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How to Attract and Maintain Pollinators in Your Garden

Introduction

Nearly all ecosystems on earth depend on pollination of flowering plants for their existence and survival; furthermore, from 70 to 75 percent of the world's flowering plants and over one-third of the world's crop species depend on pollination for reproduction (Klein et al. 2007; NAS 2007). Take a stroll through your neighborhood or a botanical garden, or hike in the hills, and experience the shapes and smells of flowers surrounding you. When most people look at a flower, they notice the shape, smell, composition, or structure of the flower, but few take a moment to consider why the blossom appears and smells as it does (Frey 2001). Plants have evolved through time to offer unique flowers that attract select pollinators, thus ensuring that the pollinator's visits will provide them with another year of flowers and fruiting. The end result of the pollination process is that humans and animals of all kinds benefit from a bountiful supply of food and beauty (NAS 2007).

Photo: Kate Frey.

What Is Pollination?

The goal of all living organisms, as well as plants, is to produce offspring for the next generation. One way plants produce offspring is through making fruits and seeds, the product of successful pollination.

Pollination is the process of transferring pollen from the anthers (male organ) of a flower to the stigma (female organ) of the same flower or of another one of the same species. Pollen grains of the correct type that land on the stigma germinate and grow a pollen tube down through the style and into the ovules (eggs). This process results in fertilization, which, in flowers, leads to the production of fruits and seeds. Seeds contain embryos that become the next generation of plants. Most flowering plants require pollination and have developed a variety of methods for pollen transfer, such as wind, water, biotic agents (bees, butterflies, moths, or other animals), and self-pollination. Some flowering plants also reproduce by vegetative means.

The relationships that exist between flowering plants and pollinators are not casual, as many plants and pollinators have coevolved over long periods of time to efficiently exchange services. Pollination of flowers by pollinators is the unintended outcome of their activity on the flower. As pollinators visit flowers to sip nectar (sugar source) or gather pollen (protein, fats, and other nutrients) for their brood, pollen grains are dispersed among plants of the same species, allowing plants to reproduce. Plants have evolved to reward pollinators for visiting their flowers by providing sweet nectar or pollen. The fates of pollinators and flowering plants are thus inextricably bound.

Figure 1. Male of *Agapostemon texanus* visiting *Aster* sp. *Photo:* R. Coville.

Who Are the Pollinators?

Bees

Bees are the most important biotic agent for the pollination of agricultural crops, horticultural plants, and wildflowers (Frankie and Thorp 2002; NAS 2007). People are often most familiar with the introduced European honey bee *(Apis mellifera)*, which was brought to the eastern United States 400 years ago; it arrived in California around 1850. The honey bee is just one species of bee in this incredibly diverse group of pollinators. Approximately 4,000 species of bees exist in the United States, with 1,600 of those residing in California (figs. 1 and 2). About 20,000 species have been recorded worldwide (DiscoverLife.org). Native bee species come in a variety of shapes, colors, sizes, and lifestyles that enable them to pollinate a diversity of plant species (see also Griffin 1997).

Figure 2. Honey bee *(Apis mellifera)*, visiting *Parkinsonia* sp. *Photo:* R. Coville.

Figure 3. Male Anna hummingbird *(Calypte anna)* hovering and showing its characteristic iridescent rose color on its head and throat. *Photo:* R. Asman.

Figure 4. Monarch butterfly *(Danaus plexippus)* visiting a *Tithonia rotundifolia* flower. *Photo:* R. Coville.

Hummingbirds

Hummingbirds are the most prominent pollinating birds in North America. These birds have long beaks and tongues that can reach deep into flowers to harvest sugary nectar. When a hummingbird stops in for a sip of nectar, pollen can be transported from the flowers to the beak, feathers, or both. Hummingbirds forage on insects and spiders for their protein source (fig. 3).

Butterflies

These gorgeous, often colorful, daytime-flying insects have long been purposely lured to flowers by gardeners. Butterfly larvae, or caterpillars, require specific plants to feed on, though the adults can use nectar from many plants. While adult butterflies are not as efficient pollinators as are bees, they do transfer pollen that sticks to their legs as they flit from flower to flower. Their stunning looks have made them attractions at many botanical gardens and zoos, where butterfly houses and gardens stock their favorite flowers for nectar resources (figs. 4 and 5) (Stewart 1997; Xerces and Smithsonian 1998).

