

# PHENOLOGY GARDENS

*A PRACTICAL GUIDE FOR INTEGRATING PHENOLOGY INTO GARDEN  
PLANNING AND EDUCATION*



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**More phenology education materials and activities are available online**, including interactive hands-on activities and lesson plans for phenology gardens; annotated lectures for universities and the public; guided analytical exercises using a real phenological data set; and seminar modules for undergraduate/graduate students. Visit the following websites to learn more and to download materials:

**The California Phenology Project**  
[www.usanpn.org/cpp/education](http://www.usanpn.org/cpp/education)

**The USA National Phenology Network**  
[www.usanpn.org/education](http://www.usanpn.org/education)

# INTRODUCTION

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For ages human societies have kept careful track of the plants and animals around them to improve their livelihoods. Familiarity with the local seasonal calendar has allowed societies to plan their activities based on the pending availability of food and natural resources, and to plan for the predicted threat of natural hazards. Our modern societies, however, have distanced or insulated ourselves from nature so effectively that many of us have lost the ability to identify even the most common plants and animals, let alone their sequence and timing of appearance each year.

This creates an unfortunate feedback loop, in which each generation is becoming less connected with nature than the previous one. One consequence is that we're raising a generation of citizens that has difficulty evaluating the many environmental challenges facing not only human societies but also the plants and animals on which we rely for our livelihoods, as well as the wildlands that are increasingly threatened by our activities. It's unfair to expect anyone to comprehend and to respond to these challenges when they're unfamiliar with the fundamental life cycles and ecological requirements of plants and animals, particularly of wild species. Given that an informed electorate is key to making legislative decisions that will determine the fate of our natural resources, it's critical to remedy this educational gap by finding ways to re-connect students and their teachers with nature.

The frequency of schoolyard-based nature education activities, as well as classroom field trips to nature preserves and to state or national parks, has drastically declined in the last two decades due to funding constraints, insurance liability, standards-oriented teaching, and the lack of familiarity that many teachers have with even their local natural world. Moreover, the field trips that some teachers are actually able to create for their students are typically one-time experiences. While these brief experiences can be powerful, they don't provide students with the opportunity to connect on a continuous basis with the cycles of nature or to hone their observational skills. In a society in which the daily cycles of news and social activity have been compressed to up-to-the-minute status updates, and where screens have become surrogates for immersive experiences, learning how to observe and record the pace of nature are novel and challenging skills that can bring a suite of gratifying rewards.

JUST AS OUR OWN PULSE AND BLOOD PRESSURE ARE INDICATORS OF OUR PHYSIOLOGICAL STATUS, THE PULSE OF OUR PLANET – MEASUREABLE IN THE PHENOLOGY, OR SEASONAL TIMING, OF PLANT AND ANIMAL ACTIVITIES – IS AN INDICATOR OF THE STATUS OF OUR CLIMATE SYSTEM AND THE WAYS IN WHICH PLANT AND ANIMAL COMMUNITIES ARE FUNCTIONING.

THE PACE OF NATURE, IT TURNS OUT, IS A KEY TO UNDERSTANDING ONE OF THE MOST IMPORTANT ENVIRONMENTAL CHALLENGES FACING OUR PLANET... AS OUR CLIMATE SYSTEM HAS CHANGED, SO TOO HAS ITS PULSE.

We can begin to remedy the obstacles to immersive experiences with nature by bringing wild plants back into our daily existence. By installing native plant gardens at our schools and in our communities, we can provide the opportunity for nature to return from exile. Perhaps most importantly, we can create the opportunity for each of us to connect with the progression of natural cycles among wild species. At schools and environmental education centers – where native plant gardens can support standards-aligned educational goals across all grade levels – students and their teachers can give themselves access to wild plants and (re)discover the pace of nature.

The pace of nature, it turns out, is a key to understanding one of the most important environmental challenges facing our planet. Just as our pulse and blood pressure are indicators of our physiological status, the pulse of our planet – measureable in the phenology, or seasonal timing, of plant and animal activities – is an indicator of the status of our climate system and the ways in which plant and animal communities are functioning.

As our climate system has changed, so too has its pulse – in recent decades the onset of spring is arriving earlier and the onset of winter is arriving later. Essentially, winter is becoming warmer and shorter. Plants and animals are responding by shifting the timing of their seasonal activities such as growth and reproduction to track the seasons – for example, plants tend to be leafing-out and flowering earlier in the spring, and birds tend to be migrating earlier in the spring. While at first it might seem as if nature is “finding a way”, it also turns out that the observed shifts in phenology vary wildly among species – so much so that some animals are imperiled because their timing is shifting so differently than that of their food source. Some plant species, too, are flowering so early in the spring that when the inevitable late-spring frost arrives, they all die – affecting not only the plants but also the pollinators that depend on them, *as well as* the animals that rely upon the fruits and seeds which normally develop from those plants that were pollinated by those pollinators!

Responses of plants and animals to climate change have been documented by scientists around the world for several decades now, and it can be verified independently in a wide variety of historical records including journals dating back to Thoreau, historical photos and satellite images, and even collections of preserved plants dating back to the early 1800’s. What we know from all of these records is that the



pulse of our planet is changing and that there are documented consequences for wild plants and animals as well as for our cultivated food supply. This much is unequivocal, but how the changing pace of biological activities is affecting other natural resources and natural hazards in our local communities and habitats is uncertain. We need more observations, in more places across the county, and over a long period of time. To achieve this goal, the USA National Phenology Network was established in 2005.

In the United States, thousands of people have begun monitoring the phenology of plants and animals around them in order to contribute to a nationwide scientific effort to study climate change. The organization coordinating this effort – the USA National Phenology Network – encourages professional scientists, citizen scientists, and students and their teachers to observe phenological events such as flowering and fruiting of plants, migrations and egg-laying of birds, and emergence of insects. The USA-NPN provides clear instructions and easy protocols, as well as a place for people to enter, store, and share their observations online. Scientists are using these observations to understand the complex links between the climate system and our natural resources, and educators are using the entire framework to engage young scientists and our future electorate in observing the pace of nature and practicing first-hand the scientific process of studying complex systems.

Native plant gardens can be used to contribute to the scientific study of climate change in the U.S. by selecting species and using protocols for monitoring that are shared and supported by with the USA National Phenology Network. The process is quite simple, and we have written this guide to help readers plan and install their own native plant phenology garden that meets these goals while also achieving a number of complementary scientific, educational, ecological, and societal goals they may have. We draw from our experiences in California planning, establishing, and using phenology gardens to provide examples for others to follow and replicate (and improve upon!) in other areas. Contact the USA National Phenology Network for additional guidance in linking phenology gardens with the nationwide effort to study climate change and its effects on plants and animals.





### ***About this guide***

There are many books and guides that describe how to construct all types of gardens for the backyard, front yard, side yard, school yard, and even the prison yard. Most western homeowners are familiar with the *Sunset Western Garden Book* (Oxmoor House, 2007), and two particularly valuable resources for Californians – which may well inspire intelligent garden designs anywhere in the country – are *California Native Plants for the Garden* (Cachuma press, 2005), and *Designing California Native Gardens* (University of California press, 2007).

These are wonderful resources that we do not aim to replace. We do, however, hope to guide gardeners, educators, and professional and citizen scientists through the process of designing and constructing gardens primarily for the purpose of monitoring phenological changes over the seasons and years.

### ***Why native plant phenology gardens?***

The value of phenology gardens extends far beyond their direct scientific contributions to the study of climate change as components of the USA National Phenology Network. It's no secret that the addition of native plants to any landscape greatly enhances its ecological value – not only do native plants help to support native wildlife, they also generally require little to no maintenance and water after establishment. We hope to help you enhance the *phenological value* of your native plant landscape by integrating phenology into the species selection process in order to ensure, for example, a long sequence of blooms of different plant species to support particular pollinators over several seasons. Moreover, by planning a garden in which several plant species are flowering, fruiting, or leafing during each season of the year, it is possible to support a diverse food web while integrating animal phenology and the phenology of plant-animal interactions into monitoring and educational programs.

THE VALUE OF PHENOLOGY  
GARDENS EXTENDS FAR  
BEYOND THEIR DIRECT  
SCIENTIFIC CONTRIBUTIONS.

We also hope to help you promote the *educational value* of your native plant garden by incorporating regular phenological observations into its use. Educational activities exploring the dynamic nature of the garden over the seasons – not to mention activities designed around planning and installing the garden – can be integrated into nearly every component of standards-aligned curricula for each grade level. Observations made in the phenology garden also can be integrated into classroom activities on such diverse topics as ethnobotany; data management and analysis; history; and fine arts. With motivation and creativity, your phenology garden can become as effective a classroom as any indoor environment. We hope these sentiments resonate with educators in the K-12 and college settings, as well as with those in “informal” science education settings (botanic gardens, National Parks, environmental education centers, etc.).

