Sierra Streams Institute Citizen Science Curriculum: Connecting with Plant Science: Backyard Phenology

Curriculum Guide for Teachers

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This curriculum was made possible through generous funding from the American Society of Plant Biologists' BLOOME grants

Connecting with Plant Science: Backyard Phenology

Introduction and Outcomes

Included:

- Background on Sierra Streams Institute
- Why use citizen science to teach phenology?
- How is phenology used in a real-world context?
- How this guide will help your students engage with science

Sierra Streams Institute

Sierra Streams Institute is a watershed science organization based in Nevada City, California. Our mission is to link water, science and people for the benefit of human and environmental health. Our vision is to be a regional leader in fostering community-based ecological stewardship in order to protect and restore the health of the environment for all living organisms.

The Sierra Streams Institute Education Department has the overall goal to foster community-based ecological stewardship in order to protect and restore the health of the environment for all living organisms. We aim to inspire youth to become the next generation of environmental stewards through our outdoor science education program. This program inspires the next generation of conservationists by fostering a love of nature and developing their understanding of climate change impacts.

For more information on our organization, visit www.sierrastreamsinstitute.org

Why use citizen science to teach phenology?

Citizen science is the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.
Phenology is the study of periodic plant and animal life-cycle events influenced by seasonal changes and climate change, i.e. the study of when things appear in nature.
"Connecting with Plant Science: Backyard Phenology" is a program developed by Sierra Streams Institute and funded by the American Society of Plant Biologists Plant BLOOME grants. This project is an effort to help teachers engage middle and high school-aged youth in a hands-on project that will allow them to 1) become familiar with the biology of their local plants, 2) understand the impacts of climate change on plant life cycles and on the health of the whole

ecosystem, 3) contribute as citizen-scientists to a national phenological dataset, and 4) analyze and interpret data to discern long term trends. The project has several educational objectives:

• Acquaint students with their local flora by using the schoolyard as an outdoor classroom
• Alleviate "plant blindness" among young students by encouraging close observation of plants
• Create a generation of "citizen scientists" who understand the value of local environmental stewardship and monitoring and its contribution to a larger body of knowledge
• Allow students to experience all aspects of real-life science by incorporating observation, discovery, analysis, critical thinking about the implications of their findings, and communication of results

How is phenology data used in a real-world context?

Observing the phenology (timing of developmental stages) of various plant species can begin to answer critical questions regarding the interaction of climate change and biology. The project aims to expand the scope of current national phenological data collection efforts in an inexpensive and replicable manner with students making observations in their own community. A key element of the project is student participation in crowd-sourced data gathering efforts, introducing them to the National Phenology Network database through the program "Nature's Notebook" and allowing them to add to a growing body of knowledge. Our project represents an important expansion in data gathering potential, with an approach that is specific to California and applicable at the schoolyard and local watershed scale. This model can be adapted to be responsive to local ecosystems, making phenology accessible to students and emphasizing that all plants, including those in urban environments, are impacted by climate change.

How this guide will help your students engage with science

The project employs several important engagement strategies:

1. Allows students to connect to the issue of climate change, developing an understanding of how plants can highlight the observable impacts of climate change in the environment
2. Takes students through the scientific process from observation, data collection, input and analysis, discernment of trends, connection to a wider dataset, and dissemination of results
3. Aligns with newly adopted Next Generation Science Standards, aimed at increasing climate change literacy so that the next generation is better equipped to face this global challenge
4. Expands the scope of the national phenology data collection efforts by making plant science readily accessible for youth and educators
5. Educates the community by having students create blogs about their experiences and design a field guide, thereby increasing public interest in student-driven research

Connecting with Plant Science: Backyard Phenology

Supplemental Materials: Site and Plant Selection

How to:

- Criteria for picking the best plants
- Criteria for picking the best site
- Things to consider

Site Selection

Before beginning the process of setting up a phenology citizen science project, it is important to consider where your project will take place. When conducting the initial pilot phase of this curriculum, Sierra Streams Institute chose sites on a school campus, at a state park within walking distance to one school, a city park within walking distance to another school, and a local land trust site that was used frequently for driving field trips at one of our partner schools. Several priorities and considerations led us to make our site selection decisions. When choosing the site where your students will collect data, please consider:

Plant Availability:

When considering site options to collect data, make sure to visit the location in person and survey the plants that live at the site. We chose not to collect phenology data at one school location because the availability of plants was very limited. We did not think that the students would have a meaningful experience collecting data at their school site because 70 students would be limited to only a few individual trees that would not display many phenophases during the semester we implemented the program. At another school site, there were no native plants, but enough individual plants and diverse ornamental species that we did choose to collect data at this particular school site. The parks we chose as study sites did have many individual species and were conducive for many groups of 4 – 16 students to visit at the same time.

Amount of Time to Travel to the Site and Frequency of Visits: It was important to be realistic about the amount of time it would take to travel to a site and understand how frequently we could visit the plants over the course of a year. This decision is greatly impacted by school

schedules, and the potential flexibility to collect data during block or combined periods that are longer than one hour.

Plant Selection

Visit potential sites with someone who has a background in botany and is proficient in identifying plants. Contact resources like the local native plant society chapter, environmental non-profit, or university research staff/faculty for help to ensure that your plants have been identified by an expert. It would not be helpful for the greater community that uses this citizen science data if students collect and upload data for a misidentified plant. Additionally, it is most useful for educational purposes to select plants that exist in the US-NPN database. That way, students can compare the data they collect with a national dataset.

Connecting with Plant Science: Backyard Phenology

Supplemental Materials: Data Collection

How to:

- Find information about your selected plants on Nature's Notebook
- Manage your site on Nature's Notebook
- Use the Visualization tool
- Make data sheets

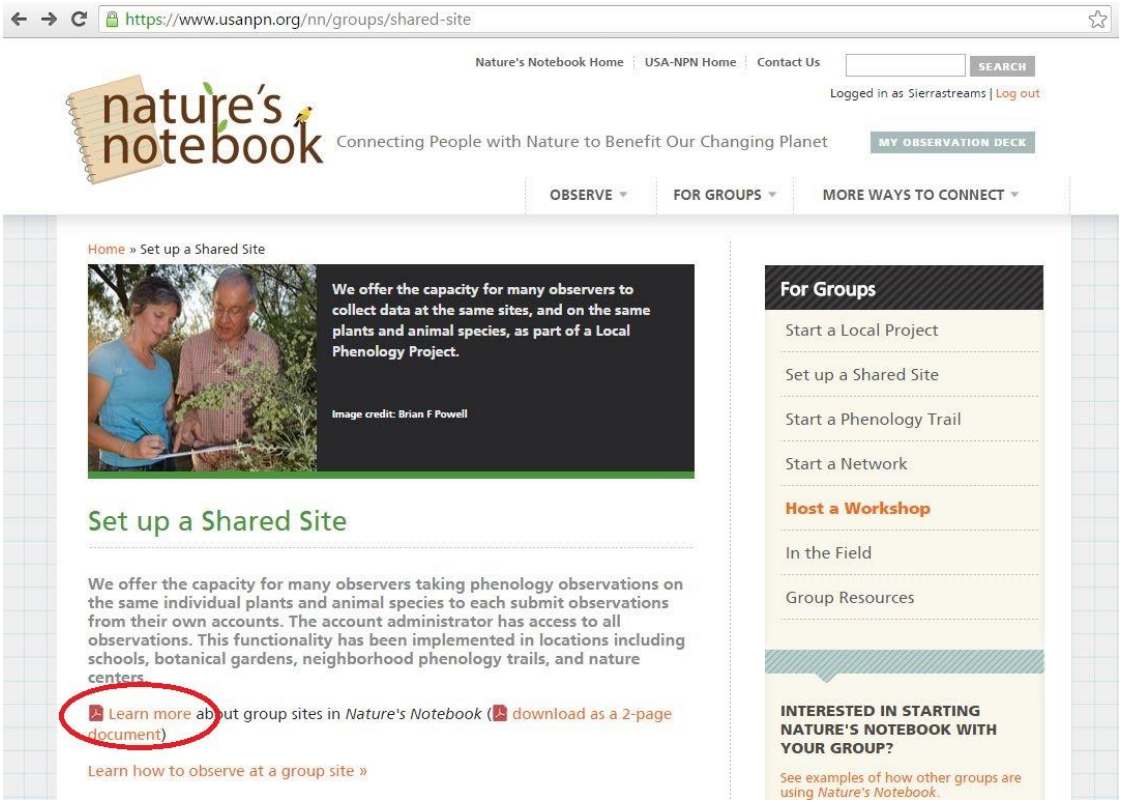
Setting up your site on Nature's Notebook

After you've gone through the hard work of choosing the right plants to observe, now you have to set them up on Nature's Notebook so students can select them and enter data.