Figure 5. An umber skipper *(Poanes melane)* visiting a *Salvia uliginosa* flower. *Photo:* R. Coville.

Moths

Moths are mostly evening fliers attracted to many late afternoon, night, and early morning sweet-smelling flowers for their nectar. Moths tend to have hairier and stouter bodies and are generally less colorful than butterflies. They are easy to differentiate from butterflies if you look at their antennae: moths do not have a swelling at the end of their antennae whereas butterflies do.

Bats

Bats are nocturnal pollinators that play an important role in the pollination of agaves and cacti in the Southwest, as well as many tropical and subtropical plants such as bananas, avocados, and cashews (Tuttle 1997). Bats are usually found visiting light-colored flowers that open at night and often produce copious amounts of pollen and nectar. For example, the Mexican long-nosed bat *(Leptonycteris nivalis)* is a species that has evolved a special head and tongue to allow access to both pollen and nectar from flowers of century plants (Bat Conservation International website; Nabhan 2004).

Flies

Flies are not typically thought of as pollinators; however, research suggests that many flies, such as hover flies (family Syrphidae) and bee flies (family Bombyliidae), are generalist pollinators. Generalist pollinators are important inhabitants of gardens because they visit wide varieties of plants, searching mostly for nectar and in some cases pollen (fig. 6).

Figure 6. The common hover fly *(Eristalis arbustorum)* visiting *Eriogonum*. *Photo:* R. Coville.

Beetles

Up to 28,000 known beetle species exist in the United States; however, as a group, few species are recognized as pollinators (Foottit and Adler 2009). While beetles are not efficient pollinators, many visit flowers to sip nectar or feed on the flower parts. Their activities may result in pollination. A few plants, such as magnolias, are typically pollinated by beetles.

Why Should You Care about Pollinators?

More than 75 percent of flowering plants worldwide rely on animals for pollination; thus ecosystems around the planet are dependent on their services (NAS 2007). Pollinators are responsible for the majority of beautiful flowers surrounding us and many of the diverse food plants we eat. In the United States over one-third of the food we eat is dependent on one type of pollinator: bees (McGregor 1976; Buchmann and Nabhan 1996). If you enjoy watermelon, kiwi, squash, almonds, cherries, peaches, blueberries, apples, and many other fruits, nuts, and vegetables, then you should be concerned about protecting our valuable pollinators.

The importance of conserving a diversity of pollinators has become more apparent as the introduced European honey bee population has declined due to colony collapse disorder (CCD). Unique to honey bee colonies, CCD causes worker bees to suddenly and mysteriously disappear. Single hive losses ranging from 30 to 100 percent have been reported by beekeepers in both North America and Europe (Nordhaus 2011). Honey bees are relatively inexpensive, and the industry standard when experiencing large hive losses is to order additional hives. A growing concern, however, is that if hive losses continue to increase, demand for honey bees will become too great to sustain. What will not decrease is flowering plants' need for successful pollination from their associated pollinator(s). While scientists still do not know the exact cause(s) of CCD, they do know that managed honey bees are subjected to a number of stressors, such as pesticide poisoning, low food-source

variety, and long transports between various climate regions. These stressors, in addition to predatory mites and pathogens, contribute significantly to honey bee mortality (Nordhaus 2011).

Besides declines of domestic honey bee populations, overall declines in populations of other wild pollinators (native bees, bats, butterflies, etc.) have been observed as well (Buchmann and Nabhan 1996). Pollinator decline is attributed to many factors, including

- habitat destruction and fragmentation
- increased use of pesticides (spraying without taking precautions to minimize impacts on nontarget wildlife). Pesticides kill insects of both beneficial and pest species.
- decline in wildland areas (loss of food sources and nesting habitats)
- introduced or imported bee species and their associated diseases
- introduced non-native plants that are unattractive to domestic pollinators or that replace native pollinator plants
- climate change

Concerned citizens can protect and conserve pollinators by supporting public and nongovernmental organizations (NGOs) that advocate pollinator research and conservation, planting habitat gardens, or supporting pollinator policies. Take the first step today by introducing pollinator-friendly plants to your yard or community garden. The "Useful Resources" section at the end of this publication includes information on pollinator research institutions and NGOs. These institutions regularly update their websites with information and often provide free educational materials.