Over the past few years we’ve installed several phenology gardens in southern California with students of all ages, and we’ve designed and tested many activities and educational materials with which to explore them. We encourage you to visit the Education sections of the California Phenology Project website ([www.usanpn.org/cpp/education](http://www.usanpn.org/cpp/education)) and the USA National Phenology Network ([www.usanpn.org/education](http://www.usanpn.org/education)) to download these materials and integrate them into your educational activities.

Finally, establishing phenology gardens creates many opportunities to cultivate a supportive community around the garden. Community-building activities and events can be integrated throughout the life of a phenology garden from planning, to planting, to teaching others how to start and use their own. Throughout this guide you’ll see some of the ways we’ve tried to cultivate a community of practice through the installation and use of phenology gardens.

### ***How do I start a phenology garden?***

The methods described here are appropriate for gardens that are being started from scratch to establish new programs in nature education, or for gardens and programs



WITH MOTIVATION AND CREATIVITY, YOUR PHENOLOGY GARDEN CAN BECOME AS EFFECTIVE A CLASSROOM AS ANY INDOOR ENVIRONMENT. IT PROVIDES MANY OPPORTUNITIES TO LINK STEM SUBJECTS WITH HUMANITIES AND FINE ARTS. THUS, PHENOLOGY GARDENS NOT ONLY PROVIDE AN ACCESSIBLE FRAMEWORK FOR CONTINUED LEARNING AT ANY AGE OR SKILL LEVEL, THEY ALSO CAN FOSTER COMMUNICATION WITHIN COMMUNITIES AND ACROSS GENERATIONS.



that are being augmented to improve their scientific and educational value. By exploring this guide you'll learn how to integrate phenology into many aspects of garden life and activities.

For those who are starting a new phenology garden, initiation can be as simple as digging a hole in the ground, putting a plant in, covering its roots with soil, giving it a little water, and then keeping an eye on how nature take its course. Really, it can be *that* simple!

On the other hand, starting a phenology garden can be as intricate as selecting local genotypes of native plant species that both suit

the qualities of your garden site and are aligned with scientific research efforts to study climate change. In this case, you'll need to dig several holes, plant several individuals per species, fill the holes with soil and mulch, wean the plants off of supplemental irrigation over several weeks, and develop activities and programs in which participants regularly record the plants' phenological status and report their observations to the USA National Phenology Network. Installing environmental sensors and starting a repeat photography project are excellent ideas too.

In both of these scenarios, native plants are installed and, once established and thriving without help, they essentially serve as biological indicators of short-term weather and long-term climatic patterns. While it may take plants 1-3 months (or longer) to become established well enough to grow and reproduce vigorously, phenological monitoring with the USA National Phenology Network can begin right away (when you 'register' your site and your plants with the USA-NPN's online monitoring program *Nature's Notebook*, you can describe the environment of each plant including watering, fertilizing, and sunlight). Even before the plants are well-established, though, opportunities abound to develop multidisciplinary hands-on educational and community-building activities throughout the entire planning and establishment phases of phenology garden projects. By using this guide, we hope that you will come to understand, as we have, that phenology gardens and phenological monitoring projects can provide a common framework for communities to re-connect with nature and with each other.







With San Francisco in the background, a phenologist in the Marin Headlands records her observations of Coyote bush (*Baccharis pilularis*) for the California Phenology Project.

## ESTABLISHING A VISION & MASTER PLAN

Whether the primary goals of a phenology garden are educational, scientific, ecological, and/or cultural, it is helpful to develop a vision of how the garden will be established and used. Consider the entire process from planning to planting to activity development to program implementation – each of these phases will influence the scope of the other phases, and each may be of interest to a different constellation of stakeholders (and funders!). Thus, taking the longview at the onset may help to generate momentum and, with motivation and some luck, lead to the cultivation of a supportive and participatory community.

Unless we're constructing a phenology garden in someone's backyard, administrative approval of some sort is likely to be required before putting shovel to ground. By developing a strong and realistic vision in advance, we're more likely to receive approval and, perhaps most importantly, to develop a strong foundation with colleagues to support our goals. We've suggested one way to manage all of this information in a table at the end of this section (page 13). Consider the following questions as ways of identifying goals and developing a vision for the phenology garden:

## 1. What are your scientific goals?

What types of data do you want to collect in the phenology garden? Will you contribute data to the USA National Phenology Network's on-line database and thereby participate in a nationwide scientific effort to study climate change? Could you purchase inexpensive environmental sensors and deploy them in the garden? Could you integrate other environmental monitoring such as stream chemistry, air quality, or soil chemistry? Are any other environmental organizations or scientists collecting environmental data in the area? Can you collaborate and coordinate with other nearby (or faraway) phenology gardens in order to increase the value and scope of your data?

## 2. What are your educational goals?

For teachers and administrators in a "formal" K-12 setting, do your goals include aligning phenology garden activities with educational standards? How many components of your entire curriculum (within an academic year and among grade-levels) can you integrate with the garden? How frequently do you hope to bring students to the garden for phenological data collection and other activities?

For educators and outreach specialists in an "informal" science education setting (e.g., botanic gardens, National Parks, environmental education centers), who are your students and visitors? Do your goals also include aligning activities with educational standards? How frequently would you like students and visitors to participate? Will they be one-time visitors only, or will some of them return regularly?

For college-level instructors and professors, how many courses in your department's undergraduate catalog could make use of some component of a phenology garden? How many other academic departments could make use of the garden? Could phenological data collected in the garden provide the basis for statistical courses in data collection, data management, data visualization & analysis, final reporting, and grant writing? Biology, Geography, Geology, Education, and Environmental Studies are just some of the departments likely to see immediate value in a phenology garden, but also consider History, Creative Writing, Fine Arts, and Anthropology, among others. Are there students in Education programs who might participate in internships designed to create and run environmental education programs out of the garden?

FROM THE OUTSET, GET INTO THE PRACTICE OF RECORDING OBSERVATIONS – START A PHENOLOGY JOURNAL AND TRACK PROGRESS TOWARD GARDEN INSTALLATION, ALONG WITH OBSERVATIONS OF THE SEASONS. INCLUDE PHOTOS AND ILLUSTRATIONS OF THE FUTURE PLANTING SITE. YOU MIGHT LOOK BACK ON IT SOMEDAY IN AWE.



### 3. What are your ecological goals?

Consider what you might want the garden to provide for wildlife (e.g., year-round blooms designed specifically to support one type of pollinator vs. a diverse assemblage of pollinators)? How many distinct local or regional plant communities could you represent in the garden? Will the conservation of genetic diversity play a role in choosing the plants to be installed in the garden?



### 4. What are your community-development goals?

Who are your potential stakeholders, and what would they want out of a partnership or collaboration? Specifically, what types of organizations and institutions for educators and scientists exist in your area with which you might collaborate? Who might want to use the phenology garden, and for what purposes? Could the garden be used as a demonstration site for others to learn not just how to conduct phenological monitoring but also how to establish their own garden? Are there community-focused or nature-focused groups (e.g., native plant societies, sports teams, Boys & Girls Clubs, 4-H, Future Farmers, Boy and Girl Scouts, religious groups, youth development) who might be interested in helping to fund, install, and/or use the garden? Would your city council see value in installing several phenology gardens across the region?



Every step in the process of creating a phenology garden can be a community-building event. At the Port Hueneme & Greater Oxnard Boys & Girls Club, over 60 community volunteers and kids worked together to improve the soil (some pictured here); 40 people helped to install plants; and another 50 members of the community including the city council were present for the ribbon-cutting ceremony.

**With an initial vision in mind for the phenology garden – or at least answers to some of the questions above – you’ll be better prepared to generate a rough time line for installing and establishing the garden.** Consider the following questions to approximate how long it could take from planning to planting:

- ✓ What’s the process for obtaining any necessary administrative approval? Do you need to obtain permits? Roughly how long might it take to receive approval to install the garden?
- ✓ How long will it take, and how difficult will it be, to track down and purchase local genotypes of native plant species? When are the local native plant society and horticultural society plant sales?
- ✓ When are the funding cycles for small local grants? Regional or national grants?
- ✓ When is the best time of year to put plants in the ground? (In most of California it’s as soon as the rainy season begins in late fall, usually in November).
- ✓ When do your peaks and troughs of work intensity occur (teaching, research, leading activities/hikes, etc.)?
- ✓ When are full-time, part-time, or seasonal staff members available to help lead activities in the phenology garden? When do docents and volunteers complete training?