First, you must fill out a Group Site Request. Once Nature's Notebook has completed processing your request, you can continue below.

You can use a document already created by Nature's Notebook for the next step. This document outlines the roles of administrators for a site (you), and its members (the students):

1. Go to: https://www.usanpn.org/natures_notebook
2. Find the drop-down menu at the top labeled "For Groups." In the menu click "Set up a Shared Site."
3. Find the Learn More link on the page to open the document. You can also access it directly with the link: https://www.usanpn.org/files/shared/files/Group%20Site%20Intro_0.pdf.

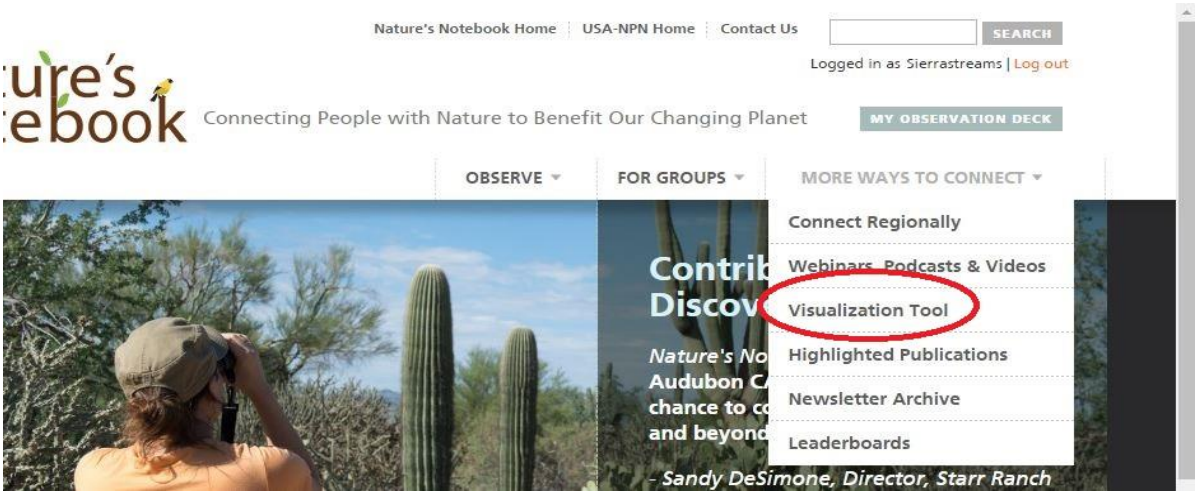


4. Follow the instructions in the how-to document to set up your Shared Site.

The Visualization tool

Nature's Notebook has a handy tool that turns your data into graphs. This can be a powerful way for your students to understand and interpret their data. However, it can be tricky to use, so putting some time in before using it with students will be well worth it.

At the top menu bar, go to "More ways to connect." In the drop-down menu, select Visualization tool.



Once on the page, you can dive straight into seeing what the tool is by clicking on the "Explore Our Data" map, which opens the Visualization tool. Scrolling down the main page, everything in the Visualization Tool is defined in writing. If you stay on this page, there are also some webinars on the right hand sidebar you can watch on YouTube to get you familiarized with how things work.

Data entry

In order for students to submit their observations as data, they need to make an account on Nature's Notebook. See the previous link for more information about creating Member accounts.

For students to create their accounts, go to the Nature's Notebook homepage. On the main menu, click "Become an observer" in the drop-down menu under "Observe."

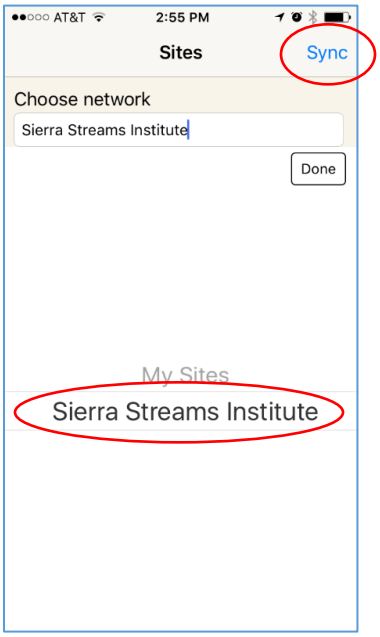
Scroll down and click "Become and observer now." Just be sure that when student are creating their accounts, that they **check the box next to your site name in the section titled "Partner Groups."**

Once they have created their accounts, they can enter data either

1. On the Nature's Notebook app
2. On the Nature's Notebook website

Nature's Notebook app

Downloading the app onto a mobile device is a lot easier (less work for you!) to submit data. You DO NOT need to use data or an internet connection in the field to submit observations – they will automatically be submitted when you regain connection. Have students download the free Nature's Notebook app on their device, login with their account, and begin submitting.

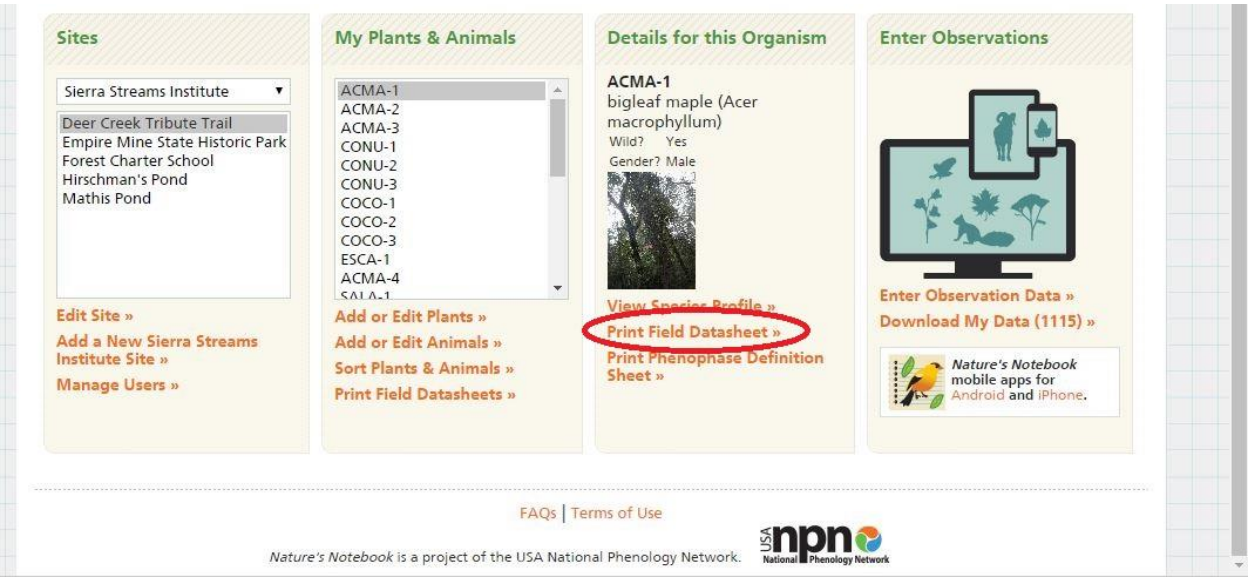


Troubleshoot tip: if you don't see your plants on the list, make sure you have: Selected your school or site under "Choose network" (instead of "My Sites")

1. Pressed "Sync" to refresh any changes that were made by the administrator

Data sheets

If your students do not have access to a mobile device in the field, then they will have to record their observations on paper. Later they can bring them to a computer to upload them using a web browser. You can download a data sheet for each individual plant from the Nature's Notebook. Go to "My Observation Deck" in the upper right hand corner, scroll down to the bottom, and highlight the plant you want under "My Plants & Animals," then click "Print Field Datasheet."



