

The California Phenology Project: Using phenology to detect plant responses to climate change

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www.usanpn.org/cpp



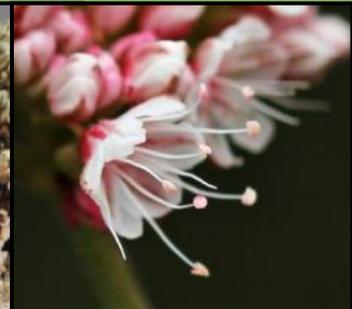
OUTLINE

- What is phenology? How is phenology related to climate and climate change?
 - Case studies
- California Phenology Project (CPP)
- USA National Phenology Network (USA-NPN)
- How to get involved with the USA-NPN and the CPP
 - At John Muir National Historic Site (JOMU)
 - On your own



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Phenology is the science of the seasons



Spring wildflowers



Foliage color change



Migration patterns

Phenology is the study of recurring plant and animal life cycle stages (***phenophases***)

Phenology is the science of the seasons



Spring wildflowers



Foliage color change



Migration patterns

Other examples?



Phenology: economic importance



Wildfires



Festivals



Flu season



Pests & Diseases



Ecotourism



Allergies



Invasions

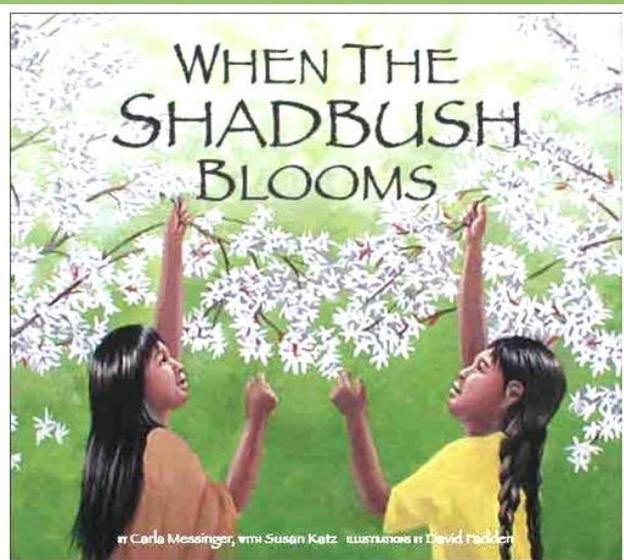
Timing and abundance are important



Agriculture

Phenological indicators used by fisherman:
plant phenophases can predict the best time to hunt

Fisherman on the east coast of Canada would not fish for shad (*Alosa sapidissima*) until after the shadbush (*Amelanchier* spp.) flowered.



Phenological indicators used by hunters:
plant phenophases can predict the best time to hunt

Okanagan indians used blooming of mock-orange
(*Philadelphus lewisii*) as an indicator that marmots
were fat and ready to hunt.



Gavin Davies

Turner et al., 1980. Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington. Occ. Pap. Brit. Col. Prov. Mus. No. 21., Ministry of Provincial Secretary and Government Services Provincial Secretary, Victoria, B.C.

Phenological indicators used by indigenous people: plant phenophases can predict harvest times of animals

The Nuu-Chah-Nulth tribe of Vancouver Island used the ripening of salmonberries (*Rubus spectabilis*) to predict the return of adult sockeye salmon (*Oncorhynchus keta*) to freshwater.



Bouchard & Kennedy, 1990. Clayoquot Sound Indian Land Use. Report prepared for MacMillan Bloedel Ltd.
Peacock, S. L. 1992 Piikani Ethnobotany: Traditional Plant Knowledge of the Piikani Peoples of the Northwest Plains. MS thesis, University of Calgary.

Phenological indicators used by indigenous people: plant phenophases can predict harvest times of animals

The Blackfoot tribe of s. Alberta and Canada used the flowering of the buffalo bean (*Thermopsis rhombifolia*) to indicate that bison males (*Bison bison*) had eaten enough spring browse to be ready to hunt (their meat was sufficiently marbled with fat).



