“Creating Pollinator-Friendly Gardens” by Nancy Gilbert

1) The pollination process:
   a) What is pollination? the male pollen grains fertilizing the female ovules.
   b) Plants are basically immobile; plant strategies for pollination and genetic diversity:
      i) Gymnosperms, such as conifer trees (pines, cedars, firs, etc.), and grasses, sedges, rushes are wind-pollinated. Insects occasionally gather pollen of grasses and conifers.
      ii) Angiosperms are flowering plants and now dominate the terrestrial plant world. Pollination = the process of transferring pollen from the male anthers of a flower to the female stigma and the resulting fertilization of the ovules. Flowering plants have evolved to reward pollinators for visiting their flowers by providing nectar (sugar source) and pollen (protein, fats and other nutrients) that attract pollinators which then inadvertently move their pollen from flower-to-flower.
      iii) A nectary (nectar-producing organ) is usually positioned inside the flower so that visitors must make contact with the reproductive parts to access nectar. Many flowers have visual nectary guides to lead the pollinator to the nectary.
      iv) There is an incredible variety of floral shapes in nature, but they are all derived from the same basic structure. Angiosperms have tailored their flowers to the specifics of their chosen pollinator, variously making sure the flower appeals to their visual system, that the scent is picked up by their sense of smell, and that the flower is the right shape, size and design to fit their body.

2) Importance of healthy pollinator populations:
   a) 1/3 of all food crops require animals for pollination, i.e. One in three mouthfuls.
   b) Provide for resources such as oil crops, fibers and biofuel production.
   c) Vital for keeping plant and animal ecosystems healthy and productive. Plant and animal diversity is the key to healthy and resilient ecosystems that can adapt to environmental stresses and changes, such as global warming.
   d) Pollinators responsible for the reproduction of 75% of the flowering plants in gardens and wildlands.

3) Pollinators, especially bees, are in decline worldwide. Reasons:
   i) Large-scale habitat destruction and fragmentation.
   ii) Decline in wildland areas as resources for food sources and nesting sites.
   iii) The expansion of monocultures of non-flowering crops and eradication of roadside flowering plants with herbicides.
   iv) The spread of non-native plants that are unattractive to domestic pollinators.
   v) Widespread and increased use of insecticides, including systemic neonicotinoids
   vi) Climate change and global warming.
   vii) The spread of introduced diseases & parasites.

4) Meet the pollinators:
   a) Bees Most eat nectar and a little pollen and gather much pollen and a little nectar, which they mix to feed
their young. They are designed for flowers; the most reliable pollinators for native plants and home gardens.

b) Introduced honeybees most familiar of bees to people.

c) There are 1600 species of native bees residing in California.

i) Types/families of bees: Bees come in wide variety of shapes, colors, sizes, and lifestyles, enabling them to pollinate a diversity of plants.

(1) Short-tongued bee families=

(a) **Membrane & Polyester Bees.** Medium to tiny, slender. Named for membranous, cellophane-like secretions females use to line their burrows in soil or hollow stems. Tips of tongues broad and forked for lining/painting their tunnels. One genus transports pollen on scopae on hind legs, the other transports it internally so no scopae.

(b) **Mining Bees.** Are solitary, soil nesting bees with underground brood chambers. Prefer flat, bare ground for nests.

(i) Emerge late winter–early spring to visit early spring flowers.

(ii) Medium to small in size, usually with pale stripes on abdomen. Males smaller.

(iii) Pollen transport structures= scopa (stiff hairs) on hind legs & corbiculae rear side of thorax

(c) **Sweat Bees.** Name refers to fact some species will land on skin and lap sweat for moisture and salts. Large and diverse family. Medium to tiny and slender. Many are nondescript in appearance, but the metallic green sweat bees are shiny and metallic green. Collect pollen in scopae on hind legs and hairs on sides of abdomen, are solitary ground nesters in bare soil.