To make things simpler for students and use less paper, Sierra Streams Institute made custom data sheets that included all the sites' plants on one page. See page 38 in the appendices for an example.

Tip: If you want to make your own spreadsheet with all the plants on one page, feel free to copy our example data sheet and update the plants to match your site. Just pay attention to the criteria that Nature's Notebook asks you to observe for each plant – for instance, some plants require a pollen release observation and other don't.

Connecting with Plant Science: Backyard Phenology

Supplemental Materials: Projects: Writing Assignment and Field Guides

How to:

- Assign field guide assignment
- Assign the writing assignments
- Templates for creating field guides and where to find them

Field guide assignment

The field guide assignments offers students to work in groups to study the long-term phenology of one of your selected plants. Assembled altogether, the groups' assignments provide a tangible product of the work they achieved.

Before getting started, see examples of completed field guides made by the two high schools Sierra Streams Institute worked with in spring 2016:

- Empire Mine State Historic Park
- Adam Ryan Reserve
- Forest Charter School

Assignment breakdown

Plant Components. For each plant used in the project, there are three pages in the field guide: data, life history, and phenophases. Students are responsible for including the following information about their plant on each page:

1. Data
    a. Data collected with their school on Nature's Notebook
    b. Compare to national data set on Nature's Notebook

    c. Create two graphs using the Visualization Tool
2. Life History
    a. Is the plant invasive or native?
    b. Describe the habitat type where you would find the plant (riparian, upland, mixed conifer, etc.)
    c. Include a distribution map of where the plant is located in the U.S.
3. Phenophases
    a. Find pictures and descriptions of each stage of the assigned plant
    b. Highlight the phenophases observed during the study

Additional Components. The field guide includes the following pages for students to complete:

1. Cover
2. Page including a description of the:
    a. Overview of the phenology project/what we did
    b. School site
3. Map of the plants in the study at your school/site
4. Page including:
    a. Student contributors to Field Guide (everyone in the class)
    b. Reference information about National Phenology Network and Nature's Notebook

Assign groups

Divvying up parts of the field guide depends of two things: 1.) how many students you have, and 2.) how many plants you took data for.

You may choose to go about this in two ways. For smaller classes, individual students can be responsible for all 3 components of one plant. Students can be assigned the additional components as their entire project or in addition to their plants.
For larger classes, assign the 3 components of the plant to a group of three students. Each group can also be assigned one of the additional components to complete.

It's your choice – you know your class best! See page 29 for an example of how Sierra Streams made groups and handed out the assignment to one school.

Field guide templates

Sierra Streams Institute created templates for students to work off of using Google Slides. Multiple students can edit the slides at the same time, and access their projects anywhere with internet connection. All updated edits are saved automatically. The template contains written Instructions for students on what to do for each slide in the Notes section underneath each slide in the editing view.

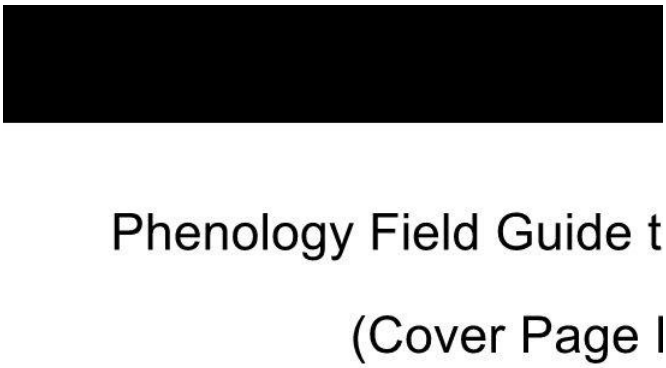
Go to this link to view the blank template.

You may also view these example templates students working with Sierra Streams Institute used:

- Google slide template for Empire Mine
- Google slide template for Adam Ryan Reserve
- Google slide template for Forest Charter School

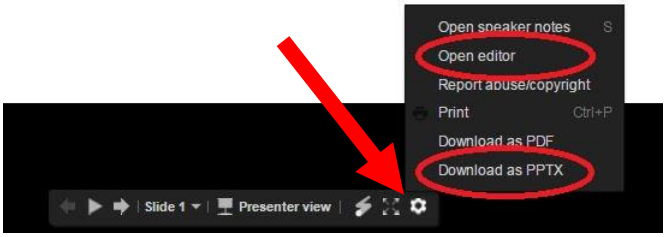
Sharing the field guide template with your students

Opening our "original copy of BLANK field guide template" will lead you straight to this view. Go down to the bottom left of the window to find the settings button.

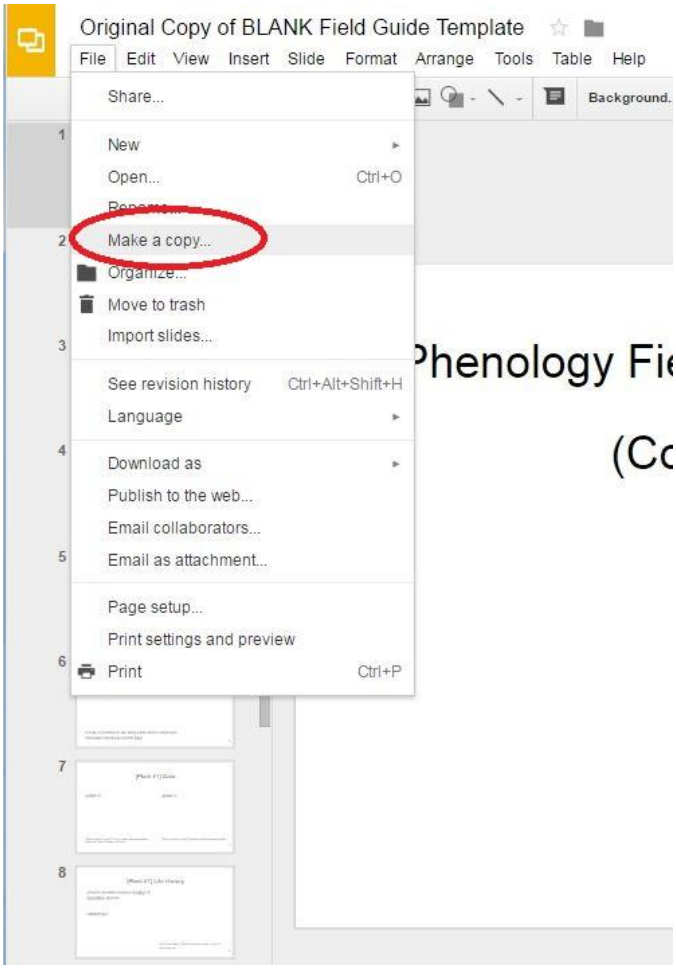


From here you have two options:

1. If you DO NOT have a Google email account, you can click "Download as PPTX" and download the template as a PowerPoint. You can then choose to send out the template as a PowerPoint or go to option number two below.



2. Make or sign in to a Google account. Click the “Open editor” option. You can view the template in Google slides, but you cannot edit it. To make a template that it editable, simply click the “Make a copy” option under File in the left hand corner. That copy will be available for you to edit and share with your students to use.



Writing assignment

The writing assignment is intended to get students thinking more deeply about the study of phenology through writing. They get a chance to ask their own questions, and do some research to gain a better understanding of their topic. If your school has a website or blog, these writing assignments can be excellent tools to post online as examples of student’s work, as well as promote the project-based learning taking place at your school. It can also allow students to use blog-style writing and technology.

See page 28 for an example rubric.

Basic requirements for the writing assignments:

- Be at least 300 words in length
- Include a minimum of 2 scientific sources (peer reviewed publications, scientific articles, relevant published magazines, etc.)