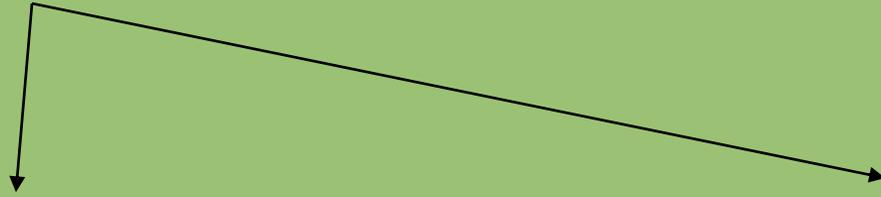
Phenological Indicators used by indigenous people: plant phenophases at one location can predict harvest times for plants at another location

The Tubatulabal tribe of Kern County (CA) used the ripening of coffeeberry fruits (*Rhamnus californica*) at low elevations to indicate that pinyon pine (*Pinus monophylla*) seeds in the mountains were ready to harvest.



Phenology: biological importance

Plants & animals are dynamic over the seasons



Vegetative phenology

Reproductive phenology

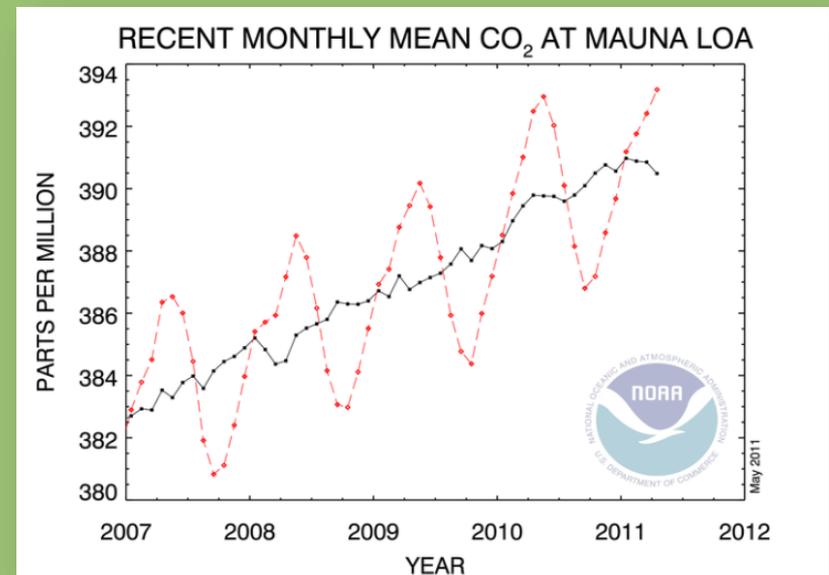


Phenology: biological importance

Plants & animals are dynamic over the seasons

Vegetative phenology:

- Leaves provide energy to the plant for reproduction & growth, food for herbivores, shade and protection for understory animals
- Influences global biogeochemical cycles (e.g., C-cycle)



Phenology: biological importance

Plants & animals are dynamic over the seasons

Reproductive phenology:

- Plant reproduction depends on flowers → fruits
- Many flowers provide nectar & pollen for pollinators
- Many plants provide fruits & seeds for animals



Phenological patterns are important, economically and biologically

... and sensitive to climate

... and sensitive to climate change.

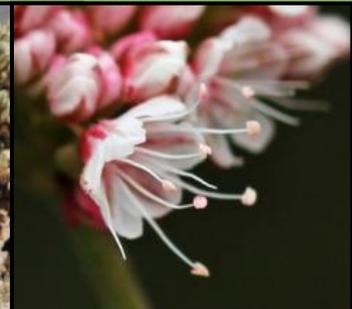
“Phenology...is perhaps the simplest process in which to track changes in the ecology of species in response to climate change.” (IPCC 2007)

“Because of their close connection with climate, the timing of phenological events can be accurate indicators of climate change.” (EPA 2010)