(2) Long-tongued bee families

(a) **Leafcutting, Mason, Resin & Cotton Bees.** Large and diverse group of bees. Architects of the bee world. Use cavities such as tunnels of boring insects, hollow plant stems, to construct brood chambers lined with pieces of leaves and flowers, plant fibers, mud, resins, hairs, and pebbles. Most females transport pollen on scopae on underside of their abdomens. Look for neat cut-outs on leaves and flowers. Will occupy nest blocks.

(b) **Digger, Honey, Bumble & Carpenter Bees.** Large and diverse group. Usually large, stout in shape.

(i) **Digger Bees**-Females larger than males. Transport pollen in scopa (tufts of stiff hairs) on hind legs. Abdominal segments separated by band of fine hairs. Solitary and nest in the soil in bare, flat ground or steep banks. Nests may be clustered together in large aggregations.

(ii) **Honeybees**- non-native and domesticated; are perennial, social, colonial bees that can nest in cavities but usually kept in hives, which can be transported about. Worker bees transport moistened pollen in corbiculae (pollen baskets) on hind legs. Only bee species that makes honey. Important for agricultural crops yet not the most efficient bee pollinators. Are in decline; colony collapse disorder, varroa mites, etc.

(iii) **Bumblebees**-Medium-sized to large and stout, with dense black hair and bands or patches of contrasting colored hairs. Females transport pollen in moist pellets in corbiculae (pollen baskets) on hind legs. Queens largest
with smaller workers and male drones; unlike honeybees, all forage at
flowers. Are social bees with a colonial nest, usually underground in
abandoned burrow or bird’s nest in cavities, or dense grass tufts. Can ‘buzz-
pollinate’ flowers with tubular anthers such as tomatoes, blueberries and
cranberries. Species with short tongues can be nectar robbers. Can be active
in cooler weather than most bees, as can shiver flight muscles to warm
themselves and their brood. Cuckoo bumblebees are social parasites.

(iv) Mountain, California and Valley Carpenter Bees - Large, shiny, stout
with sparse hair. Females mostly black. Males have some pale or golden
hairs on thorax and green or gray eyes. Females transport pollen on scopae
on hind legs. Short, blade-like tongues can pierce flowers for robbing nectar.
Females can sonicate/blast the pollen from flowers with tubed, pored
anthers, such as tomatoes and eggplants, using their flight muscles. Females
can live for several years. Nests are complex tunnels in wood (including
fence posts and beams of structures) or pithy stems.

(v) Parasitic Bees-About a quarter of bee species are parasites, laying their
eggs in the nests of other bees and letting them do all the work. Females Do
not collect pollen or construct nests. Often look wasp-like. There are solitary
parasites, called Cuckoo Bees, which enter the nest of solitary nesting bees,
lay an egg there, which hatches, kills the larvae and eats the provisions of
the host bee. Also are social parasites, such as Cuckoo Bumblebees, which
parasitize established colonies of bumblebees. They usually subdue or kill
the queen and enslave the workers with pheromones.

d) Wasps—Closest relatives of bees. Adults generally feed on flower nectar and rotting fruit,
but a few are meat eaters (Yellow Jackets). Don’t transport pollen externally and less
efficient pollinators. Some solitary and some social. Larvae are generally carnivorous
parasites on other insects or spiders. Can mimic bees and sometimes tricky to tell apart.
Key differences:
  i) Bees generally have hairy bodies, while wasps have little or no body hair and often
     have a rough integument (skin) that is pitted.
  ii) Wasps antennae generally very close together on the face.
  iii) Wasps usually have more elongate bodies, very thin waists and spindly legs.
  iv) Unlike female and worker bees, wasps don’t have adaptation on legs or bellies for
     transporting pollen.
  v) Have short tongues and frequent shallow-flowers like those in the Carrot and Sunflower
     family.

e) Flower and Bee Flies Some are bee look-alikes; are often inefficient pollinators, but
important pollinators for the carrot family (Apiaceae) and in cold climates and weather.
Adults are generalist pollinators, visiting flowers to feed on nectar, pollen or prey on insects
and their larvae often predators or parasites of other insects. Differences flies and bees:
  i) Flies have single pair of wings; bees have two pairs of wings. The second pair is
     converted into stalked knobs which are called halteres or balancers.
  ii) Flies have short antennae; bees have well-developed antennae.
  iii) Flies have wide connection between thorax & abdomen; bees & wasps have very
     narrow connection between thorax & abdomen.
iv) Flies have triangular heads when viewed from above and large, forward-facing eyes.