How Can You Attract Pollinators to Your Garden?

Properly planned sites in urban areas can provide floral and nesting resources for pollinators as wildland areas decrease. Urban habitat gardens, if planned correctly with appropriate resources, can support pollinator populations (Frey 2001; Schindler et al. 2003). A habitat garden provides wildlife with known resources for survival: food (e.g., nectar, pollen, or fruit), water (e.g., birdbath or small pond), shelter (e.g., shrubs or trees), and a place to raise young (e.g., bee box, tree, or bat box) (Owen 1991; Grissell 2001). In addition, habitat gardens may see an increase of fruits, nuts, vegetables, and showy flowers (Pawelek et al. 2009, 2010). Maximize your yard's pollinator potential by considering the following recommendations.

General Design Recommendations for Pollinator Habitat

Seasonal sequence of flowers

Plan your garden with a variety of plant types, defined as plant species, subspecies, varieties, cultivars, and hybrids (at least 20 plant types) that will bloom from late winter or early spring (February–March) to late summer or early fall (October). From 14 years of survey research by the Urban Bee Lab in urban California gardens, it has been determined that a minimum of 20 plant types is necessary to cover the entire bee and flowering seasons from midwinter to the end of October. Selecting plant species with a staggered bloom sequence ensures food for each pollinator's unique season. As with plants, each pollinator species has its own season of adult activity (Xerces and Smithsonian 1998; Burris and Richards 2006).

Diversify garden plantings

Different types of pollinators have preferences for the plant type or flower structure that they visit to collect nectar or pollen resources. For example, hummingbirds have long beaks and tongues that can access nectar that other pollinators cannot. Additionally, other pollinators such as bats and moths visit flowers that are primarily open at night. Having a large diversity of plants ensures that pollen and nectar are accessible for a variety of pollinators. Some pollinators, like bees, require both nectar and pollen from flowers to meet their nutritional needs, whereas hummingbirds need a constant supply of nectar. A large variety of flower resource types (flowers that offer nectar, pollen, or both) allows for greater pollinator diversity.

Use native plants

Many pollinators have tightly interwoven relationships to native flowering plants. Pollinator emergence and life cycles are often synchronized with their preferred plants' flowering patterns. It has been documented that native bees forage on native plants more frequently than on non-native plants (Frankie et al. 2005, 2009). Native plants are also well adapted to the state or region's localized climate and soil conditions. Native California desert plants, such as desert globemallow *(Sphaeralcea ambigua)*, may be native to hot deserts; however, they thrive in cooler, coastal parts of the state as well, and the mallow attracts native bees wherever it is planted. (See the UC Berkeley Urban Bee Lab website in "Useful Resources" at the end of this publication.)

Consider leaving flowering weeds

Many plants that are considered weeds are actually attractive to pollinators. Leave some areas of the garden weedy for use by pollinators. This area can also serve as a bare-soil nesting area for native bees. Remove weeds immediately after flowering begins to decline to discourage them from setting seed or becoming invasive. Some weeds that are regularly used by pollinators include thistles (*Cirsium* sp., *Carduus* sp., *Silybum* sp., *Onopordum* sp.), bristly ox tongue *(Picris echioides)*, and dandelions (*Taraxacum* spp.).

Provide water

Some pollinators, such as honey bees, need water for their survival. Maintain a shallow dish or bird bath with a landing surface to keep pollinators hydrated. Two methods to prevent honey bees from drowning are to place pebbles or stones in the dish or use a piece of floating cork board or wood. Some bee pollinators, including the blue orchard bee (BOB), require mud for nest construction (see the section "Cavity-nesting bees" below for more information).

Provide shelter

All pollinators need a protected place to either raise their young, lay eggs, or hide from predators. Types of cover include bird houses, bat houses, native bee boards or boxes, trees, shrubs, grasses or weeds (Grissell 2001).