- Address one of the topics or a related student topic of choice cleared a teacher

Writing topics:

- Climate change interactions with phenology
    - Example: How is climate change impacting pollinators if flowers are blooming early, or birds' food sources emerging before birds migrate
- Current phenological studies
    - Example: What is being studied using phenology data? What kinds of scientists are using phenology for their studies?
- Citizen science research – what is it, what are the benefits?
- Real-world case studies involving citizen science or phenology
    - Example: How phenology helped save Mono Lake; how citizen science data can help us understand water quality in streams
- The natural history of one or more plants we are using to observe phenophases
- Species interactions involving phenology
    - Example: Explain the evolution of the Yucca moth, which only feeds on the nectar of Yucca flowers, which bloom infrequently
- A journal entry describing the observation experience

These are some ideas, feel free to add your own!

Connecting with Plant Science: Backyard Phenology

Lesson 1: Intro to Climate Change and Phenology

Materials:

- Laptop/syllabuses
- 30 cups
- 1 cup beans
- White board + marker

Theme:

Phenology is one way scientists can measure the impacts of climate change.

Questions:

What is climate change?

What are the impacts of climate change?

How can we measure the impacts of climate change?

Goals:

Students will identify common impacts of climate change.

Students can describe how phenology is a way of observing and studying climate change.

Students can see what role they will be able to play in studying phonological changes throughout the spring via participation in B&B game and the syllabus.

Objectives:

Students will categorize impacts of climate change.

Students can define phenology.

Introduction to Climate Change

GAINING PRIOR KNOWLEDGE (INVITATION) – 5 min:
Today we're going to introduce you to two things: climate change and phenology. One of these you might know a thing or two about, the other you might not know very much about at all. For right now, I want you to focus on climate change. Talk with a partner and define climate change. *Take a moment to define climate change, explain difference between weather and climate.* We want to know what you know about the impacts climate change is having on Earth. We have a few categories that you'll be assigned as a group to think about: oceans, weather patterns and events, plants & animals, and people. With the people around you, discuss the impacts climate change is having on one of these topics we will assign to you. One person should be scribe and take brief notes on all the ideas your group generates. GO—*Let students discuss in groups for 2-3 minutes.*

(EXPLORATION – 10 min): Write at least three things you came up with on the board. *Take 5 minutes for this; once everyone is done:* Now take a moment to examine what your peers came up with. Is there anything up there that you would add? Talk with your group.

(CONCEPT INVENTION – 5 min): You guys have all demonstrated an understanding of these impacts. But – how do we *know* that these things are all caused by a changing climate? Discuss with a partner. *Rove plus take a few student responses.*

Introduction to Phenology

TRANSITION: Scientists have observed changes in previously predictable environmental factors over time. From their observations, they have come up with ways to test their hypotheses about why these changes are happening, and the broad consensus is: climate change. So what can we, as ordinary people, do? Over the course of the spring, we are going to participate in our own study, and contribute our data to a larger national study.

The impact from climate change we're going to focus on is this: *circle plants & pollinators impact that has been written on the board by the students.* The word phenology can be broken up into its Greek roots: "ology" meaning "the study of," and "phaino," which means "to show, to bring to light, make to appear." In this way, we're looking at the study of when things appear, and in this case, when things in nature appear: when the flowers bloom, when the leaves bud, etc. The best way to understand it is to experience it!

BIRDS & BUTTERFLIES GAME (CONCEPT INVENTION – 20 min): We are all going to have the chance to experience the impacts of climate change on animals by playing a game. For this game, we are going to have some people be birds, and some people be caterpillars. If you are caterpillar, what do you need to survive? FOOD! Food helps you metamorphosis of caterpillars is triggered by warmer temperatures of spring. So caterpillars get a stomach to hold all their food *pass out cups and show them some beans*. I will be holding all the food. Caterpillars must collect 5 pieces of food from me in order to have enough energy to metamorphose into a

butterfly. You may only take one piece of food from me at a time. Once you collect 5 pieces, run back to the center where I am so that you can become a butterfly. You will bring your one piece of food to your stomach, which is hidden strategically. Your stomach is hidden, because when the temperature is warm enough to trigger the migration of the birds, the birds will be flying around, hungry and looking for some caterpillars to eat! The birds will try and find the caterpillar stomachs and steal all the food from inside. The birds can also tag the caterpillars as the caterpillars are running back to the center to metamorphose, so watch out! Birds must collect at least 7 pieces of food from the caterpillars to survive. *Assign birds and butterflies. Place birds with you in the center of the playing field. Have them close their eyes as the caterpillars go hide their stomachs. Start the game, but wait until about the second piece of food is collected to release the birds to eat the caterpillars.*
Once the round is over, record the number of caterpillars, butterflies, and birds. Have students reflect on what their experience as a bird/butterfly was like. Have them brainstorm ways they could better survive the next time. Play a second round, but wait until about the fourth or fifth piece of food to release the birds. Record number of caterpillars/birds/butterflies.

DISCUSSION (APPLICATION AND REFLECTION – 5 min): How was your experience as a bird or a butterfly different this round than from the first round? What key environmental factor changed? (Spring came earlier – butterflies metamorphosed earlier, but bird migration stayed the same). What does this mean for plants and animals in real life?
The timing of when things appear – phenophases – can mean life and death for animals. If it shifts because of climate change, then that can have serious impacts on life. Throughout our time together, we're going to explore the phenophases of plants, record our observations, and contribute to a growing database that can help us understand the impacts of climate change.

Overview of Spring Schedule and Syllabus

Discuss upcoming spring schedule and answer questions (10 min)

Connecting with Plant Science: Backyard Phenology

Lesson 2: Basic Plant Anatomy and Plant Lab

Materials:

- Laptop/projector
- Plant samples
- Data sheets and phenophase definitions
- Printed Nature's Notebook plant descriptions
- Photos of original plants used as samples
- Plant anatomy powerpoint
- Beech Bud Leaf Opening Youtube Video
- Plant anatomy and phenophase matching game worksheets
- 30 hand lenses (optional for this lesson)
- Journal example

Theme:

Becoming familiar with plant anatomy can help us be better observers of phenology in the field.

Questions:

What plant parts are important to observe?
How does studying plant anatomy help us be better scientists?
What tools can we use to quantify our observations?

Goals:

Students will observe and take phenological data.
Students can identify plant parts.
Students understand why it's important for our study to be familiar with plants.

Objectives:

Students will draw and label plant diagrams.
Students will use Nature's Notebook plant definitions to take data.
Students will make observations and use data sheets.
Students can use a hand lens.
Students can define phenology.

Plant Lab Materials Preparation

Material prep is important to this lesson. Plan ahead to gather your teaching materials.
Collect specimens of the various species you plan to study. Take cuttings that include as many parts of the plant possible (eg. Leaves, flowers, buds, etc.). Place the cuttings in containers with water and transport to the classroom or location where the plant lab will take place. Collect enough specimens that students can split up into pairs and rotate through the various species of interest and collect data using the provided datasheets.

Overview of Spring Schedule and Syllabus

Discuss upcoming spring schedule and answer questions (10 min).

Introduction to Plants: Anatomy and Phenophases

(INVITATION – 5 min): Today we're going to get ourselves familiar with plants, and get some practice taking data before we go out and take data in the field. This class will:

- Go more in depth with plant anatomy
- Help you understand what phenophases are
- And put what we learn into practice in a plant lab

This class is going to help you get a better idea of what to look for when you go out and do the real thing in a couple weeks.

(EXPLORATION – 20 min): *This section requires the use of provided materials in the appendix.*
Remember, phenology is the study of when things appear in nature. It is important to understand when various phases of a plant's life cycle appear to be able to collect phenological data. Let's review the flowering plant life cycle (*show the plant life cycle illustration on pg 31 and go over each stage*).
We also need to understand basic plant anatomy in order to make informed decisions about what parts of a plant we are observing. *Go over the reproductive parts of a flower and various leaf structures. There are simple diagrams provided on pages 32-33. Have students follow along using the Plant Lab: Anatomy worksheet on pg 37.*
Let's watch a youtube time lapse video of beech bud leaves opening. This is a fascinating demonstration of the transition from the phenophase 'breaking leaf bud' to the phenophase 'leaves'. (*Search for beech bud leaves opening on youtube before the lesson begins*).
Here is an example of all of the phenophases of a California Buckeye. What phenophases do you think we will observe during our study? *Show the various pictures on page 34 using a powerpoint.*
Before we start the lab, we want you to test your knowledge of various phenophases. *Pass out*

the Phenophase Matching Game located on page 38. Draw a line to match the phenophases on the left with the correct picture on the right.