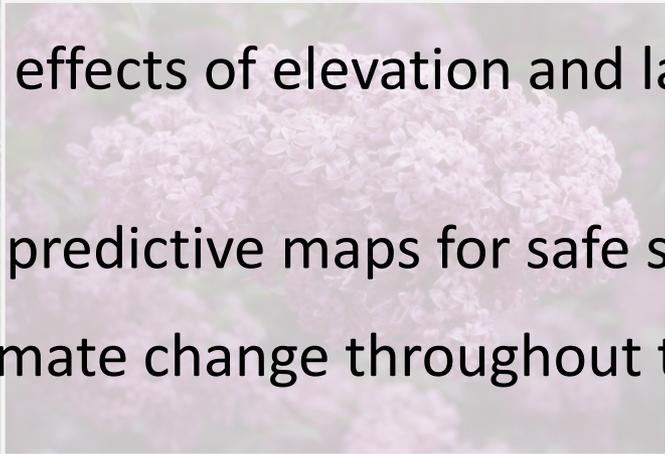
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Cloned Lilac Monitoring Nationwide

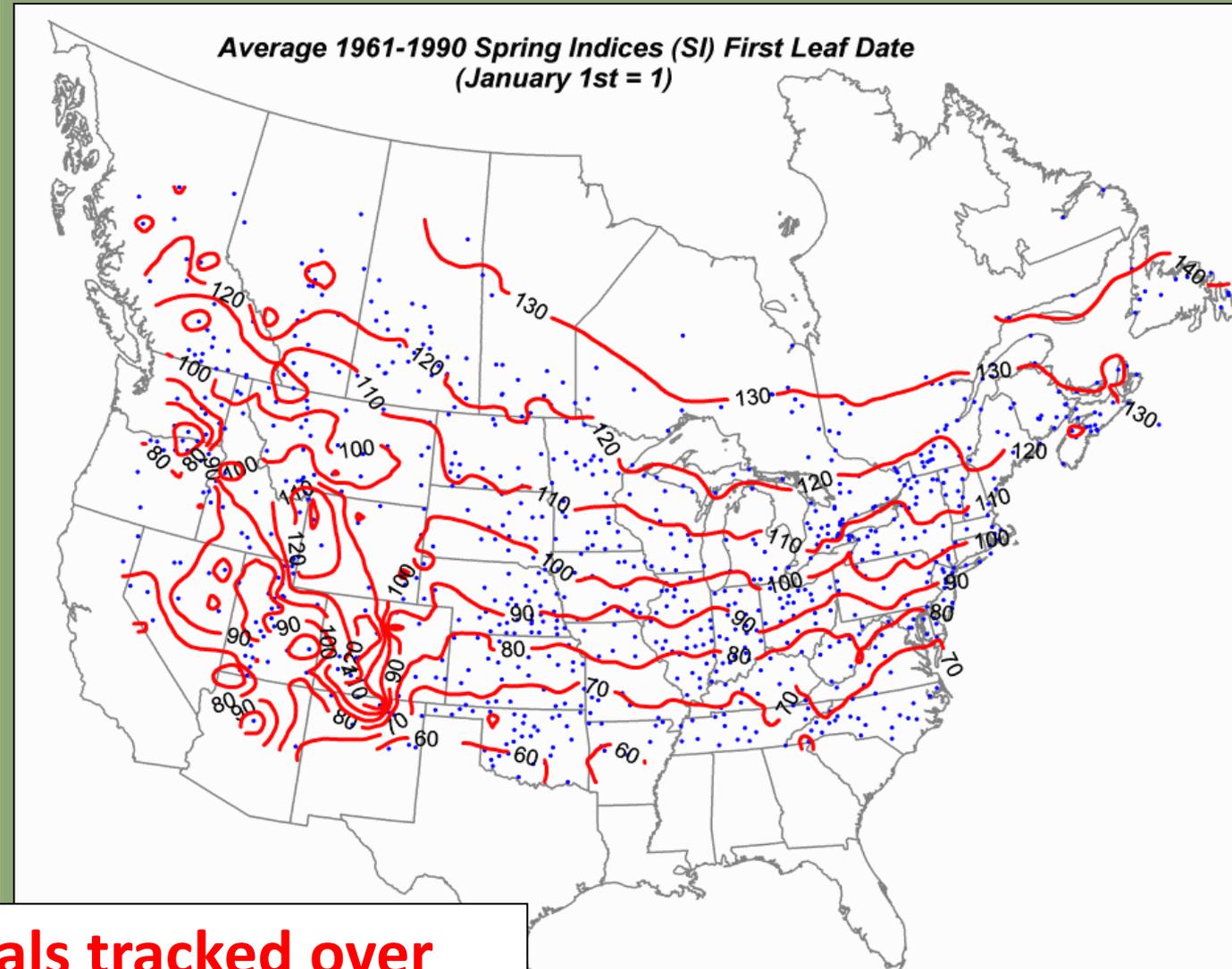
- The first phenological monitoring effort in the U.S.
- 1950's - 1990's: ~3500 private citizens monitored lilac plants in backyards and gardens
- Each year, they sent postcards reporting the date of first bloom to Professor Joe Caprio at Montana State Univ.
- First bloom dates of these lilacs have been used:
 - To show the effects of elevation and latitude on the onset of spring
 - To generate predictive maps for safe sowing dates
 - To assess climate change throughout the U.S.