Avoid pesticides

Pesticides not only kill the desired pest in your yard, but they can also harm valuable pollinators and beneficial insects that can provide pest control, given the chance. Using pesticides in your garden may do more harm to your environment, including your pets and you, than what you might gain from using them. Avoid pesticides whenever possible, and use only cultural or biological controls to control the target pest. Also consider removing problematic plants and replacing them with another plant type. Refer to the University of California Integrated Pest Management (UC IPM) website (see "Useful Resources" at the end of this publication) for information about controlling home garden pests safely by using the least toxic methods. Another resource is the brochure on pollinator-friendly pest solutions found on the Pollinator Partnership website (see "Useful Resources" at the end of this publication).

Designs to Attract Specific Pollinators

Bee Gardens

Recent news media has attracted public attention to honey bees since they have begun to decline under a series of pressures, including colony collapse disorder (CCD). Although native bees are not affected by CCD, they are susceptible to population decline from their own natural enemies and human disturbances. A growing public concern is currently about bee conservation. This new awareness, coupled with education surrounding native bees, has gardeners searching for ways to provide habitat.

Honey bees are the most recognized and abundant bee in most gardens. Domesticated honey bees are generalized foragers, meaning that they visit a wide variety of host flowers. Native bees have more specific relationships to plant types and groups; they come in an array of colors, sizes, and shapes, and exhibit a wide range of fascinating foraging and nesting behaviors. **These predictable relationships between native bees and their flowers are the basis for planning a successful bee habitat garden.**

Select plants from the recommended plant list (table 1) that attract both honey bees and a variety of native bees. A bee garden

Table 1. Pollinator plants that are successful in most California gardens

Plant name	Common name	Plant family	Plant form	Duration	Host	California native
Abutilon palmeri	Palmer's indian mallow	Malvaceae	shrub	perennial	bee	yes
Achillea spp. & CVS	yarrow	Asteraceae	herb	perennial	bee	varies by species
Agastache spp.	hyssop	Lamiaceae	herb	perennial	bee, BA, HB	varies by species
Alcea rosea	hollyhock	Malvaceae	herb	perennial	bee, BL	no
Antirrhinum majus	snapdragon	Plantaginaceae	herb	perennial	bee, BL	no
Aquilegia formosa	western columbine	Ranunculaceae	herb	perennial	HB	yes
Arabis spp.	rockcress	Brassicaceae	herb	perennial	BA, BL	varies by species
Arctostaphylos spp.	manzanita	Ericaceae	ground cover/ shrub/tree	perennial	bee, HB	yes
Asclepias eriocarpa, A. fascicularis, A. tuberosa	milkweed	Asclepiadaceae	herb	perennial	bee, BL, BA	yes
Aster x *frikartii*	'Monch'	Asteraceae	herb	perennial	bee, BA	no
Baccharis pilularis	coyote brush	Asteraceae	shrub	perennial	bee, BA, BL	yes
Berberis nevinii	Nevin's barberry	Berberidaceae	shrub	perennial	bee, HB	yes
Bidens ferulifolia	Apache beggarticks	Asteraceae	herb	perennial	bee, BA	no
Buddleja davidii	orange eye butterflybush	Scrophulariaceae	shrub	perennial	BA	no
Calendula officinalis	pot marigold	Asteraceae	herb	annual	bee	no
Calliandra californica	California fairyduster	Fabaceae	shrub	perennial	bee, HB, MO	no
Senna armata (*Cassia armata*)	desert senna	Fabaceae	shrub	perennial	bee, BA, BL	yes
Ceanothus spp. & CVS	California lilac	Rhamnaceae	ground cover/ shrub/tree	perennial	bee, BL, BA	yes
Chilopsis linearis	desert willow	Bignoniaceae	tree	perennial	bee, HB	yes
Ericameria nauseosa (Chrysothamnus nauseosus)	gray rabbitbush	Asteraceae	shrub	perennial	BA,BL	yes
Collinsia heterophylla	purple Chinese houses	Plantaginaceae	herb	annual	bee, BA, BL	yes
Coreopsis lanceolata	lanceleaf coreopsis	Asteraceae	herb	perennial	bee, BA	no
Cosmos bipinnatus	garden cosmos	Asteraceae	herb	annual	bee, BA	no
Dalea spp.	prairie clover	Fabaceae	herb	varies	bee, BA, HB	varies by species
Echinacea purpurea	purple coneflower	Asteraceae	herb	perennial	bee, BA	no
Epilobium canum	hummingbird trumpet	Onagraceae	herb	perennial	HB, BA	yes
Eriogonum spp.	buckwheat	Polygonaceae	shrub	perennial	bee, BA, BL	yes
Gaillardia x *grandiflora* CVS	blanketflower	Asteraceae	herb	perennial	bee, BA	no
Galvezia spp.	bush snapdragon	Plantaginaceae	shrub	perennial	HB	varies by species
Gilia capitata	globe gilia	Polemoniaceae	herb	annual	bee, BA	yes
Grindelia camporum	common gumplant	Asteraceae	herb	annual	bee, BA	yes
Grindelia hirsutula	hairy gumplant	Asteraceae	herb	perennial	bee	yes
Grindelia stricta	gumweed	Asteraceae	herb	perennial	bee	yes
Helianthus annuus	sunflower	Asteraceae	herb	annual	bee, BA	yes
Ipomoea alba	moonflower	Convolvulaceae	herb/vine	annual	MO, BA	no
Keckiella cordifolia	heartleaf keckiella	Plantaginaceae	shrub	perennial	HB, BL	yes
Lantana spp.	lantana	Verbenaceae	herb	perennial	BA	no
Lavandula spp. & CVS	lavender	Lamiaceae	shrub	perennial	bee, BA	no