Plant Lab

Before class set up a station for each plant sample. The station should include the plant sample, its Nature's Notebook description sheet, and printed photos of the entire plant at its real life location.

TRANSITION (CONCEPT INVENTION – 5 min): The illustrations you've made can be taken into the field to help identify what life stage your plant is in. *If accessible, use an actual field journal as an example to demonstrate how their illustrations could be used in the future.* You'll have the opportunity to witness these stages with at least one plant each week until mid-May. By revisiting your plant, you'll become familiar with these life stages you've studied up close and personal! After you make your observations, you will enter them into the national database that we've mentioned before. From there, we can take a look at the phenology of your species of plant nationwide and look at any long term changes. Before we learn how to enter your observations, though, we want you first to be familiar with what sort of things you might see and practice observing with some plant specimens.

(CONCEPT INVENTION – 10 min): *Pass out packets of phenophase cycle definitions.* You will be observing your plants in each of these phenophases. Take a moment and read through them so you are familiar with what data you'll be looking for. *Take 5 minutes for them to read through the definitions.*

We have a plant lab set up for you. The plant lab will allow for you to hone in your knowledge of plant anatomy and get a feel for how to take data in the field. There are six different stations, each station has a different plant. Your job is to visit every station and record the data on your data sheets. We'll go through the data you need to collect together. *Pass out data sheets*. When we go out into the field, you will record these electronically, so these sheets are just to help you get a feel for what data to collect. We will learn how to use the electronic version next week.

For now, look at your data sheet. Starting on the left-hand column, you'll see funny italicized words first – that's the plant's Latin name. The plant's common name is on the right. Beneath the name will be a list of different plant life stages, with a y/n/?/blank next to those. You'll look at each plant and determine if you can observe that phenophase occurring. If it is happening, you'll mark y, if it isn't happening mark n, and if you're not sure mark ?. For the blank space, you'll either do a count or a percent. For these, consult the definitions and the photos at each station. Each plant is different, so please read your materials carefully. We will be wandering around to help, but also use your peers to discuss what you think should be the answer. You will be working with a partner to collect data for all the stations. Also remember use your phenophase handouts if you need reminders on the definitions. *Go through an example data*

collection with the students. Answer questions. Split the class into pairs, and assign each pair a different station.

(APPLICATION – 35 min): *Have the students rotate through the stations. Take a clipboard and notetaking materials with you to write down any questions they have that you cannot answer, so that you can get the correct answer to them later.*

DISCUSSION (REFLECTION – 15 min): *Review the data for each plant with the class.*

Connecting with Plant Science: Backyard Phenology

Lesson 3: Using the Nature's Notebook Database

Materials:

- Laptop
- Scientific method vocab words
- Tape or magnets

Theme:

Inputting our observations into a national database will contribute to real scientific data and help us learn more about the plants we are studying.

Questions:

What phenology data collection has there been?
What can scientists use the data for?
How can the data we collect be used to tell us about changes in phenophases?
How can shifting phenophases be evidence for climate change?
How can we display the data to help us understand what's happening?

Goals:

Students will familiarize themselves with the technological devices that they will use to take data.
Students will be logged in to their accounts and be ready for data collection in the field and writing blogs.
Students will understand how they contribute to a database of useable scientific data.

Objectives:

Students will set up their accounts on Nature's Notebook.
Students will set up their accounts on Wordpress.
Students will use the Visualization tool.
Students will practice entering and submitting data.

CA Phenology Project: What the can data show us

(INVITATION – 10 min): *Write on the board before class an empty diagram of the scientific method, with a word back on the side; write the question "How do iconic, widespread species respond to climate change?"* Today we're going to get familiar with the national database that you'll be using to enter all of your phenological observations. You'll be setting up your accounts, and you'll set up the accounts you'll be using for your blog entries. If we have time at the end, we'll show you some tools that are available for you to make graphs of ALL the data ever inputted into this site. But for the first half of class, I want to show you the potential that all your data, and the preexisting data on Nature's Notebook, has for scientific study, and where you fit in to it all.

Now we're going to start off with a bit of review. Up on the board, I have written up a blank diagram of something you might remember: the scientific method. With the person next to you, I'd like you to brainstorm where these words *point to the word bank* fit into the blanks. Together, complete the scientific method. I will be asking one person from your group to write up any one of these words in the diagram, so make sure you're ready to share what your group has come up with. *Take 5 minutes for discussion.*

(EXPLORATION – 15 min): Now we're going to fill this out as a class. I need a volunteer from one group to write up where they think the word "hypothesis" should go. *Pick a new volunteer from each of the groups to fill out the diagram*. *Go over their responses and go over any misconceptions.*

We're going over the scientific method to better understand how phenology was used in a study called the California Phenology Project. Here they started with a question: "How do iconic, widespread species respond to climate change?" What part of the scientific method does this fit into? Yes, this is where they started their study: with a question. *Circle question on the scientific method diagram*. Then scientists moved on to the next step: background research. Next was the hypothesis. What do you think they came up with? Think back to our game with the birds and butterflies. *Take a few ideas.* There are many different possibilities as to how species might respond, but one of the main hypotheses they chose to focus on was: Plants will change their normal patterns to adapt to the new environmental conditions created by climate change. Next they needed data to indicate if the species they chose for the study were altering their normal patterns. They recruited thousands of citizen scientists, like you, trained them on the proper methods of data collection, like we did last week, and used Nature's Notebook to collect the data, like you'll practice today!

The happened at 7 National Parks, involved hundreds of trained citizen scientists collecting twice per week, and went on for 2-3 years. What did they have to do after data collection? *Refer back to the diagram*. They interpreted their findings. In the 2-3 years of data collection, they found that species' phenophases responded less with temperatures, and more with when the highest rainfall occurred.

The California Phenology Project demonstrates the potential use of the data you are collecting. Even though this study has ended, there are many more questions involving phenology that

climate scientists are examining at a broader scale. That's why your data collection is so important – so you can help contribute data to ongoing climate science.

Nature's Notebook & account set-up

TRANSITION (CONCEPT INVENTION – 5 min): The US National Phenology Network (USA-NPN) is the lead organization that coordinates standardized phenology projects among researchers, students, and volunteers. They provide resources that connect partner groups, have educational resources available on their website, manage the standardized phenology data, and publish articles about phenology research taking place nationally. USA-NPN created Nature's Notebook, an online program that allows citizen scientists to enter data into a national database that allows users to catalogue and visualize data.

(APPLICATION – 20-30 min): Each student will be using Nature's Notebook to enter data collected at the designated field sites near their school. To do this, every student needs to create an account that links to our partner group on the site, Sierra Streams Institute. *Use powerpoint slides to walk students through the process of creating an account with Nature's Notebook.*

Next, take a poll to see how many students have smart phones that can be used in the field with the Nature's Notebook app. Have the students download the app to their phones and login (assuming the majority of students have a smartphone).

Show students how they can enter data on both their phones and/or the computer using the data that was collected in the plant lab. To enter data on a phone, students just need to open up their app. To enter data on a computer, login to the nature's notebook account, click on observation deck in the top right corner, scroll down to "Observations", to the lower right you will see a box titled "Enter Observations", beneath the image of the computer, click "Enter Observation Data", begin entering data – skip submit for this exercise – the lab data should not be entered as it is not representative of the entire specimen*. You may also chose to add plants on Nature's Notebook that are labeled LAB, so that students can use those as a throw away entry*.