**Lastly, who are your best contacts and colleagues for the project?** Based on our experiences, lots of people will be very excited about the possibility of establishing a native plant phenology garden, but rare are the individuals who share the enthusiasm and motivation needed to construct it. Are additional colleagues necessary in order to install the garden or run activities?



		Planning	Implementation			Activities
		Select site & species	Site prep	Planting	Establishment & maintenance	Educational activities & data collection
Goals	Science					
	Education					
	Ecology					
	Community-building					
Logistics	Who's involved?					
	Educational activities to be integrated					
	Supplies & materials needed					
Timeframe				<i>Cool rainy season if possible</i>		

**Table 1.** This might be one way to organize your thoughts as you plan the phenology garden.



*Scientists with the California Phenology Project and the National Park Service have co-located phenological monitoring sites near this environmental monitoring station in Sequoia & Kings Canyon National Parks. Where is the nearest climate monitoring station to your phenology garden?*

## SITE SELECTION AND ASSESSMENT

With a clear vision in mind and a rough estimate of the project timeline, it's time to consider the practicalities of installing the phenology garden. Where should the garden be installed?

### ***Regional site selection***

Sometimes there are options for selecting sites within a large geographic area. For example, education & outreach specialists might have the capacity to install one or more phenology gardens somewhere in the county, but they may need to decide upon a specific school or two. The following components may help to narrow the regional focus while maximizing the “added value” provided by each phenology garden.

- **Motivation & Participation** – Installing native plant gardens anywhere in the region will immediately enhance the ecological value of the area. The educational and scientific value of a phenology garden, however, depends in large part on its use by educators, students, scientists, and members of the community. Who are the likely users of a phenology garden in your area, and are they more available and numerous in some locations than in others? Alternatively, can the installation of a garden help to increase the awareness and ecological literacy in areas where natural habitats are unavailable or difficult to access?

- **Co-location with existing environmental sensors** – Where is the nearest climate monitoring station? Are there stream gauges established in local watershed(s)? Are there any “phenocams” in the region (phenocams are webcams used to study the phenology of landscape-level processes such as forest green-up in the spring; see the *Additions to the phenology gardens* section at the end of this guide)? Are there local scientists or land managers conducting research at a site(s) where a phenology garden might also be installed? Are there any graduate or undergraduate students who might co-locate a research project to be in or near a phenology garden?
- **Environmental gradients** – Is there an environmental gradient across which several phenology gardens could be installed to detect phenological responses to environmental variation across the gradient? Some gradients to consider include: elevation; latitude; water availability; slope or aspect; pollution; urban heat island effects; urban-to-rural transitions; ecological communities; relatively disturbed vs. pristine sites; sites burned by wildfire vs. unburned; proximity to agricultural zones; coastal vs. inland zones; or fog zones.
- **Potential partnerships** – Is there a centralized location in the region that would facilitate use by several organizations? Is there a popular science or nature education center or an organization that runs a suite of standard programs for different school groups and visitors?

### **Local site assessment**

Once we know roughly where the phenology garden will be installed, how should we go about selecting the exact location of the garden on the landscape? There may be a limited number of sites for garden placement, or there may be several possibilities that seem to be quite different. How do we assess the best possible site? Consider the following factors:

- **Garden footprint** – What are the dimensions of the proposed garden? Do those measurements include the potential to expand in the future? Are there features nearby that either add to the utility of the garden (e.g., handicap access, exposure to passersby) or detract from it (e.g., a paved parking lot or a busy street)? A garden can take many shapes – would a square or rectangular garden be any better or worse than an elongated linear garden that would be easily accessible from a sidewalk or path?
- **Water sources & drainage** – Consider irrigation sources (spigots, hoses) and natural water sources (streams, ponds, rain, snow). Where is the nearest irrigation source? Can a hose or drip irrigation system be connected to a spigot for a week, month, or year while establishing the garden? Will foot, bike, or auto traffic in the area damage hoses, and will hoses pose hazards to pedestrians? Can rain-catching barrels be installed under nearby roof



gutters to supply the water for the garden? How does rainwater flow across the landscape? Will it be funneled into the garden and cause damage?

- **Soil type(s) and quality** – While many plants perform best in rich organic soils that have an even balance of clay, silt, and sand, native plants often thrive in unimproved clay-dominated soils that many vegetable gardeners would avoid. With that in mind, chances are that the soil characteristics won't vary much over your site. Nevertheless, it's a good idea to take a hike around the area and



on some local nature trails to note the appearance and texture of the soil on which plants seem to be thriving. If the soil at your site appears similar (or perhaps even more organically rich), then you should consider installing the same wild species that grow naturally nearby. If the soil at your site consists of intimidating hard-packed clay, talk with growers at local nurseries about ways to improve it. Consult your county Extension office for local expertise (and often times free soil testing!). Generally, tilling the top layers of the soil and adding organic material such as compost or mulch will help immensely (we discuss this later in the *Site Preparation* section).

- **Sunlight** – How much direct sunlight does the site receive at different times of the day? Generally, all plants will thrive with direct morning light, whereas some plants will be stressed by direct early- or mid-afternoon light. Shade from trees will do little harm to the garden (because some sunlight filters through), whereas buildings can block all direct light and limit the types of plants that can thrive in a given site. If the site is directly next to the north-facing side of a building, you should plant shade-loving plants (e.g., shrubs and wildflowers generally associated with the forest understory). If the site is completely exposed with no shade, then sun-loving shrubs and trees might thrive and, eventually, provide some shade to plants that are a bit more shade-loving.
- **Exposure** – This includes exposure to wind, heavy water flows (e.g., drainages, gutter downspouts), sunlight, and human disturbances such as foot traffic and litter. Generally there's not much we can do to limit these factors, so try to locate the garden to minimize these and other disturbances.



Photo: UCSB Kids In Nature



## SPECIES SELECTION – ESTABLISHING A PLANTING PALETTE

*With over 300,000 species of plants on the planet, which are best for the Phenology Garden?*

Given that one of the major goals of phenology gardens is to observe how life cycles change in response to environmental variation across the seasons, it really doesn't matter which plant species are selected long as they survive. On the other hand, with a bit of planning, we can create thriving phenology gardens that not only allow us to observe the pace of nature but also:

- provide a beautiful place to rest and think;
- contribute to a diverse and healthy ecosystem;
- require no watering and little maintenance after establishment;
- attract and support wildlife such as pollinators and birds;
- conserve local genetic diversity of wild plants;
- grow and reproduce during our peak visitor or educational seasons; and
- align with large-scale scientific research programs.

Each of these attributes is sufficient to justify creating a species-rich garden that also serves as an effective educational tool. Together, they unambiguously demonstrate that phenology gardens provide high scientific, educational, ecological, and cultural value that can be appreciated by a wide range of users, from casual visitors to the dedicated scientists.



With funding from the US Fish & Wildlife Service, participants in a series of “Phenology & Climate Change” workshops at the Santa Monica Mountains National Recreation Area received California sunflower (*Encelia californica*) and coast goldenbush (*Isocoma menziesii*) plants to take home. Contact botanists at National Parks, botanic gardens, nurseries, and colleges to learn where to obtain local genotypes of native plants.

We understand that the species selection process may seem daunting. Don't fret! Whether you're unfamiliar with plants, or actively learning the local flora, you'll probably find the process more interesting and manageable by teaming up with someone who is familiar with the native plants of your region. Many local botanists will be happy to offer sound advice regarding the selection of species for your native plant garden and we encourage you to contact botanists and plant ecologists at botanic gardens, natural history museums, colleges, county extension offices, nurseries, habitat restoration companies, landscape architecture firms, and local chapters of native plant societies and horticultural societies. You'll be surprised how quickly you realize that some of the same plant names are brought up in each discussion. Some of these botanists probably will have good ideas for tracking down local genotypes of native plants too.

For those who consider themselves experienced botanists and could easily generate a list of their favorite local species, you'll find a fun challenge in testing your list against the criteria below.

For educators at all levels and settings, the species selection process can be a great educational process that helps students (and teachers) develop a stronger understanding of biology and ecology as well as a deeper connection with their local landscape.

In this section we'll guide you through the process of considering a plant list from different ecological, educational, and scientific perspectives.

THE SPECIES SELECTION  
PROCESS IS A GREAT  
LEARNING  
OPPORTUNITY FOR  
STUDENTS *AND* THEIR  
TEACHERS.