Cloned Lilac Leaf Phenophases

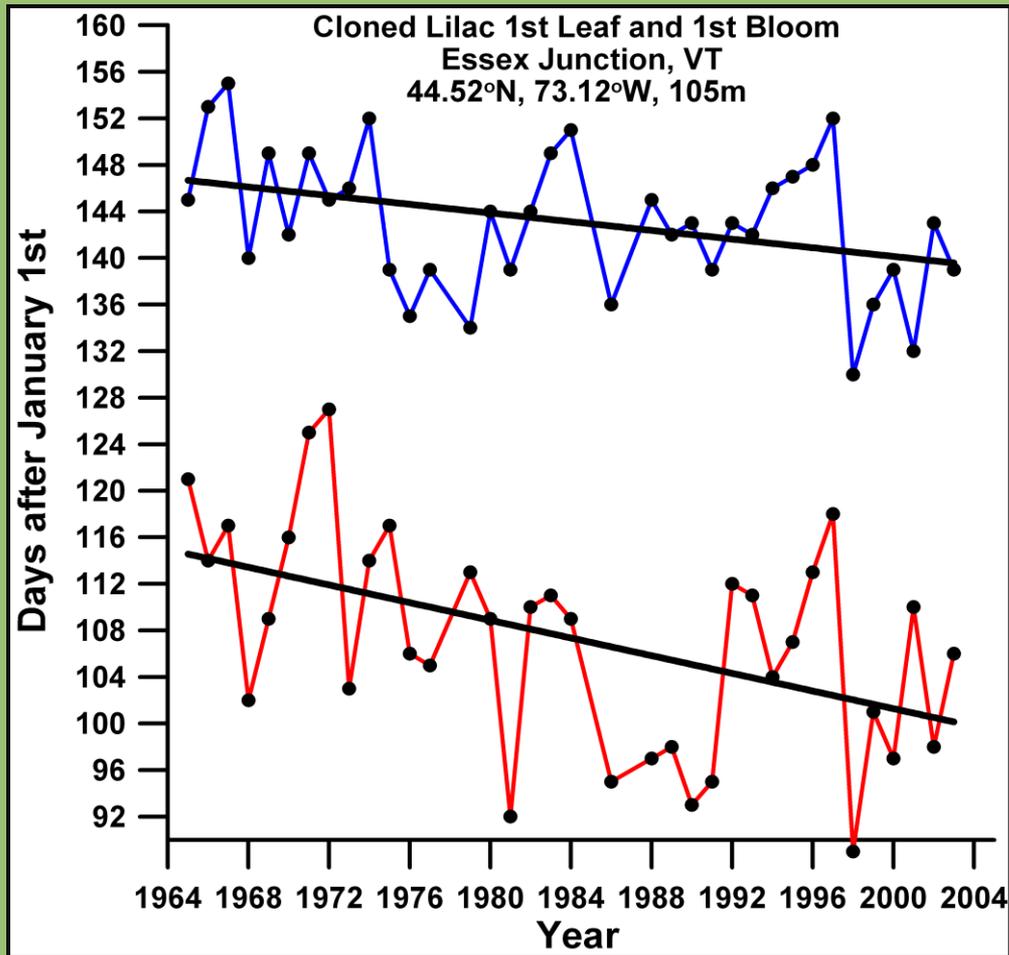


Cloned Lilac Monitoring Nationwide



Many individuals tracked over time... what about one individual?