Blog platform account setup

(15 minutes) Spend some time while your students have computes with them to set up their accounts on the blog platform of your choice. This may take some time if your school has a slow internet connection! Setting this up will be helpful in advance in case students have technical issues. *Sierra Streams Institute has a Wordpress account that we link our newsletter articles to. You may choose to use this for your own blog submissions, or you may use another blog platform – **See more about this in the Projects section**.*

If you use Wordpress, you can watch this video on Youtube to get familiar with setting up accounts and even show it to students.

Data displays: The visualization tool

(CONCEPT INVENTION – 15 min): Nature's Notebook has a tool that allows you to graph the data. Graphs are important so we can observe patterns and trends that can lead to conclusions about our findings. You can use Nature's Notebook's visualization tool to give you more information for your blog posts, and/or presentations.

From Nature's Notebook homepage: at the top on the far right, find MORE WAYS TO CONNECT. The dropdown menu will show VISUALIZATION TOOL, then click on the image that says EXPLORE YOUR DATA. Here, we used a common snowberry as an example for visualizations, because it is a plant that both Sierra Streams and the CA Phenology Project has collected data for.

First, you can see all the data that has been collected for common snowberry in the U.S. *On the lefthand sidebar, choose Filter: enter the years 2010-2016.* Then, using their Calendar tool, you can see what was happening with the common snowberry's phenophases for up to two years. To make things simple, let's just look at a phenophase we observed for the snowberry in our lab. *In the graph, choose the years 2014/2015 and display breaking leaf buds.* You can also graph phenophases against other variables, like precipitation, minimum/maximum temperatures per season, and so on, using the Scatter Plot tool. *In the graph, choose breaking leaf buds and accumulated precipitation as an example.*

Next, you can display the data for the snowberry, other whatever plants you choose, that only Sierra Streams Institute has collected. *In the Filter, add Sierra Streams Institute from the Partners menu. Make a Calendar graph.* As you can see, there isn't much going on for us in terms of long term, consistent data.

For that, we can add the CA Phenology Project to observe more state-specific trends with snowberry phenology. *In the Filter, add CA Phenology Project from the Partners menu. Make Calendar and Scatter Plot graphs.* Having this much data taken for a whole year is what you will be helping SSI and climate scientists with for the spring.

Practice data entry

(APPLICATION – 20 min): Next we'll be entering the data that you all took during the plant lab as our first entry! If you finish this part early, then feel free to go back to the visualization tools and explore the possibilities of the different graphs.

(REFLECTION – 5 min): *Time for questions and survey students who had technical issues.*

Connecting with Plant Science: Backyard Phenology

Appendices

Table of Contents

SAMPLE SYLLABUS

2/9/16 12:53 -2:12, 2:16 – 3:35
Introduction to climate change: What is climate change? How can we measure climate change? How do we know it's really happening?
Introduction to phenology

a. What is phenology – why use it? (Importance in measuring climate change)
c. Birds and butterflies game

2/16/16 and 2/18/16 10:23 – 12:23
Plant lab

a. Basic plant anatomy through drawing and labeling
b. Students will practice skills needed in the field to take accurate data

2/22/16 9:00 -10:19, 10:23 – 11:42
Technology introduction

a. Case Study: CA Phenology Project (NPS)

What will we be doing with our data?

b. Introduce Nature's Notebook
c. Tutorial – Run through Nature's Notebook as a powerful tool for cataloguing data
d. Make predictions as to what we expect our findings to be

Introduce Blog Assignment (DUE: _____)

2/25/16 All day
Field trip – Collect data at
Introduce Field Guide Assignment (DUE: _____)

3/1/16 12:53 – 3:35
Data collection
3/15/16 12:53 – 3:35
Data collection
3/31/16 All day
Field trip to– Collect data at

4/5/16 12:53 – 3:35
Data collection

4/19/16 12:53 – 3:35
Data collection

4/21/16 All day
Field trip to – Collect data at

5/3/16 9:00 10:19, 10:23 – 11:42 (tech ed)
Class time to work on presentation

5/12/16 9:00 10:19, 10:23 – 11:42 (tech ed)
Presentations

Connecting with Plant Science: Backyard Phenology

Blog Assignment: Topics and Rubric

Assignment:

You are responsible for writing one blog post that will be submitted for review, then posted on Sierra Streams Institute's news site. Your assignment must:

- Be at least 300 words in length
- Include a minimum of 2 scientific sources (peer reviewed publications, scientific articles, relevant published magazines, etc.)
- Address one of the topics below, or a related topic of your choice cleared by your teacher

To enter and submit your assignment, use your account information to log in to WordPress on http://sierrastreamsinstitute.org/news/wp-login.php.

Double spaced draft due to Josh due Wednesday April 6th.

Final drafts will be submitted for review no later than Wednesday May 4th.

Topics:

- Climate change interactions with phenology – Summer Thyme, Leif, Reed
- Current phenological studies – Tiger Lilie, Kylie, Alissa
- Citizen science research – what is it, what are the benefits? – Angie, Kyle, Izze
- Real-world case studies involving citizen science or phenology - Jude
- The natural history of one or more plants we are using to observe phenophases – Maddie, Rhianna
- Species interactions involving phenology – Isobel,
- A journal entry describing your observation experience – Sophia, Ohmala

Rubric:

Blogs will be graded using the following criteria by your teachers:

1.	Organization/flow of ideas	6 points
2.	Spelling and grammar	6 points
3.	Stays on topic	6 points
4.	Uses 2 scientific sources	6 points
5.	Blog is at least 300 words	3 points
6.	Submitted on time	3 points
	TOTAL POINTS	_____ / 30

Phenology Field Guide and Presentation Assignment

Plant Species

Work in groups to create plant profiles on the species we have studied at Forest Charter.

Species	Student Groups
American Sycamore	Reed, Isobel, Kylie, Leif
Tulip Poplar	Ohmala, Angie, Jude
Black Walnut	Maddie, Kyle, Rhianna, Alissa
Black Locust	Izze, Tiger, Sophia, Summer

Assigning Profile Pages for Field Guide

Each group will make 3 pages for the field guide and final presentations about their species. The content for each of the three pages are outlined below:

1. Data
    a. Data collected with Sierra Streams on Nature's Notebook
    b. Compare to national data set on Nature's Notebook
    c. Create a graph using the Visualization Tool
2. Life History
    a. Is the plant invasive or native?
    b. Describe the habitat type where you would find the plant (riparian, upland, mixed conifer, etc.)
    c. Include a distribution map of where the plant is located in the US.
3. Phenophases
    a. Find pictures and descriptions of each stage of the assigned plant
    b. What phenophases were observed during the study?

Other Items to Include in the Field Guide

Each group will also create one of the following items for the field guide:

Item	Student Groups
Cover	Izze, Tiger, Sophia, Summer
Page including a description of the: 1. Overview of the phenology project/what we did 2. Forest Charter 3. Sierra Streams Institute	Reed, Isobel, Kylie, Leif
Map of the plants in the study at Forest Charter	Ohmala, Angie, Jude
Page including: 1. Student contributors to Field Guide (everyone in your class) 2. Reference information about National Phenology Network and Nature's Notebook	Maddie, Kyle, Rhianna, Alissa

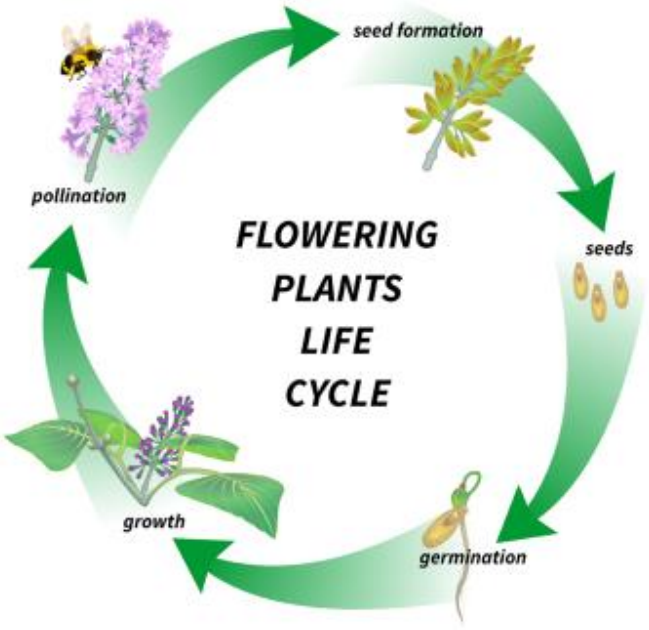
Templates

Sierra Streams will provide templates for each of the three profile pages (data, life history, and phenophases) in Google slides.