f) **Beetles**—Beetles represent the greatest diversity of pollinators. Adult beetles not efficient pollinators, but do pollinate plants as they feed on pollen. Pollen collects on them and is transported. Most common beetle types to visit flowers are: Soldier beetles, Long-horned beetles, Jewel Beetles, Blister Beetles, Flower Scarabs, Checkered Beetles, Tumbling flower Beetles, and Sap Beetles. Certain species, such as California Anemone, Coffeeberry, Deerbrush, and many native bulb species attract large numbers of beetles.

g) **Butterflies** Stunning daytime pollinators that gardeners enjoy luring into their gardens. Not as efficient pollinators as bees, but as they visit flowers for nectar, they collect pollen on their bodies and hairs of legs, thus pollinating as they go. Butterflies consume only nectar as adults; don't feed on or gather pollen. Have long tube-like tongue for feeding that bypasses the pollen-bearing anthers. Caterpillars (butterfly larvae) require specific host plants to feed on. If you want butterflies in your garden, you need to tolerate some plant damage from their caterpillars. Antennae have a bulb-like swelling at the ends.

h) **Moths** Have hairier and denser bodies than butterflies. Males have feathery antennae for tracking females and female antennae lack a swelling, or know, at the tip. Mostly evening fliers attracted to late afternoon, night, and early-morning fragrant flowers. Colorful moths, such as Tiger Moths, usually bad-tasting as a defense. Day-flying Hawk Moths such as the Snowberry Clearwing resemble. Bumblebees in appearance and in flight resemble hummingbirds. Moth larvae also are caterpillars that feed on specific host plants.

i) **Hummingbirds** Most prominent pollinating bird in N. America. Long beaks and tongues for drinking nectar from tube-shaped flowers Pollen grains adhere to feathers so pollinate as they visit many flowers per day. Attracted to red toned, tubular flowers most.

5) **General strategies for ‘Bringing Back the Pollinators’**: Many native bees, honeybees, butterflies and other pollinator species are in world-wide decline. Ways to help restore pollinators to healthy levels:

a) Don’t use toxic pesticides to combat insect problems. Use IPM techniques and tolerate some damage to vegetation as an aspect of co-existence within sustainable ecosystems.

b) Reduce routine use of herbicides by agencies and agriculture, including in roadway ditches and easements. Work with and pressure state, county and federal agencies to bring back roadside vegetation that supports pollinator plants.

c) Support regional public and private efforts to preserve and restore pollinator habitats, including preserving existing sensitive and valuable habitat as a requirement in County community general plans and regulations, promoting pollinator-friendly, low water use landscaping in residential, commercial, industrial, and public/institutional projects.

d) **Restore pollinator habitat one garden at a time** by adding pollinator-friendly plants into your yard, orchard, veggie garden, or community gardens.
e) On a larger scale, plant pollinator supporting hedgerows around and between fields in larger scale farmland, orchards, pastures and vegetable growing plots.

f) Create pollinator habitat at nature centers, state, regional and national park facilities, commercial and industrial business parks, etc.

6) **General Design Guidelines for creating pollinator friendly gardens and habitats:**

a) Evaluate the site: get to know your outdoor spaces, whether a small yard, large rural property or a farm etc.

i) What type of soils & geology do you have, where are the sunny and shadier areas, where is it windy and where is it calmer, what are your drainage patterns, dry areas and moist areas? These factors all determine habitat niches for different insects and which plants that will grow where?

ii) What plants and pollinators already exist in your woodlands, orchard, yard, farm or garden? Go out and observe and take photographs

iii) Educate yourself with books and the internet; the Xerces Society website is invaluable, as is the CNPS state website.

iv) Visit your County Resource Conservation District (RCD) office for information and workshops.