Phenology is an indicator of environmental change



Phenology for one Lilac individual

Date of first flower

Date of first leaf

Phenological events in this lilac have advanced as the climate has warmed

“Phenological mismatches” may cause population crashes



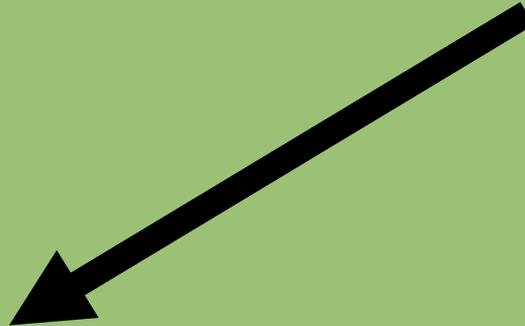
Leafing out earlier

English oak



Emerging earlier

Winter moth

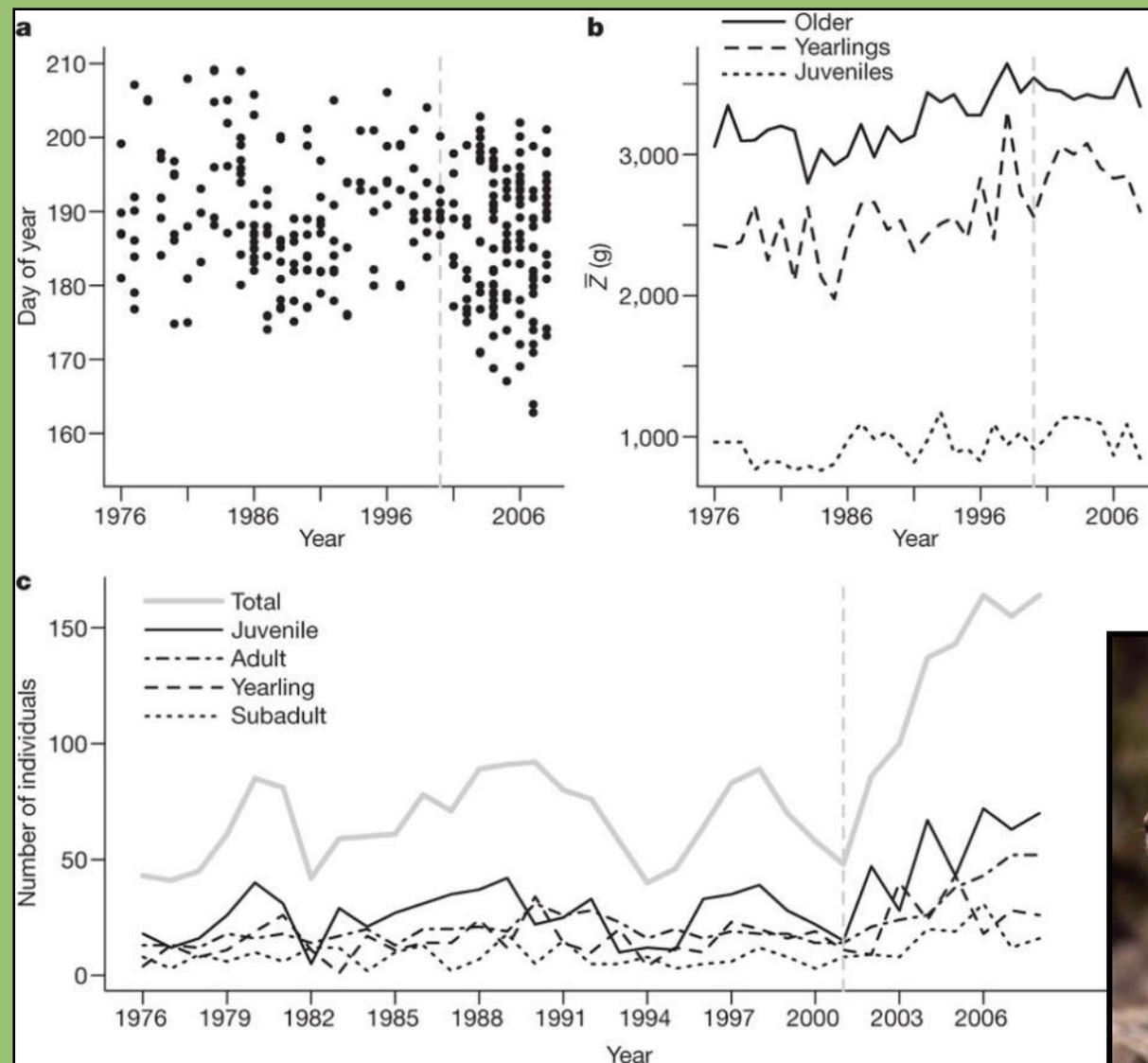


Pied flycatcher

Migrating the same time each year

Bird populations have declined by 90% where food for nestlings is peaking earlier in the season and the birds' arrival and breeding events are now mistimed.

Shifts in phenology result in changes in body mass and population dynamics



(a) time of weaning
(b) mean mass on August 1st
(c) total abundance at each age class



*Can you think of other **ecological** consequences of changes in plant phenology as a result of climate change?*

*Can you think of a few potential **economic** consequences of changes in plant phenology as a result of climate change?*

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California Phenology Project



California Phenology Project: Goals

establish a coordinated phenological monitoring network



monitor across a large geographic area and along key environmental gradients



- 1) address important scientific questions,***
- 2) guide resource management decisions, &***
- 3) engage Citizen Scientists in phenological monitoring***
- 4) educate the public about phenology & climate change research***

CPP in the National Parks



California Phenology Project

- identify key scientific questions
- facilitate selection of focal species for three bioregions (desert, coastal, mountains)
- identify historical datasets