Plant Lab Powerpoint

Phenology Lab

- Flowering Plant Life Cycle
- Flower Anatomy
- Leaf Anatomy
- Phenophases



Flower Basics

1. Label the parts of the flower.

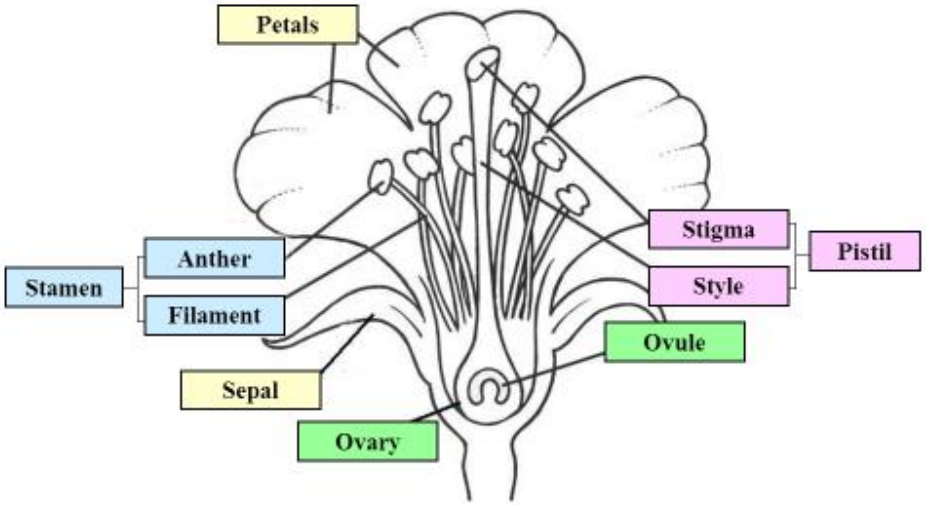
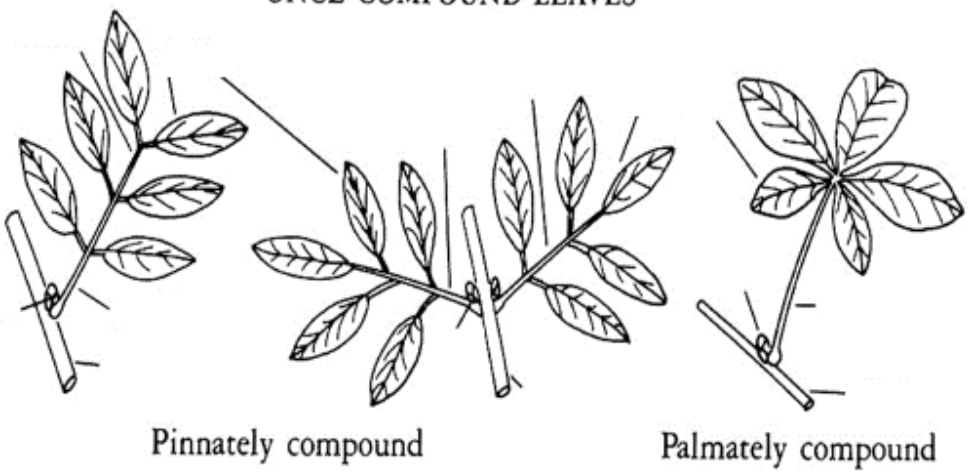
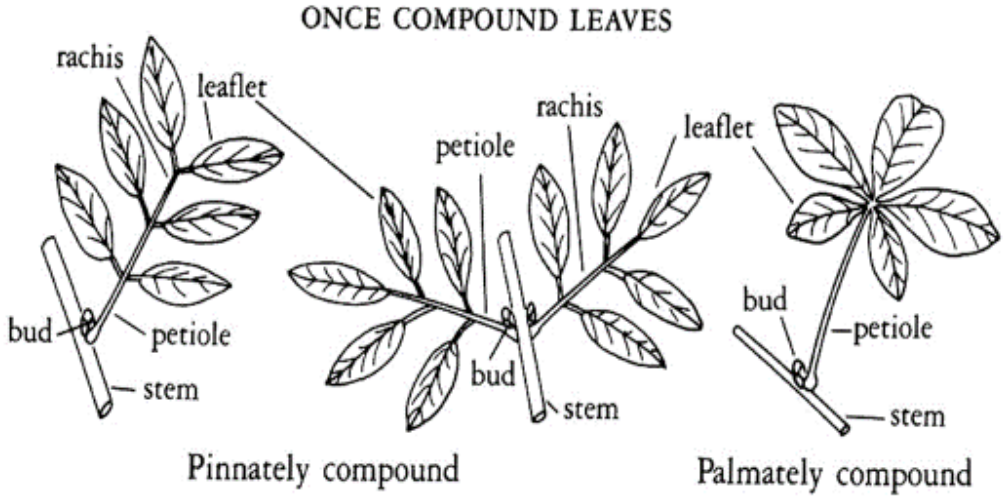


Image: http://www.smithlifescience.com/SciFlowerDiagramBlank.jpg





Beech buds and leaves opening time lapse

Breaking leaf buds

Leaves

Increasing leaf size

Colored leaves

Flowers or flower buds

Open flowers

Fruits

Ripe fruits

California Phenology Project:
species profile for
California Buckeye
(*Aesculus californica*)

USA npn National Phenology Network
UCSB

Breaking leaf buds
A leaf bud is considered "breaking" once a green leaf tip is visible at the tip of the bud, but before the first leaf from the bud has unfolded to expose the leaf stalk or base. ***Can you see the leaf tips emerging from the bud in this picture?***

Leaves
Can you see the base of the leaflets? New leaflets may need to be bent backwards to see whether the petiole is visible.

Increasing leaf size

Colored leaves

Flowers or flower buds
When monitoring ***flower or flower bud abundance*** *for this species, count each inflorescence as a single flowering structure! For example, if there are two inflorescences with many flowers or buds each, then abundance should be recorded as =2.*

Open flowers
Do you see the pollen-producing anthers protruding from the flowers? ***Proportion of open flowers*** *should be recorded at the scale of individual flowers, not inflorescences (i.e. estimate the proportion of individual flowers that are open.)*

Note: *flower phenophases are nested; if you record* ***Y*** *for "open flowers" you should also record* ***Y*** *for "flowers or flower buds"*

Fruits
The fruit is a large, leathery capsule that changes from green to tan or grayish-tan and splits open to release a large seed when ripe.

Ripe fruits
A fruit is considered ripe when it splits open.
Note: *fruit phenophases are nested; if you record* ***Y*** *for "ripe fruits" you should also record* ***Y*** *to "fruits"*

Phenophases not pictured: ***Falling leaves, recent fruit or seed drop***

California Phenology Project:
species profile for
Greenleaf Manzanita
(*Arctostaphylos patula*)

USA npn National Phenology Network
UCSB

Breaking leaf buds
Leaf buds originate at the nodes of existing leaves, in the leaf "axils".
Note: *The photo shows leaf buds right before they have broken to reveal the tips of young leaves.*

Young leaves
Young leaves tend to be thinner and brighter than mature leaves.

Flowers or flower buds
When monitoring ***flower or flower bud abundance*** *for this species, count each inflorescence as a single flowering structure! For example, if there are two inflorescences with many flowers or buds each, then abundance should be recorded as =2. Note: there are no flower buds in the photo.*

Open flowers
Each flower has both male and female parts contained within the urn-shaped floral tube; this makes it difficult to see both the anthers and the stigma. ***Proportion of open flowers*** *should be recorded at the scale of individual flowers, not inflorescences (i.e. estimate the proportion of individual flowers that are open.)*
Note: *flower phenophases are nested; if you record* ***Y*** *for "open flowers" you should also record* ***Y*** *for "flowers or flower buds"*

Fruits
The fruit is berry-like and changes from green to red, reddish-brown or purplish-brown; it then drops from the plant when ripe.