v) Visit bee and pollinator gardens at arboretums, display gardens in your area

vi) Think creatively: no outdoor space is too small to create a positive impact on pollinators. Even a small outdoor patio or deck can be made very attractive to pollinators. You can plant in pots as well as in the ground.

b) Create a habitat garden that provides pollinators with the resources they need for survival. What is good for the bees generally supports the other pollinators and wildlife. Insects need the same basics for survival as all life and to provide them with what they need to thrive, habitat gardens will be bit messier than conventional gardens...here’s how and why:

1) **Provide Food:** Flower nectar provides sugar for energy and lipids, amino acids, vitamins and minerals. The higher the sugar content, the more attractive a flower is to pollinators. Pollen is high proteins, carbohydrates, lipids and vitamins. It is especially valuable to bees which feed it to their larvae. Some pollinators utilize fruit, sap, minerals from mud or animal dung for some butterflies. Butterfly and moth caterpillars require their preferred or required larval host plants in your garden or nearby.

2) **Provide Water:** birdbaths with pebbles and stones to climb on, shallow dishes, shallow depressions in rocks or logs that collect water, irrigation sprinklers and misters to moisten leaves; puddling areas for butterflies so they can access minerals. Honeybees need a water source, but native bees don’t.

3) **Provide Shelter:** to hide from predators and rest, include a variety of trees, shrubs, groundcover plantings and bunchgrasses; rocks and rock outcrops, dry stacked rock walls, retaining walls, cracks and crevices in fences and posts, etc., fallen logs, small brush piles, leaf, needle and bark/wood chip ground mulches. burrows and other ground cavities.
(4) Provide places to rear their young; protected areas to lay eggs and raise young, which includes many of same strategies listed under shelter. Examples: tree and ground cavities, pavers and stepping stones on a sand or gravel base, hollow plant stems, patches of bare dry and muddy soil, tree stumps, and various larval host plants for caterpillars.

(5) Structure garden so tallest plants are in the back, tapering to shorter plants in front for ease of observation and maintenance and so pollinator plants benefit from the maximum sunshine.

(6) Location...Location: Locate your pollinator garden where it is sunny most of the day and sheltered from high winds. Most pollinators prefer to visit flowers in the sun.

c) Provide a succession of flowers throughout all of the seasons by planting a diversity of plant types and species/cultivars.
   i) You want a succession of overlapping blooms from late winter to early spring (Feb-March) through summer and into late fall (October).
   ii) Ideally would have a minimum of 20 plant types to accomplish this, but if your space is small, plant a few groupings of the very best pollinator attracting plants
   iii) Insect pollinator species have varied seasons of adult activity and you want to ensure food is available for their individual seasons.
   iv) Pollinators have differing preferences for the types of flowers they visit to collect pollen and/or nectar. Plant wide variety of flower types, shapes, sizes and colors that offer nectar and/or pollen or both. Plant annuals, perennials, shrubs and trees.
   v) Some flowers are structured to attract particular pollinators and have fascinating strategies to ensure they are pollinated by their insect or hummingbird visitors
   vi) Most butterflies prefer fairly flat-topped flowers and flower clusters that give them a good landing pad.
   vii) Provide a diversity of flowering plants and group plants of the same species in large drifts/patches rather than a one-here, one-there approach as this makes foraging easier for pollinators. Plant each plant species in patches approximately 4 ft. x 4 ft.
   v) Leave some flowering weeds and don’t prune back all your plants over winter. Many plants, such as non-native thistles and dandelions, are actually good pollinator plants, so leave a few; discourage them setting too much seed by removing them after flowering.

vi) Butterfly and moth larvae often overwinter among vines, under mulch, logs, stumps and branches, attached to stems and branches, under rocks and logs, so don’t be overly tidy if you want to see adult butterflies in your garden.

d) Use mostly native plants in pollinator gardens. Native plant gardens are a magnet for pollinators.
   i) Most pollinators evolved with and are best adapted to foraging at native flowering plants.
   ii) California has one of the richest bee-flower faunas in the world. We host over 6,000 species of flowering plants in California.
   iii) Pollinator life cycles often synchronized with their preferred native plant patterns and time of flowering
   iv) Native plants are better adapted to our local and regional soils and climate, thus using less water, fertilizers and pesticides
v) Butterfly and moth larvae often have specific larval host food plants and the majority of those are native plants, since they evolved together.