## 1. ALIGNING THE PHENOLOGY GARDEN SPECIES WITH THE USA NATIONAL PHENOLOGY NETWORK

**What plant species in your state are being monitored currently as part of the USA National Phenology Network?**

In order to contribute data to the USA National Phenology Network database, you simply monitor particular species and record their phenological status. First, identify the species in your area that area already being monitored by the USA-NPN by searching the species list on their website ([www.usanpn.org/species\\_search](http://www.usanpn.org/species_search)). There are over 320 focal plant species that the USA-NPN has selected specifically for scientific study across the United States – these species have been selected after a thorough vetting process undertaken by a large group of scientists in order to coordinate climate change research across the nation. The USA-NPN is creating a scientifically-sound, long-term dataset around these species so that scientists can compare similar species in different areas and map their responses to climate change. In California alone, over 175 of these focal species are being monitored. This list of species targeted by the NPN is a good starting point for selecting species for your own phenology garden.

**Which of the USA-NPN's targeted plant species in your state are actually found locally?**

After identifying the species in your region that are on the NPN's list, determine which of these species can be found locally by looking them up in local field guides or by asking local botanists. Local botanists



might be able to narrow down your list quickly simply by reading through it, and local field guides often report the habitats and locations where local species may be found. Alternatively, if there is an herbarium nearby that houses a collection of pressed plant specimens from your region, you may examine specimens of your species to identify the sites where they were collected.

During this process it may be worthwhile to record the plant communities in which each of the local species can be found and to record other species traits of ecological or phenological interest. Based on your proximity to each habitat type, this process could help you to determine which species should be planted in your garden. Information on each species may be tabulated (see Table 1) in order to compare and contrast candidate species and to facilitate their collective selection on the basis of multiple criteria. For example, recording published information on the flowering times of candidate species would allow species to be selected in such a way that the garden is likely to display flowers of at least one species year-round.

Plant species	Plant community	Flowering time	Flowers support...	Fruiting time	Fruits support...	Leaves support...	USA-NPN species?
<b>Blue elderberry</b> <i>Sambucus nigra ssp. cerulea</i>	Coastal sage scrub, coast live oak woodland, back dune	Mar-Oct	Bees, flies, beetles	May-Nov	Birds, small mammals	Diverse suite of arthropod herbivores & sap-suckers	Yes
<b>California buckwheat</b> <i>Eriogonum fasciculatum</i>	Chaparral	May-Sep	Bees, flies, beetles, butterflies, moths, more	June-Nov	Small mammals & birds	General arthropod herbivores	Yes
<b>California fuchsia</b> <i>Epilobium canum</i>	Coast live oak woodland, chaparral, Back dune	July-Oct	Hummingbirds, bees	July-Nov	Caterpillars & small mammals	General arthropod herbivores	No

**Table 2.** This table illustrates one method of managing species information. Don't exclude species just because they aren't on the USA-NPN species list – other species may fulfill your educational goals or be of particular local interest, and they may eventually be added to the USA-NPN's list. To determine the general flowering, fruiting, and leaf-production times for any species, consult local field guides, use internet resources, and question local botanists. In California, *The Jepson Manual* (accessible online through the Jepson Interchange website) reports flowering times for many species; fruiting times generally lag behind flowering by about one month. Other ways to learn a species' flowering time include: examining preserved plants in local herbaria to discover the collection dates of flowering specimens, and conducting internet searches using keywords that include combinations such as “[species name] + flowers” and then scanning photos for dates and locations.

## 2. ALIGNING PHENOLOGY GARDEN SPECIES WITH OTHER ENVIRONMENTAL EDUCATION PROGRAMS

Many outdoor and nature education organizations have ongoing environmental monitoring programs that engage participants and students and that are currently monitoring plant and animal phenology with the USA National Phenology Network. It may be of value to learn about these programs and how a phenology garden could complement those activities. For example, could a phenology garden be planned to accommodate the goals and activities of other programs? Could you collaborate with them to enhance each others' goals? This could enhance the use of phenology gardens while increasing the amount of phenological data being collected.

### 3. PLANNING FOR HUMAN PHENOLOGY

Phenology gardens can be planned to suit a variety of needs, and species can be selected such that many educational and scientific goals can be addressed at once. The availability of people to run activities and participate in activities, however, can limit progress toward these goals. Consider constructing a calendar on which the following components are included:

- Educational activities that might take place in the garden – *When does the academic year start and stop for students who will be visiting the garden? When do summer camp programs run that will use the garden?*
- Phenological events and activities that can be expected to occur in the garden – *When might each species produce leaves, flowers, and fruits, relative to when students or visitors will be in peak abundance? When might the pollinators of each plant species be visiting the garden so that plant-pollinator interactions can be a focus of formal or informal lesson plans?*
- Human capacity – *When are staff members and volunteers available to help to maintain the garden and to lead activities?*
- Seasonal climate patterns – *When does the growing season generally begin and end? What is the best time of year to plant seedlings? Seeds? When are plants most stressed by seasonal drought, high or low temperatures, or intense sunlight?*

Answering these questions will inform your vision of what comprises the capacity of your phenology garden, both in terms of natural cycles and human availability. See the figure below for an example of how to integrate this information into a visual aid that may help to determine your own limitations and constraints.

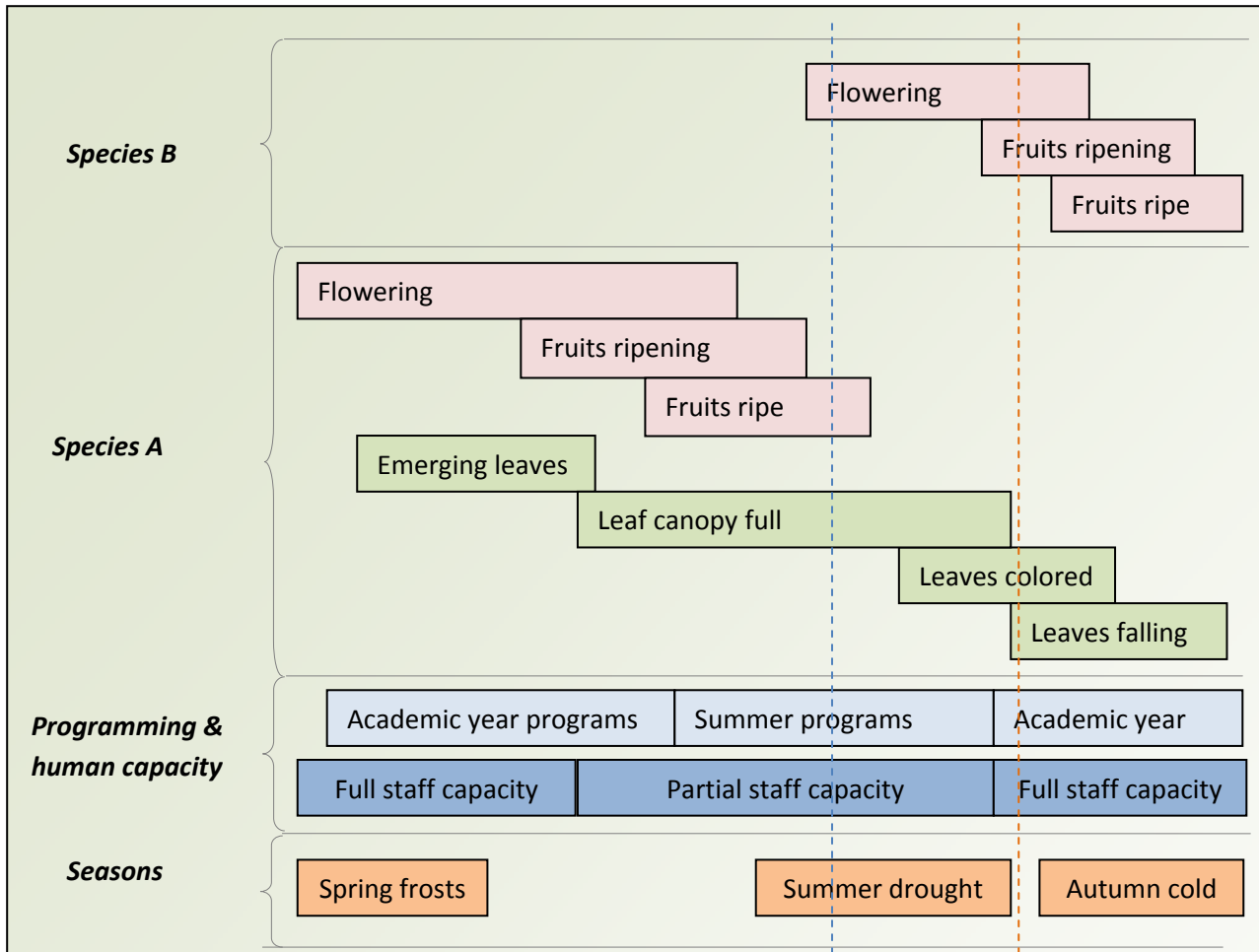
### 4. SELECT SPECIES BASED ON NATIVE PLANT COMMUNITIES

The plant species found in local natural habitats are likely to inform the species selection process. While hiking on local trails or while visiting a local botanic garden, pay particular attention to the assemblages of wild plant species that you observe. Which plant species tend to be found adjacent to one another? Do some shade-tolerant plants only occur under certain tree species? How is each plant community distributed across the landscape – which communities are generally sun-loving? Shade-tolerant? Water-loving? Drought-hardy?