- develop phenophase descriptions appropriate for California plant taxa
- develop and refine monitoring protocols, infrastructure, and tools in pilot parks
- engage Citizen Scientists in phenological monitoring



Monitoring by Citizen Scientists

1. Visit and monitor labeled and mapped plants: each plant is visited frequently when it is phenologically active
(e.g., CPP plants in National Parks)
2. Visit and monitor labeled (unmapped) plants whenever it's convenient
(e.g., plants in a schoolyard)
3. Visit and monitor unlabeled plants whose location you're familiar with
(e.g., the big tree at the corner)
4. Visit and monitor unlabeled plants one time, or opportunistically
(e.g., plants you encounter while hiking the Pacific Crest Trail)

CPP: outreach and education



CPP: outreach and education



CPP: outreach and education

National Phenology Network Data Sheet Site One

School Name:

Date:

Weather:

Plant ID Tag	New Leaves	Leaves	Fresh flowers	Open Flowers	Pollen	Fresh Seeds	Ripe Seeds	Recent Seed Dispersal
BAPI 3	N Y		N Y _____	N Y _____				
BAPI 2	N Y		N Y _____	N Y _____				
HELA 4	N Y	N Y	N Y _____	N Y _____				
BAPI 1	N Y		N Y _____	N Y _____				
HELA 5	N Y	N Y	N Y _____	N Y _____				
HELA 6	N Y	N Y	N Y _____	N Y _____				



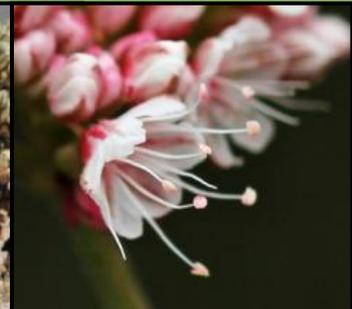
California Phenology Project

www.usanpn.org/cpp

- Tools for monitoring: maps, monitoring guides, species profiles, and more
- A wide array of phenological education materials for formal and informal settings
- CPP documentation: scientific questions, species-selection process, and more
- Powerpoint presentations
- CPP *DRAFT* Interpretive Guide
- ***Instructions for joining the CPP listserv***

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What is the USA-NPN?