7) **Specifics for Bees Gardens**: Honeybees are generalized foragers and visit a wide variety of flower types over all four seasons. Native bees usually have more specific types of plants and flowers that they visit and are more efficient pollinators than honeybees.
   a) Must have flowers that provide both nectar and pollen over early spring, summer and fall. Native bee species emergence is timed to forage and pollinate their preferred plant species’ flowers.
   b) Plant each plant species in patches approximately 3.5 ft. x 3.5ft. (or about one square meter) to attract bees and to make their foraging time more efficient. Shape of patches can vary. Bees have floral constancy and small-sized native bee species do not travel large distances for food sources.
   c) Diversity of flower types. Short--tongued bees (also flies) have difficulty accessing the nectar or pollen in long-tubed flowers and are attracted to more open-shaped flowers with shorter corolla tubes. Long-tongued bees can access longer-tubed flowers.
   d) Provide nesting sites for native bees to raise their young.
      i) 70% are **ground nesters**, most are solitary but some social (bumblebees) or semi-social. don’t heavily mulch everywhere in your garden. Leave or create large patches of bare earth and light leaf litter in sunny locations, both in flat areas and on sloping banks; don’t disturb these bare areas with tilling, raking, foot traffic. Pavers or stepping stones set in sand also provide nesting sites and shelter for ground nesting bees.
      ii) **Cavity nesting bees**- Carpenter bees, mining, leafcutter and mason bees: use existing holes or spaces to construct nests, except Carpenter bees, which construct tunnels in wood; so add a few redwood fence posts to your garden. Natural cavities include hollow stems of plants, tree holes, abandoned mice burrows in soil, beetle burrows in wood, and old bird houses.
      iii) Can construct special bee boxes for bumblebees, bee boxes and boards with tubes of various sizes and materials for cavity nesting bees. For tubes, can use bamboo sections, straws, hollow reeds, rolled cardboard, holes drilled into wood blocks. A small roof can be added for protection from rain. Locate where they will not be exposed to direct sunlight for long periods.
         1) Wasps and other beneficial insects may also use your artificial nests
         2) Most prefer dead-end holes 4”–6” deep and 3/16 to 5/16 inch in diameter.
         3) Clean nests every 2 years to prevent parasites and diseases.
   iv) Mason bees need mud to line their nest cavities so leave bare areas where soil becomes muddy from rain or irrigation.
   v) Leaf-cutting bees line their nests with pieces of leaf they cut out, so don’t panic and apply pesticides if you see neatly cut-out holes in the leaves of some of your plants.
vi) Honeybees use resins from plant such as willows, alders, conifers to make bee propolis (bee glue). Used as a sealant in the hive. Polyester, resin and membrane bees also manufacture secretions to line their nests. Tolerate sap flows and resins on bark and buds.

8) **Specifics for Butterfly Gardens:**
   a) Provide the preferred nectar rich pants for the adult butterflies from spring through autumn. Preferred flowers vary by species, but most all butterflies are attracted to members of the carrot, mint, milkweed, buckwheat, buckthorn, and sunflower families, as well as the flowers of our CA native bulbs.
   b) Male butterflies of many species receive mineral nutrients they need to attract mates by puddling. They gather in large numbers on the edge of mud puddles and wet soil to take in the minerals. Provide puddling areas in your garden by leaving low lying bare areas of soil that can be moistened or shallow trays filled with mud.
   c) Sunny, sheltered spaces out of the wind are best locations for butterfly gardens. Provide sunning rocks and branches for them to warm themselves on cool mornings.
   d) Many butterflies drink water and look for shallow sources such as edges of birdbaths, puddles in rock depressions, water left on the surface of leaves.
   e) Butterflies and moths do not feed and raise their offspring. Larval host food plants are critical to maintaining butterflies’ habitat.
      i) Females are selective and instinctively only lay their eggs on the preferred larval host plants. The eggs hatch, the larvae feed on the host plant, eventually pupate and then emerge as adult butterflies. Only a few out of hundreds of eggs survive to adulthood.
      ii) Most important native food plants for caterpillars are buckwheats, willows, ceanothus, deerweed, milkvetch and lupines, mallows, oaks, rock cress and mustards, violets and grasses.
      iii) Specialty larval host plants include Milkweeds for Monarchs, Dutchmans’ Pipe for Pipevine Swallowtail, False Indigo for the CA. Dogface Butterfly (state insect), Bleeding Heart for the Clodius Parnassian.
   iv) Caterpillars are often beautiful and/or amazing looking in their own right, but are messy; leave droppings (frass) and chewed-up leaves, but this is the price we pay for having these beautiful insects in our gardens. If this is undesirable for you, locate your butterfly host plants in out-of-the-way parts of the garden.