CONSIDER PARTNERING WITH “SISTER PHENOLOGY GARDENS” IN YOUR REGION. ENABLE STUDENTS TO COMMUNICATE WITH EACH OTHER TO DESCRIBE AND COMPARE THE PHENOLOGY OF THEIR GARDENS.

Choosing species from among local plant communities will help to ensure that plants thrive in the phenology garden. Contact local botanists and use online resources to identify the dominant plant communities in your region. In California, consult *The Jepson Manual* and the *California Vegetation Manual*, or visit websites for the California Native Plant Society and CalFlora. Which plant communities and species are likely to thrive in your phenology garden? Refer to the site assessment you already completed and consider again the soil, sunlight, water, and disturbance qualities.



**FIGURE 1.** An example of a phenological calendar that could guide the seasonal activities and lesson plans offered by a place-based environmental education center. Focusing on the blue dashed line, summer education programs might be focused on detecting or collecting the ripening fruits of Species A and on recording the onset of flowering of Species B. Other attributes of these species might have additional educational value, such as their ethnobotanical uses or their ecological roles in supporting pollinators or stabilizing riparian soils. Focusing on the orange dashed line, the beginning of the academic year in the autumn might focus on observing the process and timing of leaf color-change and leaf-drop exhibited by Species A, along with the end of flowering and ripening fruits of Species B. Garden maintenance such as re-planting probably would be planned for the autumn cold season (and integrated with educational programming of course!); weeding probably would be planned between spring frosts and summer drought (also integrated with educational programming!).

## SPECIES SELECTION TO ENHANCE ECOLOGICAL COMMUNITIES

The species planted in a phenology garden can help to provide year-round habitat for wildlife and a diverse and healthy food web. Here are some options to consider.

### **Select species that support a diverse assemblage of animals through each of their phenophases.**

Some plants, such as blue elderberry (*Sambucus nigra* ssp. *cerulea*), support a diverse animal community throughout each of their phenophases. Blue elderberry's flowers are visited by many types of bees, flies, and beetles that forage for nectar and pollen; its fruits are consumed by squirrels, insects, and birds; its young leaves are consumed by grazing animals such as deer; and its young stems are consumed by sap-sucking arthropods such as aphids. Each of these animals then supports another set of predatory animals, forming a native food web that depends on a single plant species. *Blue elderberry is a species that is being monitored by the USA-NPN.*



blue elderberry

### **Select a suite of species that support a particular pollinator throughout the year.**

Review your phenology garden species list from the perspective of different pollinators. Which pollinators will be best supported across the year by the species on the list? For example, hummingbirds generally are attracted to red tubular flowers that contain a lot of nectar. How many species in your local area could support hummingbirds? When, generally, does each of them flower? Is it possible to select 2-4 species that would bloom sequentially across most of the year so that hummingbirds would be attracted to the phenology garden during multiple seasons? In southern California, we would select a variety of native Aloes for winter-spring blooms, hummingbird sage (*Salvia spathacea*) for spring-summer blooms, and California fuchsia (*Epilobium canum*) for summer-autumn blooms. *None of these species are on the USA-NPN's list of species being monitored... that's ok, but do try first to use USA-NPN species.*



hummingbird sage

### **Select species that support a diverse assemblage of pollinators.**

The flowers of some plant species attract many different species of pollinators. When, generally, do these species bloom? Is it possible to select a few species that bloom sequentially across seasons so that a diverse assemblage of pollinators is supported year-round? In southern California, for example, California buckwheat (*Eriogonum fasciculatum*) attracts many different species of bees, flies, butterflies, moths, beetles, and even other predatory insects and birds that eat those pollinators. This plant species blooms in mid-summer, and a similar pollinator-supporting role is played by other native sage species that bloom in the spring and summer (*Salvia* species including black sage, purple sage, and white sage), and by spring-summer-autumn flowering blue elderberry. *California buckwheat and blue elderberry are species that are being monitored by the USA-NPN.*



California buckwheat

## PURCHASING NATIVE PLANTS FOR PHENOLOGY GARDENS

Armed with a plant list that represents the best possible combination of species for your site, for your programming and logistics, for participating in the USA-NPN, and for supporting local habitats, you're ready to locate these plants and bring them to your garden for planting. In some parts of the country where local nurseries stock native plants, this will be easy; in others, it may be more challenging. Just do the best you can, and ask local sellers to carry more natives!

### General types of organizations & centers to contact for native plant availability:

- Horticultural Society, Garden Club, and Native Plant Society events
- Botanic gardens, natural history museums
- Farmers bureaus (native plants that support pollinator populations can be planted around agricultural fields to improve fruit crop production)
- Local habitat restoration companies (these often collect or cultivate wild seed used in restoration efforts)
- Natural reserves, and "Friends of..." groups affiliated with them
- Nurseries that grow native plants

### Specific resources for purchasing and exploring California native plants:

- California Native Plant Link Exchange – <http://www.cnplx.info/>
- Theodore Payne Foundation – <http://www.theodorepayne.org/>
- Nopalito Native Plant Nursery – <http://nopalitonursery.com/>
- Las Pilitas Nursery - <http://www.laspilitas.com/>

ALWAYS ASK  
FOR LOCAL  
GENOTYPES!

THEY'RE MORE  
LIKELY TO  
THRIVE IN  
YOUR SITE,  
AND THEY  
WON'T  
POLLUTE THE  
LOCAL  
GENETIC POOL.

### ***How local is local when it comes to genotypes?***

Many plant nurseries, ranging from small-scale family nurseries to large-scale corporate nurseries, will import "native" plants from other regions of the state or even from across the country. The species may be the same, but the genotype may not be well-suited for the local climate. At least two main consequences may arise from using non-native genotypes of native species: 1) non-native genotypes may not thrive or even survive because they're adapted to a different climate, and 2) just as invasive species or seasonal colds spread, the foreign genes can "escape" and disperse into the surrounding wild populations when pollinators move among plants. The foreign genes then can contaminate the local gene pool by mating with local genotypes, potentially generating a new generation of seeds that are poorly adapted to local conditions. Care should be taken when purchasing native plants because of these reasons.

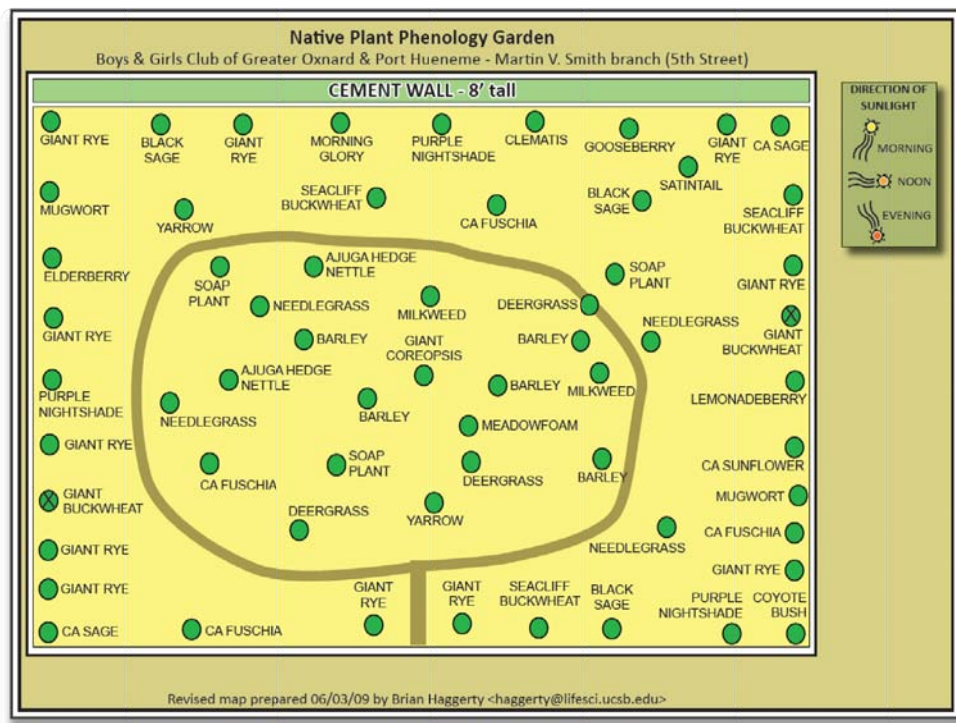
For example, big leaf maple (*Acer macrophyllum*) grows in the western states from the Mexico border to Canada, and it's being monitored in the U.S. by the National Phenology Network. It's possible to purchase seedlings of big leaf maple at many nurseries throughout this area, but where did the seedlings come from? Were the seeds collected nearby, or were they collected far away? Will the plant survive the local conditions or will it have to be replaced quickly? Ask these questions of your seed and seedling seller. Generally, seeds collected within the same watershed and/or within 1-10km of your prospective garden are a good ideal to aim for; work your way out from there.