Table 1. Pollinator plants that are successful in most California gardens *(continued)*

Plant name	Common name	Plant family	Plant form	Duration	Host	California native
Linum lewisii	blue flax	Linaceae	herb	perennial	HB	yes
Lippia spp.	lippia	Verbenaceae	herb	perennial	BA, BL	no
Mimulus aurantiacus	monkey flower	Phrymaceae	shrub	perennial	bee, BL, HB	yes
Monardella villosa	coyote mint	Lamiaceae	herb	perennial	bee, HB	yes
Oenothera biennis	evening primrose	Onagraceae	herb	biennial	MO	no
Opuntia littoralis	coastal prickly pear	Cactaceae	cactus	perennial	bee, HB	yes
Penstemon heterophyllus CVS	bunchleaf penstemon	Plantaginaceae	herb	perennial	bee, BL	yes
Peritoma arborea (Isomeris arborea)	bladderpod	Capparaceae	shrub	perennial	BL, HB	yes
Phacelia campanularia	desert bells	Boraginaceae	herb	annual	bee, BA	yes
Phacelia cicutaria	caterpillar phacelia	Boraginaceae	herb	annual	bee, BA	yes
Phacelia distans	distant phacelia	Boraginaceae	herb	annual	bee, BA	yes
Phacelia minor	minor phacelia	Boraginaceae	herb	annual	bee, HB, BA	yes
Phacelia tanacetifolia	tansy leaf phacelia	Boraginaceae	herb	annual	bee, BA	yes
Phacelia viscida	tacky phacelia	Boraginaceae	herb	annual	bee, BA	yes
Ribes sanguineum	red flower currant	Grossulariaceae	shrub	perennial	bee, HB, BA,BL	yes
Rosmarinus officianalis CVS	rosemary	Lamiaceae	ground cover/shrub	perennial	bee, BA	no
Salvia brandegeei	Brandegee's sage	Lamiaceae	shrub	perennial	bee	yes
Salvia chiapensis	Chiapas sage	Lamiaceae	herb	perennial	bee, HB	no
Salvia clevelandii	Cleveland sage	Lamiaceae	shrub	perennial	bee, HB	yes
Salvia greggii	autumn sage	Lamiaceae	shrub	perennial	bee, HB	no
Salvia 'Indigo Spires'	indigo spires	Lamiaceae	shrub	perennial	bee, HB	no
Salvia mellifera	black sage	Lamiaceae	shrub	perennial	bee	yes
Salvia microphylla	baby sage	Lamiaceae	shrub	perennial	bee, HB	no
Salvia spathacea	hummingbird sage	Lamiaceae	herb	perennial	bee, HB	yes
Scabiosa atropurpurea	pincushion flower	Dipsacaceae	herb	perennial	bee, BA	no
Sidalcea malviflora	dwarf checkerbloom	Malvaceae	herb	perennial	bee, BL	yes
Sphaeralcea ambigua	desert globemallow	Malvaceae	herb	perennial	bee, BL	yes
Solidago californica	California goldenrod	Asteraceae	herb	perennial	bee, BA	yes
Tithonia rotundifolia	Mexican sunflower	Asteraceae	herb	both	bee, BA	no
Verbena bonariensis	purple top vervain	Verbenaceae	herb	both	bee, BA	no
Wisteria sinensis	Chinese wisteria	Fabaceae	vine	perennial	bee, HB	no
Yucca spp.	yucca	Agavaceae	shrub/tree	perennial	MO	varies by species

