *Prosopis sp.* - mesquite (Erin E. Posthumus; CC BY-NC 4.0)

3 - 6 *Prosopis velutina* - velvet mesquite (Patty Guertin; CC BY-NC 4.0)

7 *Prosopis velutina* - velvet mesquite (© Eric Hough via iNaturalist.org; CC BY-NC 4.0)

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27 *Prosopis velutina* - velvet mesquite (Patty Guertin; CC BY-NC 4.0)

PAGES 188-193: TREE/SHRUB—DROUGHT DECIDUOUS *(CEANOTHUS GREGGII)*

1 - 5 *Ceanothus greggii* - desert ceanothus (Patty Guertin; CC BY-NC 4.0)

6 - 7 *Ceanothus pauciflorus* - Mojave ceanothus (© Tom Chester via iNaturalist.org; CC BY-NC 4.0)

8 - 10 *Ceanothus greggii* - desert ceanothus (Patty Guertin; CC BY-NC 4.0)

11 *Ceanothus pauciflorus* - Mojave ceanothus (© Cliff McLean via iNaturalist.org; CC BY-NC 4.0)

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26 *Ceanothus pauciflorus* - Mojave ceanothus (© Amy (She/Her) via iNaturalist.org; CC BY-NC 4.0)

27 - 28 *Ceanothus pauciflorus* - Mojave ceanothus (© Steve Jones via iNaturalist.org; CC BY-NC 4.0)

29 *Ceanothus pauciflorus* - Mojave ceanothus (© Jim Brighton via iNaturalist.org; CC BY-NC 4.0)

PAGES 194-195: TREE/SHRUB—SEMI-EVERGREEN *(FUNCTIONAL GROUP)*

1 *Quercus douglasii* - blue oak (© Daniel George via iNaturalist.org; CC BY-NC 4.0)

2 *Quercus douglasii* - blue oak (© Alex Jones via iNaturalist.org; CC BY-NC 4.0)

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4 *Quercus douglasii* - blue oak (Eugene Zelenko via Wikimedia Commons; CC BY-SA 4.0)

PAGES 196-201: TREE/SHRUB—SEMI-EVERGREEN *(QUERCUS DOUGLASII)*

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PAGES 202-203: TREE/SHRUB—EVERGREEN *(FUNCTIONAL GROUP)*

1 - 4 *Kalmia latifolia* - mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

PAGES 204-209: TREE/SHRUB—EVERGREEN *(KALMIA LATIFOLIA)*

1 - 10 *Kalmia latifolia* - mountain laurel (Ellen G. Denny; CC BY-NC 4.0)

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PAGES 210-215: TREE/SHRUB—EVERGREEN *(GAULTHERIA SHALLON)*

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