## GARDEN DESIGN – ARRANGING PLANTS IN THE GARDEN

There are countless references on garden design that are available to guide you through the process of arranging the spatial layout of your garden; we refer you to these guides to create low-impact and visually-stunning gardens. You might consult with local landscape architects who have an interest and experience in promoting the use of native species; some may be happy to volunteer to design your garden as a means of earning some great PR and free advertising. You also might want to consult guides focused on ecological impacts, such as the Surfrider Foundation’s *Ocean Friendly Gardens* program. As you plan the spatial distribution of your garden’s plants, keep in mind the potential for providing access for different physical capabilities; potential vandalism; any existing structures such as walls and pathways that may provide access but also block light; the potential to expand the garden in the future; and access to water. Here we provide three examples from some of the education-oriented phenology gardens that we’ve established in southern California over the past few years.

### Case study I: After-school facility with plentiful open space

With funding from the Ventura office of the US Fish & Wildlife Service, and with support from a broad range of community organizations and city council members, we established a phenology garden at the Greater Oxnard & Port Hueneme Boys & Girls Club. There was abundant open space around the parking lot of the facility, but after considering issues such as foot traffic and vandalism, we decided to install the garden in a more secluded area. This resulted in an area that measured approximately 75’x50’ but that had long been a dumping ground for cement blocks and unwanted heavy clay soils. After clearing the site, we improved the soil by roto-tilling the top 6” of soil and mixing in a thick layer of mulch.



Simple garden diagrams like this can be hand-drawn, or generated in Microsoft Powerpoint, Adobe Photoshop or InDesign, or specialized design software.



Perennial shrubs and herbs were interspersed near the outer edges of the garden, forming a “green fence” that we hoped would keep errant foot traffic to a minimum and provide some shade to surrounding plants. Grassland species and sun-tolerant woodland species were planted in the exposed middle area of the garden. Wildflower seeds also were scattered throughout the area.

Species selection was made based on the availability of local genotypes of native species from regional habitat restoration companies; this included four species that are on the USA-NPN species list (elderberry, coyote bush, yarrow, and milkweed). Additional species from the USA-NPN species list could be obtained and planted in remaining open areas to augment the educational and scientific values of the phenology garden.



This time series shows the development of the Oxnard Boys & Girls Club phenology garden from (A) prior to soil improvement (with concrete piles, weeds, and hard-packed clay soil); to (B) just after the soil had been improved and the plants had been installed; and to (C) two years later, by which time perennial shrubs and herbs filled in much of the area. Some areas of the garden appear bare in (C) because the photos were taken during the summer after some perennial herbs had died back for the year, but also because few plants were installed after the initial effort.

**Case study II: Urban elementary schools with limited flexibility in site locations**

In collaboration with UC Santa Barbara's *Kids In Nature* environmental education program (founded by UCSB's Cheadle Center for Biodiversity and Ecological Restoration) and with funding from the UCSB Coastal Fund, the National Science Foundation, and the US Geological Survey, we installed phenology gardens at two urban elementary schools in Santa Barbara in which we have run year-round phenology education activities. Site selection was limited at each school and we worked closely with administrators and groundskeepers to cultivate the necessary enthusiasm and support for installing and maintaining native plant gardens over the existing water-demanding landscaping.

Our planting palette consisted of local genotypes of about 20 native species from each of several regional plant communities including chaparral, coast live oak woodland, grassland, and coastal sage scrub. We obtained these plants from the Cheadle Center for Biodiversity and Ecological Restoration, which runs a small native plant nursery dedicated to local restoration projects. We sought to sub-divide the available garden space by plant community in order to facilitate our educational goals. In both sites, the available space was linear (approximately 15'x75') and adjacent to the school classrooms.



Development of the phenology garden at Adelante Charter School. (A) Just after improvements, (B) during planting, and (C) 8 months after planting. Students conducted phenological monitoring during this time, as well as recorded basic vegetative attributes such as plant size. Indoor activities were conducted to engage the students in graphing growth rates and to compare phenological progression among species.



The development of the phenology garden at Franklin Elementary School. (A) Just after soil improvements, (B) planting (with curious passersby who would go on to inherit the garden in two years), (C) planted garden, and (D) one year after planting.

One site (Adelante Charter School) was accessible only from one side of the garden (it was bounded by a cyclone fence and a sidewalk on the other side). The light, soil, water, and disturbance environments were evenly distributed, so with the students' help we turned mulch into the top 4" of soil and then we planted tall spreading shrubs to provide a low-density green fence (care was taken so that passersby would be able to observe their kids or fellow students working in the garden and see the garden grow over its lifetime). Subsequently, short-statured shrubs and wildflowers were planted by their respective plant communities, with a narrow walkway snaking throughout the garden for access.

At the other site (Franklin Elementary School), there were three separate but adjacent locations for planting. Sunlight ranged from shady to sunny depending on the shadow cast by a nearby roof.

Again with the students' help, we turned mulch into the topsoil, discussed soil ecology and recorded observations about soil quality, and then we installed representatives of three plant communities according to the light environment (oak woodland species in the shadiest plot; coastal sage scrub and grassland species in sunnier plots). Generally, tall and spreading shrubs were planted in one row in the middle of each plot, with shorter shrubs, perennial herbs, vines, and wildflowers planted along the garden edges. As plants grew and filled in the space, it remained easy to access the large shrubs in the middle, while the low-lying plants around the border made a visible border.



***Case study III: Integrating phenology gardens into existing landscaping***

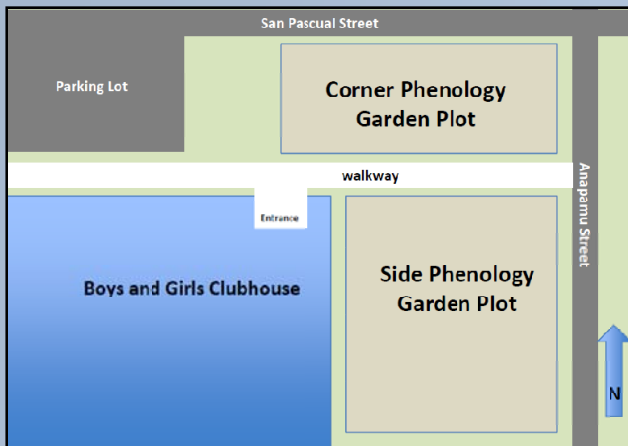
In the examples above, each site was completely razed in order to install the phenology garden – existing plants were taken out, and the topsoil across the entire garden’s footprint was turned and mulched before seedlings and seeds were planted. As a result, the garden area appeared a bit bare until the plants grew large enough to fill the space. There are some situations where this approach is not desirable, such as in the case of a phenology garden we installed at the Westside Boys & Girls Club in Santa Barbara, California.