A collaborative monitoring network that brings together citizen scientists, government agencies, non-profit groups, educators, and students of all ages to monitor the impacts of climate change on plants and animals in the U.S.



USA-NPN monitoring sites



nature's notebook

a project of the USA-NPN



www.usanpn.org

- 300+ plant species
- 160+ animal species
- Core protocols

1 
Search plants & animals

2 
Learn how to observe

3 
Register yourself

4 
Start reporting

Aesculus californica
California Buckeye



USA-NPN datasheets



Aesculus californica California Buckeye

Trees and Shrubs *Deciduous*

Directions: Fill in the date and time in the top rows and circle the appropriate letter in the column below.
y (phenophase is occurring); n (phenophase is not occurring); ? (not certain if the phenophase is occurring).
Do not circle anything if you did not check for the phenophase. In the adjacent blank, write in the appropriate measure of intensity or abundance for this phenophase.



	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see...	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Breaking leaf buds	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Leaves	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Increasing leaf size	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Colored leaves	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Falling leaves	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Flowers or flower buds	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Open flowers	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Ripe fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Recent fruit or seed drop	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Check when data entered online:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments:

USA-NPN datasheets



California Buckeye

(*Aesculus californica*)



Phenophase Definitions

Directions:

As you report on phenophase status (Y, N or ?) on the datasheets, refer to the definitions on this sheet to find out what you should look for, for each phenophase in each species. To report the intensity of the phenophase, choose the best answer to the question below the phenophase, if one is included. Feel free not to report on phenophases or intensity questions that seem too difficult or time-consuming.



	Date:	Date:
Do you see...	Time:	Time:
Breaking leaf buds	y n ? ____	y n ? ____
Leaves	y n ? ____	y n ? ____
Increasing leaf size	y n ? ____	y n ? ____
Colored leaves	y n ? ____	y n ? ____
Falling leaves	y n ? ____	y n ? ____
Flowers or flower buds	y n ? ____	y n ? ____
Open flowers	y n ? ____	y n ? ____
Fruits	y n ? ____	y n ? ____
Ripe fruits	y n ? ____	y n ? ____
Recent fruit or seed drop	y n ? ____	y n ? ____
Check when data entered online:	<input type="checkbox"/>	<input type="checkbox"/>

Leaves

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 stalk (petiole) or leaf base.

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 the breaking bud so that the leaf stalk (petiole) or leaf base is visible at its point of attachment to the stem. Do not include fully dried or dead leaves.

What percentage of the canopy is full with leaves? Ignore dead branches in your estimate.

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

Comments:

CPP species profiles

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



CPP site(s) where this species is monitored: Sequoia National Park; John Muir National Historic Site

What does this species look like?

This deciduous species is a large shrub or tree, up to 12 meters tall. The leaves are palmate (the leaflets emerge from a single point) and made up of 5 to 7 leaflets, each 6 to 17 cm long. Flowers are white to pale rose-colored, with petals 12 to 18 millimeters long. The flowers are clustered in an erect inflorescence with many showy, ill-smelling flowers. Only the flowers at the tip of each inflorescence are fertile and produce fruit. Each fruit contains one large (2 to 5 cm) glossy brown seed.



Photo credit: Martin Jambom (flickr)

When monitoring this species, use the USA-NPN **deciduous trees and shrubs** datasheet.

Species facts!

- The CPP four letter code for this species is **AECA**.
- The bark, leaves, stems, fruit, and seeds of this plant contain toxic glycosidal compounds.
- Native Americans used the ground seeds to poison fish, but the seeds could also be used for food when leached of their poison and mashed.
- Although honeybees are the primary pollinator of buckeye, the nectar and pollen can be toxic to them.