KEY
bee = native and honey bees
HB = hummingbirds
BA = butterfly adults
BL = butterfly larvae
MO = moths
CVS = cultivars

Source: This table is based on a literature review, the Frankie Lab (UC Berkeley) California Statewide Survey (http://helpabee.org), and recommendations from Dr. Arthur Shapiro (UC Davis).
Note: Plant selection was based on medium to high levels of attractiveness to one group or multiple pollinators, commercial availability, and ability to flower within 2 years.

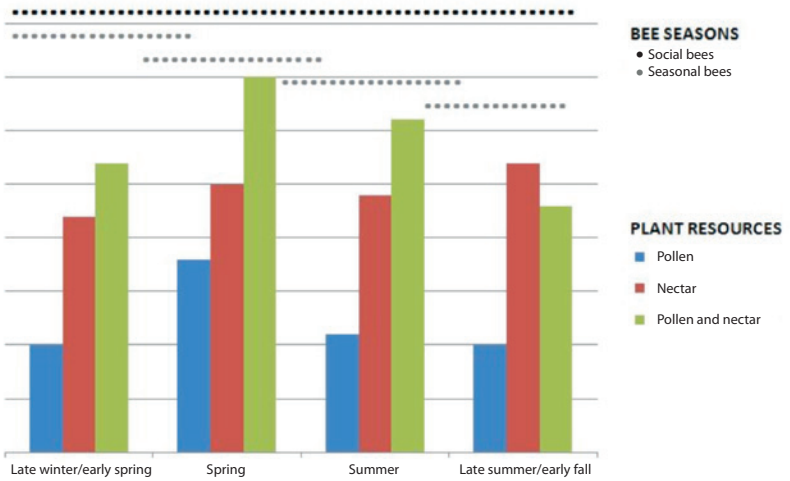

Figure 7. Generalized seasonality of native bees and floral resources in California.

has four main components: 1) preferred plants, 2) single-flower types grouped into individual patches, 3) seasonal sequence of nectar and pollen (fig. 7), and 4) at least 20 plant types. A water source is necessary for honey bees but not for native bees.

A highly variable habitat garden should start with at least 20 plant types to provide resources for a variety of bee species throughout the year. An ideal bee garden would have at least 20 patches of flowering plants with each plant type in its own patch. To select plants, consult table 1 as well as recommended plant lists from recognized online resources, such as the UC Berkeley Urban Bee Lab website (see "Useful Resources" at the end of this publication). It is important to select a variety of plants with nectar or pollen, as they are both necessary to meet the nutritional needs of native bees. Native bees have taxonomic groups with distinct emergence times (seasons) that can be matched with their preferred floral hosts. Native bees have four distinct foraging seasons, while honey bees continue to forage through all four seasons (see fig. 7). For example, early spring bees emerge in February to visit plants such as *Ceanothus* species (California lilacs) and *Arctostaphylos* species (manzanitas). Selecting plants to match multiple bees' foraging seasons (February–October) will encourage diverse groups of bees to visit your garden.

Through careful placement of plants, one can increase flower foraging for bee visitors. Arranging plants in patches of one plant type, with patches measuring at least 4 by 4 feet, will catch bees' attention as they search for flowers. (For converting U.S. customary units to metric units, see the table at the end of this publication.) Patches encourage bees to forage longer, and they make bees easier for gardeners to observe. Bees are always searching for new plants (new floral resources), which means that once the new habitat is completed they will be quick to appear.