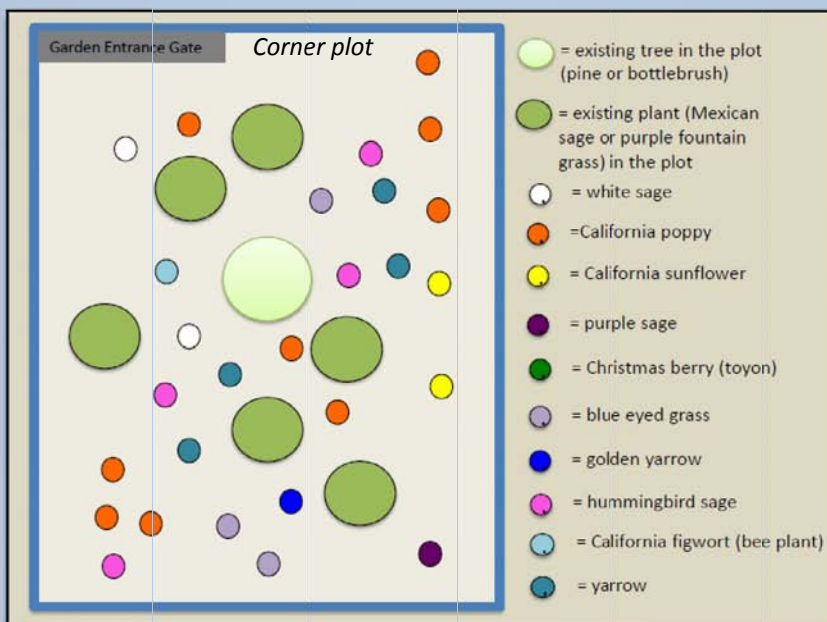
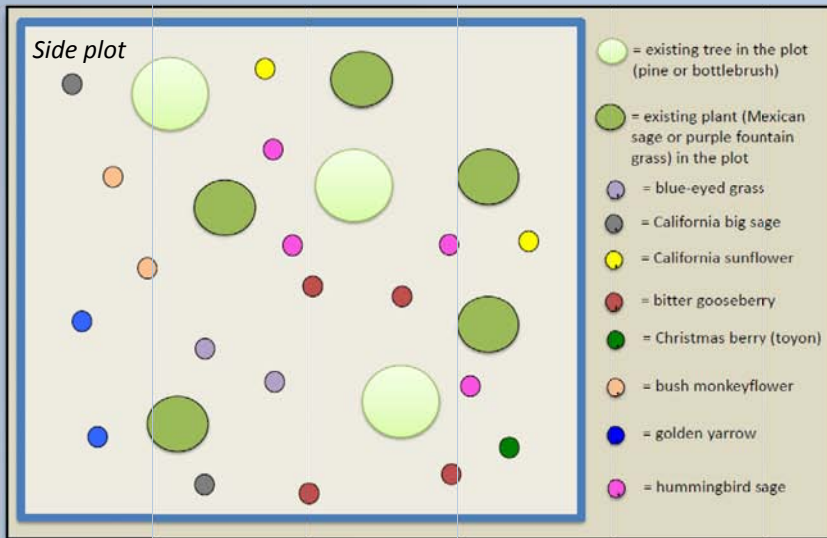
Here, with funding from the US Geological Survey, we identified two locations for phenology gardens, both highly visible to club members and to neighborhood residents. Several common and hardy exotic species were already established in both plots, including purple fountain grass, New Zealand flax, bottlebrush, and Mexican sage. Although administrators encouraged us to remove as many of the exotic plants as needed, we did not want to drastically change the appearance of the facility so we integrated native plants into the existing landscaped plot. Instead of applying mulch to the entire area, we did this only for the hole dug for each new plant (see next page for garden diagrams).

We chose to install only low-mid-statured perennial plants, including shrubs and herbs; care was taken to trim back or to remove some existing plants to make room for natives, with plans to remove additional exotic plants as the native plants grow and fill the space. Both plots receive moderate sunlight, with the most sunlight falling on the plots in the mid-late morning; nearby pine and sycamore trees provide ample shade for both gardens in the afternoons. We planted several individuals for each of roughly 15 species (about 60 native plants in total) representing the dominant plant communities in the region – coast live oak woodland, coastal sage scrub, and chaparral. The location of each plant was chosen based on its eventual mature size and so that each plant would be accessible for phenological monitoring.

Garden design for case study III – integration with existing landscaping



These simple diagrams, made with Microsoft Powerpoint, represent how native plants were integrated into an existing managed landscape for phenological monitoring at the Westside Boys & Girls Club. Large circles indicate large well-established trees and shrubs; smaller circles represent the various plant species native to our region that were planted. Notice that several individuals of



each species were planted – this provides a backup system for each species in case a plant dies early during establishment. Moreover, if several individuals per species become established then not only do they provide greater resources for insects, birds, and other animals, they also provide increased genetic variation in the phenology garden which is beneficial both for the reproductive success of those plants as well as for students tracking variation among individuals in the garden.



## SITE PREPARATION – SOIL, WATER, SHADE

By planting local genotypes of native plants, you're stacking the odds in your favor that the plants in the garden will thrive. With just a bit of attention to improving the site characteristics before installing plants, the plants will have a much easier time becoming established and growing rapidly.

### Soil Preparation

#### *Water*

Think of the soil like a sponge. Plants will establish their roots best when the sponge is saturated but not dripping, and when the texture is dense but not hard-packed. Depending on the quality of the soil, it should be watered days or weeks before planting so that it is wet (but not muddy) on planting day. Several long and slow soaks should be sufficient. Prior to planting, dig up a scoop of soil with a full-sized shovel. You should be able to sink the shovel into the soil with some (but not a lot of) effort, but you don't want soil to be so saturated that the soil-filled shovel blade retrieves standing water.

#### *Mulch*

Mulch is chipped plant material that is always good to apply to the soil of native plant gardens. The addition of this organic material improves biological processes in the soil (on which plants depend) and helps to retain moisture in the upper soil layers. Mulch can be applied in a ½"-4" thick layer on the soil surface, or it can be applied in a layer and then mixed into the upper 1"-6" layer of soil. Many city or county waste companies provide free "green waste mulch", or it can be purchased in bags from nurseries or the gardening section of hardware stores.

#### *Texture & density*

When starting a native plant garden, some people dig down deep (up to a foot or so) and turn over and break up the soil. Alternatively, a roto-tiller can be used to break up that same layer of soil with relative ease. Generally these methods are effective in breaking up the dense upper layers of clay-rich soils, and this approach can be used to cultivate richer organic soils everywhere in the garden.

The roots of many native plants will penetrate the soil well below the first 12 inches, so it may be unnecessary to prepare the entire garden in this way. Instead, identify which plants will go in which areas of the garden, and then



SITE PREPARATION IS A GREAT COMMUNITY-BUILDING ACTIVITY. IN OUR PHENOLOGY GARDENS WE'VE HAD PARTICIPANTS FROM ALL WALKS OF LIFE HELPING OUT – INCLUDING COLLEGE STUDENTS, PARENTS, INCARCERATED TEENS, TEACHERS, DRUG & ALCOHOL REHABILITATION PATIENTS, RELIGIOUS GROUPS, CITY COUNCIL MEMBERS, AFTER-SCHOOL PROGRAMS, AND EMPLOYEES OF LOCAL BUSINESSES AND CORPORATIONS, BRING SUPPLIES AND SNACKS FOR THEM, AND INVITE THEM BACK FOR THE PLANTING EVENT!

dig a small deep hole for each plant. Put each plant in its hole, refill the hole with its soil, pat the soil down lightly to pack it around the roots, and then toss in some mulch with the top layer as you break up any remaining clumps of dense soil (imagine you're tossing a salad).

### Water sources and applicators

Be sure you have a long enough hose to reach comfortably from a water source to the garden. A few items that will save water and make the process easier include a valve at the hose handle (so you can turn off the water when not in use), a watering “wand” (an attachment that broadcasts the water lightly over an area), and drip hoses. The watering wand can be used during planting and in the days and weeks afterwards to provide a good soaking to the plants that need it most. The drip hoses should be distributed around the garden so that a hose snakes around the base of each plant. You may also want to purchase a timer for the drip hoses – not only does it automate the entire process so you don't have to be present, but it also ensures the water is turned off when forgotten (which often happens in groups)!

### Shade structures

Shade structures can help to protect plants from inhospitable environmental conditions during the establishment phase. Typically, supplemental shading is necessary only if gardens are being established during the peak of summer sunlight and heat. Inexpensive shading cloth can be affixed to structures made of PVC framing or wood. Consider the time of day you'd like to shade the plant the most – afternoon shading may require that the framing be angled towards the west to intercept the afternoon sun.

## PLANTING THE PHENOLOGY GARDEN

Once all the plans have been made, the administrative approval has been received, native plants have been obtained (hopefully native genotypes), and the soil has been prepped, it's time to put the plants in the ground! It's really quite simple – dig a hole, put the plant in it, cover it back up, give it some water, and *voilà!* A few specific planting considerations, though, might help your plants become established more easily.

### Planting seedlings:

- Dig a hole up to 3-4” inches deeper than the pot in which the plant is living. Break up any large clumps in the soil as you pull the loose soil out of the hole and pile it nearby, being sure to leave about 1” of loose soil at the bottom of the hole.
- If the soil is crumbly and dry, then pour a small amount of water in the hole and mix it around to moisten the loose soil at the bottom.
- Take the seedling out of the pot by carefully turning it on its side or upside-down. If gravity doesn't do the trick, lightly tap the bottom of the pot, or lightly squeeze the edges of the pot's base.