Ripe fruits
The fruit is considered ripe when it is red, reddish-brown or purplish-brown.
Note: *fruit phenophases are nested; if you record* ***Y*** *for "ripe fruits" you should also record* ***Y*** *for "fruits"*

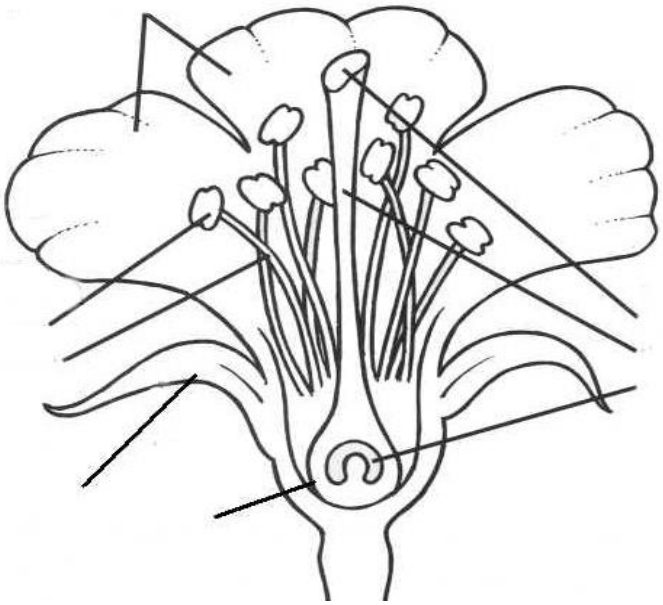
Important note regarding sequence of ARPA phenophases: *The phenological progression of ARPA can be confusing as its phenophases do not appear in the sequence presented on USA-NPN datasheets. Observers should look for the following progression: Inflorescence structures (i.e. buds) begin to develop early in the growing season and are mostly, if not exclusively, terminal; the buds on these inflorescences do not open into flowers until the following spring (flower buds form one year prior to maturity). Flowering of last year's inflorescence begins after the flower buds for next year have developed. Following flowering, leaf buds break. Following leaf bud break, fruits set and ripen. Leaves are often fully developed before the fruits become ripe.*

Phenophases not pictured: ***Recent fruit or seed drop***

Plant Lab: Anatomy

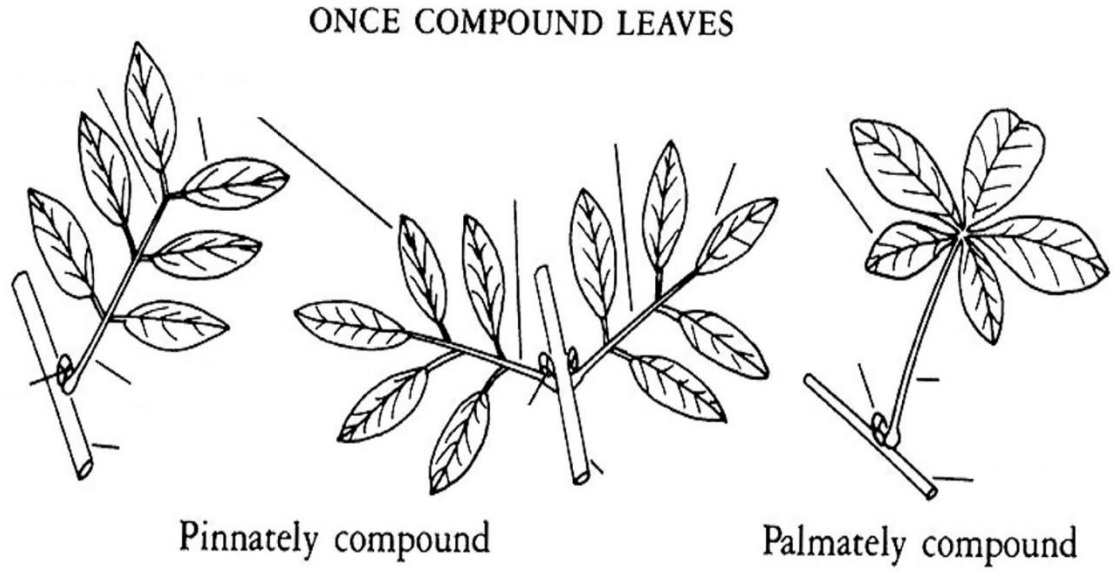
Flower Basics

1. Label the parts of the flower



Leaf Basics

2. Label the parts of a leaf



Plant Lab: Phenophase Matching Game

Directions: Draw a line to match the phenophase vocabulary words below with the correct picture.

Breaking leaf buds

Open flowers

Increasing leaf size

Ripe fruits

Fruits

Flowers or flower buds

Sample Data Sheet

					Snow on ground?	y	n		_____%
					Snow on trees?	y	n		
Symphoricarpos albus	**common snowberry**								
Breaking leaf buds	y	n	?	_____	***Cornus sericera***	**redosier dogwood**			
Leaves	y	n	?	_____%	Breaking leaf buds	y	n	?	_____
Increasing leaf size	y	n	?	_____%	Leaves	y	n	?	_____%
Colored leaves	y	n	?	_____%	Increasing leaf size	y	n	?	_____%
Falling leaves	y	n	?		Colored leaves	y	n	?	_____%
Flowers or flower buds	y	n	?	_____	Falling leaves	y	n	?	
Open flowers	y	n	?	_____%	Flowers or flower buds	y	n	?	_____
Fruits	y	n	?	_____	Open flowers	y	n	?	_____%
Ripe fruits	y	n	?	_____%	Pollen release	y	n	?	_____
Recent fruit or seed drop	y	n	?	_____	Fruits	y	n	?	_____
					Ripe fruits	y	n	?	_____%
Populus fremontii	**cottonwood**				Recent fruit or seed drop	y	n	?	_____
Breaking leaf buds	y	n	?	_____					
Leaves	y	n	?	_____%	***Salix lasiolepis***	**arroyo willow**			
Increasing leaf size	y	n	?	_____%	Breaking leaf buds	y	n	?	_____
Colored leaves	y	n	?	_____%	Leaves	y	n	?	_____%
Falling leaves	y	n	?		Increasing leaf size	y	n	?	_____%
Flowers or flower buds	y	n	?	_____	Colored leaves	y	n	?	_____%
Open flowers	y	n	?	_____%	Falling leaves	y	n	?	
Pollen release	y	n	?	_____	Flowers or flower buds	y	n	?	_____
Fruits	y	n	?	_____	Open flowers	y	n	?	_____%
Ripe fruits	y	n	?	_____%	Pollen release	y	n	?	_____
Recent fruit or seed drop	y	n	?	_____	Fruits	y	n	?	_____
					Ripe fruits	y	n	?	_____%
Alnus rhombifolia	**white alder**				Recent fruit or seed drop	y	n	?	_____
Breaking leaf buds	y	n	?	_____					
Leaves	y	n	?	_____%	***Cornus nuttallii***	**pacific dogwood**			
Increasing leaf size	y	n	?	_____%	Breaking leaf buds	y	n	?	_____
Colored leaves	y	n	?	_____%	Leaves	y	n	?	_____%
Falling leaves	y	n	?		Increasing leaf size	y	n	?	_____%
Flowers or flower buds	y	n	?	_____	Colored leaves	y	n	?	_____%
Open flowers	y	n	?	_____%	Falling leaves	y	n	?	
Fruits	y	n	?	_____	Flowers or flower buds	y	n	?	_____
Ripe fruits	y	n	?	_____%	Open flowers	y	n	?	_____%
Recent fruit or seed drop	y	n	?	_____	Fruits	y	n	?	_____
					Ripe fruits	y	n	?	_____%
					Recent fruit or seed drop	y	n	?	_____