Nesting Resources for Native Bees

Soil-nesting bees

Providing nesting resources for native bees transforms a habitat garden that allows bee populations to build up through time. Approximately 70 percent of native bees in California are solitary ground nesters, while 30 percent are cavity nesters. Ground-nesting bees look for patches of bare soil or soil with light leaf litter to construct nest tunnels to build their brood cells. Nesting is the least studied component of native bee ecology, and only general knowledge exists about the best soil type(s) for native bees. Soil preferences vary from species to species, with preferences ranging from sandy soils to clay-based soils. The best approach to encourage bee nesting is to leave the entire yard or a sunny area mulch-free. Common gardening practices of heavy mulching create physical barriers that prevent native bees from nesting, so use mulch sparingly.

Cavity-nesting bees

Cavity-nesting bees include those that use existing holes or spaces in which to construct their nests. One can help these bees by providing artificial nest sites for them, which are easy to construct or purchase from commercial outlets. Most cavity-nesting bees prefer to use dead-end holes 4 to 6 inches deep and $\frac{3}{16}$ to $\frac{5}{16}$ inch in diameter. Hollow sticks, reeds, bamboo sections, and drilled holes in wood blocks meeting these measurements are suitable for use. Normally these are tied into bundles with wire and hung horizontally in a protected and warm, north-facing area. A tiny roof can be added for additional protection from rain. Note that exposure to direct sunlight for extended periods may overheat the nests and kill the brood. We also recommend cleaning or discarding nests after 2 years of use to prevent a buildup of parasites and diseases. On its website, the USDA Agricultural Research Service provides a wealth

of information on techniques for constructing artificial nests and managing bees that use them (see "Useful Resources" at the end of this publication).

One cavity-nesting bee, *Osmia lignaria*, commonly referred to as the blue orchard bee (BOB), has proven effective in pollinating crops such as apples, cherries, and almonds. This bee prefers 5⁄16-inch-diameter holes for its nest sites, but it also requires mud to construct the brood cells and close the entrance of completed nests. Growers and gardeners wishing to attract this bee can assist it by providing a nearby source of clay mud in a tub or trench (Bosch and Kemp 2001; Griffin 2011).

Besides the blue orchard bee, many other bees and beneficial predatory wasps may use the nests, providing a fascinating window into the little known world of garden ecology (Grissell 2001).

Butterfly Gardens

A butterfly garden provides habitat for adult butterflies and their offspring to thrive (Xerces and Smithsonian 1998). Host plant flowers are critically important to maintaining butterflies' habitat. Providing preferred nectar-rich plants for adults is the starting point for providing habitat for these magnificent insects (see table 1) (Burris and Richards 2006). It is important to plant various flowers that provide nectar in bloom from late summer into early fall when butterflies are most abundant. When adults visit a garden, they are not only looking for a sip of sweet nectar—they are also scoping out potential plant hosts upon which to lay their eggs. Butterflies do not feed and raise their offspring; once their eggs hatch, the larvae feed on the plant their mother has chosen for them until they are ready to pupate, transforming into a chrysalis. These eggs will be laid on specific host plants known instinctively by the adult to be a nutritious source of food for her caterpillar offspring. Caterpillars are messy eaters, leaving chewed-up leaves and droppings (frass) as evidence of their presence. While their feeding results in less-than-picture-perfect plants, these host plants are a necessary food source for the growing caterpillar. If chewed leaves or flowers are undesirable, consider planting host plants in an out-of-the-way part of the garden (see also Shapiro and Manolis 2007).

Hummingbird Gardens

Plant attributes associated with hummingbirds include floral characteristics like a long trumpet shape, red color, large amounts of nectar, and little or no scent. Many tropical plants and at least 150 flowering plants in North America have evolved these characteristics to encourage hummingbird visitation (see table 1). Hummingbirds use their uniquely shaped long bill and tongue to dip deep into flowers to access nectar that is inaccessible to most other pollinators. The flowers in turn have evolved to place pollen on the hummingbird's head or body when it drinks nectar. Creating a garden with hummingbird plants, nesting habitat (trees), and feeders will ensure visits from these fascinating birds.