Photo credit: randomtruth (flickr)

Where is this species found?

- This species is endemic to California.
- It is found in dry slopes, canyons, and the edges of streams.
- Found at elevations less than 1700 meters



Photo credit: James Gaither (flickr)

For more information about phenology and the California Phenology Project (CPP), please visit the CPP website (www.usanpn.org/cpp) and the USA-NPN website (www.usanpn.org)

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



Terrie Schweitzer

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?



Eugene Zelenko

Leaves

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



Liz Matthews

Increasing leaf size



Cliff Hutson

Colored leaves



Devra

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 <3.



Dawn Endico

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"



Eugene Zelenko

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.



randomtruth

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 Buckeye phenophases



CPP: focal species

- 30 CPP species with profiles
<http://www.usanpn.org/cpp/meet-the-species>
- >100 USA-NPN plant species occur in CA
http://www.usanpn.org/species_search

The screenshot shows the USA NPN website interface. At the top left is the logo for USA NPN (National Phenology Network) with the tagline "Taking the Pulse of Our Planet". To the right is a "Log In" button. Below the logo is a navigation menu with links for ABOUT, PARTICIPATE, RESOURCES, EDUCATION, RESULTS, and ARCHIVE. A search bar is located to the right of the navigation menu. The main content area is titled "Search Plants & Animals to Observe" and includes a sidebar for "nature's notebook" (A project of the USA-NPN) with links for Overview, Observe Plants & Animals, Rescue Historical Data, Share Existing Data, Join Email List, Partner your Organization, and Learn About Other Efforts. The search filters include: Sort by (Common Name), Name contains (text input), State (All States), Partner (All Partners), Plant type (All Species), Animal group (All Species), and Results to Display (radio buttons for 25, 50, 100, All). There are "search" and "Clear Filters" buttons. Two image galleries are shown: "All Species" and "Focal Species".

USA **npn**
National Phenology Network
Taking the Pulse of our Planet

Log In

ABOUT PARTICIPATE RESOURCES EDUCATION RESULTS ARCHIVE Search Site search

Home » Search Plants & Animals to Observe

Search Plants & Animals to Observe
Search plants and animals to observe

Sort by:
Common Name

Name contains:
[text input]

State:
All States

Partner:
All Partners

Plant type:
All Species

Animal group:
All Species

Results to Display:
 25 50 100 All

search Clear Filters

All Species Focal Species

CPP focal species monitored at John Muir NHS

California Bay– *Umbellularia californica*

California Buckeye– *Aesculus californica*

Blue Oak– *Quercus douglasii*

California Live Oak– *Quercus agrifolia*

California Wild Rose– *Rosa californica*

Common Snowberry– *Symphoricarpos albus*

Coyotebrush– *Baccharis pilularis*



Monitoring by Citizen Scientists

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Benefits of monitoring CPP focal species



- **species-specific monitoring tools**, including species profiles, are available for download on the CPP website;

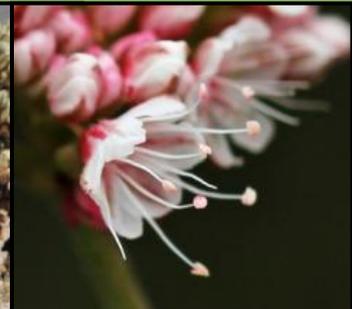
- **new sites complement CPP data** collected at the National Parks and UC Natural Reserves, which collectively contribute to our understanding of how CA taxa respond to environmental & climatic variation; and,

- **benefit from the collective experiences** of the CPP observer network, share your experiences monitoring CPP species, and mentor new CPP observers in your area.



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Get involved at John Muir NHS!

How can you participate?

- If you are a naturalist, participate in monitoring at the park
- If you are an educator, create a phenology garden at your school (*see the CPP education page for guidance*)
- If you are a community organizer, coordinate volunteer monitoring efforts
- If you are an undergraduate student, arrange an internship or directed study project to create interpretive media, signs, blogs, etc.
- If you are a university educator, supervise undergraduate or graduate student research on phenology

Contact info:

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