Photo: Boys & Girls Club of Oxnard/Port Hueneme

- *When you remove the seedling from the pot – do not touch or pull the roots!* Sometimes vegetable gardeners loosen up the roots when they pull plants out of pots. This damages the roots; in addition to rupturing many of the fine roots, it damages the ultra-fine root hairs that do most of the water and mineral absorption. Simply insert the plant in its hole as it is.
- Fill the hole around the inserted plant with the loose soil you piled nearby, and then lightly (but firmly) pack the soil above and around the plant. Use your entire hand to make a large surface area when packing soil rather than a couple of fingers that can unevenly pack the soil and even damage roots through the compaction process. You might pack the soil so it forms a minor depression in the surface – this way, water pools up near the plant and filters down to the roots during watering.
- Be sure to add a layer of mulch around the plant, and if a plant identification tag was in the pot, place it next to the plant (if you're not familiar with plant species, then this helps garden visitors to remember which species went where).
- Give the plant some water. Do this in a long-and-slow stream, not a fast- or high-pressure stream. Congratulate yourself and admire your handiwork, then continue planting your phenology garden!



***Be sure to examine the roots while planting!***  
*This is a great opportunity to observe the fine structure of roots – they're quite beautiful! Use hand lenses, take photos, create drawings. Students of all ages can learn how plants obtain the nutrients and water that allow them to thrive. For more advanced students, this activity is an opportunity to discuss the differences between stems and roots as well as root anatomy and physiology (e.g., xylem, phloem, endodermis, the casparian strip, and apoplastic vs. symplastic diffusion of water and minerals).*





**Planting seeds:**

Tossing seeds on top of the soil surface will likely lead to poor germination success. Seeds generally require stable environmental conditions, so try to avoid wet-dry cycles by keeping a continuously moist (but not soaked) soil surface. Follow these simple steps to increase the probability of success.

- Use a rake or hoe to remove approximately ½"-1" of soil from the soil surface. Pile the loose soil next to where you want to plant the seeds.
- Broadcast the seeds across the area. Broadcast in a high density rather than a low density – not all seeds will germinate, and of those that do, typically only a portion will actually survive and thrive. Don't worry about those that don't germinate this year; they might actually start the following year. Most seeds can last for years in the soil (some grains have germinated after being stored for over 1,000 years in tombs).
- Cover the seeds with the loose topsoil and gently pack the soil. Water the area with a fine mist or light sprinkle (not a heavy downpour).
- Over the coming days and 1-3 weeks, keep an eye on the area and water it often. Keep the upper few inches of topsoil (where the seeds are located) humid.

**Watering to ensure plant establishment**

The first few weeks are the most important time for plant establishment. Try to maintain a reasonably constant level of soil moisture (e.g., by watering every day), rather than allowing the garden to dry up between waterings. Be sure the soil stays well-watered but not inundated and soggy or muddy. If the weather is warm, sunny, and/or windy, be sure to

CONTINUE MAKING ROOTS THE FOCUS OF EDUCATIONAL ACTIVITIES DURING THE WEEKS THAT PLANTS ARE GETTING ESTABLISHED. EVEN THOUGH ROOT ESTABLISHMENT IS NOT VISIBLE, BY KEEPING STUDENTS FOCUSED ON ROOTS YOU'LL HELP BRIDGE THE GAP UNTIL MORE EXCITING THINGS HAPPEN ABOVE GROUND WHEN LEAVES AND FLOWERS DEVELOP. CUT OPEN CARROTS AND STUDY THEM WITH LABELED IMAGES THAT YOU CAN FIND ONLINE. WHEN PULLING WEEDS OUT OF THE GARDEN AREA, PLAY A GAME OF "WHO CAN FIND THE LONGEST ROOT?" (OR "WHO CAN FIND THE HAIRIEST ROOT?... WHY DO PLANTS HAVE HAIRY ROOTS ANYWAY?").



water often (probably once per day minimum) for the first 1-2 weeks. After about 2 weeks, you may water less frequently (twice per week), weaning the plants off of the additional water you're providing over the following few weeks to few months.

You'll probably notice that the plants don't show signs of growth for a couple weeks or even a month. This is to be expected! Newly transplanted seedlings generally will divert most of their accumulated energy into producing new roots. This process can take a few days to several weeks, but once a larger root system is established they'll begin to produce new leaves and shoots above ground. Keeping an eye out for new leaves and stems also lets you know that you can back off the watering frequency – the plant has established roots more deeply into the soil, where water is generally more available.

Be sure to invite members of your local community to participate in the creation and maintenance of your garden! Consider inviting specific organizations and people who you think might use the phenology garden or who might be interested in supporting activities in the garden. Community-based websites are also a great way to get the word out, such as craigslist, local weekly entertainment guides, news websites, local garden columnists, and high-profile bloggers. Don't forget about social media, too.



Photo: Boys & Girls Club of Oxnard/Port Hueneme

## ADDITIONS TO THE PHENOLOGY GARDEN

There are several items that can add substantial educational and scientific value to phenology gardens. We discuss some basic items here, certainly there could be more.

### Garden signage

- ✓ **Species identification signs** should include both the common and scientific name of each species. Ideally, the signs will also report the taxonomic family to which each species belongs. They might also include basic habitat information for the species, its geographic distribution, ethnobotanical uses, important phenophases to observe, probable pollinators, and/or any other interesting facts.

An inexpensive and highly educational option is to encourage students to use field guides and online references to record ecological or historical facts about each species in the garden. Students (or other garden users) may then hand-write and illustrate signs for each plant; these signs can then be laminated and stapled to inexpensive wooden stakes that can be installed near the appropriate plants. A computer also can be used to generate a more standardized and professional appearance before printing and laminating.

- ✓ **A Phenology Garden welcome sign** helps to orient visitors and tells the story of the garden. Describe what makes a phenology garden different than other types of gardens, and include information about the USA National Phenology Network.



### **Environmental sensors**

When conducting cutting-edge research in wild areas, many ecologists deploy automated environmental sensors in their study sites to record at fixed intervals temperature, precipitation, humidity, soil moisture, and other environmental parameters. Once every few months (or as often as daily, if desired) they synchronize the automated “data logger” to a computer in order to download the data from the sensor. It’s quite simple, and the cost of individual sensors can range from quite inexpensive (\$40 or less) to thousands of dollars (for full-featured weather stations). Consider installing some type of environmental sensor; whether it’s a fully automated data logger or a simple thermometer, environmental sensors help to remind us about the connection between phenology and climate. A quick internet search on “iButton” or “temperature data logger” will provide a good starting point for automated systems.

### **Automated “remote sensing” equipment – digital cameras and more**

More and more scientists are detecting and recording environmental events and patterns by using digital cameras and microphones as “remote sensing” devices. Digital photos, taken repeatedly at the same place over time, can provide detailed records of phenological change. For students, in fact for most people, seeing sequential photos that record how their garden and their landscape have changed over time connects them with nature in deeper ways – the “snapshot” that they see each day then fits into a bigger seasonal picture. Consider installing in your garden an automated internet-connected “phenocam” (<http://www.oeb.harvard.edu/faculty/richardson/phenocam.html>), or registering your garden as a “picture post” location (<http://picturepost.unh.edu/>) where any visitor may take photos of the same view(s) – orienting their camera in the same cardinal direction(s) – and then share the photos online. Participation in both of these programs connects your local efforts (and phenological data) with much larger programs that are being used to study effects of climate change on wild species and landscapes.



Photo: Stephanie Sutton, National Park Service



At left, a phenocam takes daily photos of the landscape at Sequoia & Kings Canyon National Park. Phenology education activities are then implemented with these images in classrooms throughout the region. At right, and in the same national park, a dendroband measures changes in tree girth that occur over the course of days, weeks, seasons, and years. What types of environmental sensors, remote sensing equipment, and repeat photography could you install in or near your phenology garden?

**Additional habitat for wildlife (bee structures, bird houses and feeders)**

- ✓ Building a variety of bee nests in the phenology garden may not only help to conserve pollinator abundance and diversity, it may also help to increase fruit and seed production of the plants in and around the garden. Providing bee nests can be as simple as bundling straws together and hanging them in secure locations, or drilling holes in wood blocks and securing them in trees or in protected areas. A good starting point for pollinator conservation and bee nests is the Xerces Society website and their bee nest factsheet:

[http://www.xerces.org/wp-content/uploads/2008/10/nest\\_factsheet1.pdf](http://www.xerces.org/wp-content/uploads/2008/10/nest_factsheet1.pdf)

- ✓ Installing bird houses or bird feeders in the garden also can attract a variety of bird visitors. To learn more, visit the National Audubon Society website, particularly this page:

<http://athome.audubon.org/>



Photo: UCSB Kids In Nature

For more phenology education materials, visit the Education section of the California Phenology Project website ([www.usanpn.org/cpp](http://www.usanpn.org/cpp)) or the USA National Phenology Network ([www.usanpn.org/education](http://www.usanpn.org/education)).

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