Providing hummingbird feeders is an easy technique to lure hummingbirds to your garden. However, supplying them with a clean, nutritious food source requires weekly maintenance. Begin with a clean feeder and add a sugary solution that is one part sugar to four parts water. Using honey or a stronger sugar concentration could be harmful or even fatal. Adding red dye to the solution is discouraged; most hummingbird feeders have red parts that will catch the hummingbird's eye. Feeders need to be taken down to be cleaned and refilled weekly. Wash the feeder with hot, soapy water, and rinse with hot, boiling water. Refill it with a fresh supply of solution, which can be made ahead and stored in the refrigerator. It is important to discard the old solution, as it can ferment into alcohol. If you live in a very hot area, the feeder should be cleaned and solution replaced every 2 to 3 days.

Conclusion

The services pollinators provide are usually taken for granted until we imagine a world without our favorite fruits, vegetables, and wildflowers. We can help pollinators by providing them food and habitat in our urban areas and encouraging the conservation of the wild areas surrounding us. Whether you tear out your lawn and install a pollinator-friendly paradise or replace a few of your ornamental plants with pollen- and nectar-rich natives, you are helping conserve a valued natural resource.

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Useful Resources

Annie's Annuals and Perennials Nursery: Plant information and pollinator planting guides. Annie's Annuals and Perennials website, https://www.anniesannuals.com/.

Art Shapiro's Butterfly Site: 34 years of central California butterfly research. Art Shapiro's Butterfly Site website, http://butterfly.ucdavis.edu/.

Brenzel, K. N., ed. 2012. The new sunset western garden book: The ultimate gardening guide. 9th ed. Menlo Park, CA: Sunset. (Contains plant information for over 8,000 plants as well as lists of recommended butterfly and bee plants.)

California Master Gardener Program website, http://camastergardeners.ucdavis.edu/. (Regional groups occasionally host local pollinator experts at meetings and workshops.)

Great Sunflower Project: Gretchen Le Buhn's (SFSU) citizen science native bee monitoring program. The Great Sunflower Project website, http://www.greatsunflower.org/.

Hedgerow Farms: Seed source for many California native plants. Hedgerow Farms website, http://www.hedgerowfarms.com/.

Las Pilitas Nursery: Native plant information and pollinator planting guides. Las Pilitas Nursery website, http://www.laspilitas.com/.

North American Butterfly Association: Information on butterfly gardening, research, and monitoring efforts. North American Butterfly Association website, http://www.naba.org/.

Pollinator Partnership: Pollinator-friendly planting guides. Pollinator Partnership website, http://pollinator.org/guides.htm.

Theodore Payne Foundation website, http://www.theodorepayne.org/. (Seed source for California native plants.)

UC Berkeley Urban Bee Lab website, http://helpabee.org. (Information on California native bees and planting guide.)

UC Davis Arboretum All Stars. UC Davis Arboretum website, http://arboretum.ucdavis.edu/arboretum_all_stars.aspx. (Information on "All Star" plants that are mostly native and support wildlife.)

University of California Integrated Pest Management (UC IPM) website, http://ipm.ucdavis.edu.

USDA Agricultural Research Service website, http://www.LoganBeeLab.usu.edu.

Xerces Society: Pollinator Conservation Resource Center. The Xerces Society for Invertebrate Conservation website, http://www.xerces.org/pollinator-resource-center/.

Local Bee Gardens in Northern California

Häagen-Dazs Honey Bee Haven Garden at UC Davis. Laidlaw Facility / Häagen-Dazs Honey Bee Haven website, http://beebiology.ucdavis.edu/HAVEN/index.html.

The Melissa Garden: A Honeybee Sanctuary. The Melissa Garden website, http://themelissagarden.com/index.html.

UC Berkeley-Oxford Tract Bee Evaluation Garden. UC Berkeley Urban Bee Lab website, http://www.helpabee.org/current-projects.html.

Measurement Conversion Table

U.S. customary	Conversion factor for U.S. customary to metric	Conversion factor for metric to U.S. customary	Metric
inch (in)	2.54	0.394	centimeter (cm)
foot (ft)	0.3048	3.28	meter (m)

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