9) **Specifics for Hummingbird Gardens:**
   a) Hummingbirds have uniquely shaped bills and tongues to dip deep into tubular flowers to access nectar. The flowers they visit evolved mechanism to deposit pollen on the hummingbird’s head or body as it drinks nectar.
   b) You can put up hummingbird feeders, but they must be taken down, cleaned and disinfected regularly and refilled with fresh supply of refrigerated solution or you can do more harm than good. Bears, raccoons, squirrels, and bees and wasps, etc. also like to visit hummingbird feeders so locate with care.
c) Best flowers for attracting hummingbirds are usually trumpet shaped and red in color but also visit flowers of other colors.
d) Hummingbirds also eat small insects and spiders and sip tree sap.
e) Provide drinking water in shallow bird baths or pans, or from drippers and misters.
f) Most nest on branches in trees and use lichens and mosses knit together with spider silk to camouflage their tiny nests. They sometimes nest in unexpected locations in more urban settings.
g) Hummingbirds are very territorial and like sentinel perches from which to survey their flower patch and preen their feathers.

• Top California Native Pollinator Attracting Plants:

**Trees:** Mostly spring blooming. CA. Buckeye (*Aesculus californica*), *Cornus nuttallii* (Pacific Dogwood), *Arbutus menziesii* (Pacific Madrone), all *Quercus spp* (Oaks), *Chilopsis linearis* (Desert Willow), *Fraxinus dipetala* (Flowering Ash), all *Salix spp.* (Willows), *Prunus spp.* such as Chokecherry and Hollyleaf Cherry, Serviceberry species, native plums, etc., *Acer macrophyllum* (Bigleaf Maple), Mountain Mahogany (*Cercocarpus betuloides*).


**Perennials:** Bloom periods vary spring–fall: All native bulbs and corms, *Amorpha californica* (Flase Indigo), *Asclepias spp.* (Milkweeds), all members of the *Asteraceae* family (Sunflower family), *Epilobium canum* and cultivars (CA. Fuchsia), *Eriogonum spp.* (Buckwheats), *Heuchrea spp.* (Alumroots), Native *Iris spp.* and hybrids, the Mallow family, such as *Sidalcea spp.* and *Sphaeralcea spp.*; *Mimulus spp.* (Bush Monkeyflowers), Mint family, such as *Monardella spp.* (Coyote Mints and Pennyroyal), *Agastache urticifolia* (Horsemint), Lepechinia (Pitcher Sages) spp., *Penstemon spp.*, *Romneya coulteri* (Matilija Poppy), *Salvia spp.* (native sages); native bunch grasses, vines, such *Aristolochia californica* (Dutchman’s Pipe), *Lonicera spp.* (Honeysuckles) and native *Clematis spp.*

**Native Annual Wildflowers** (best planted from seed): Most are spring to early summer bloomers—*Clarkia sp.*, *Lupinus spp.* (Lupines), *Eschscholzia spp.* (CA & Tufted Poppies), *Lotus spp.* (Hill & Spanish Lotus), *Nemophila spp.* (Baby Blue Eyes, Five spot), Common Tidy Tips, *Gilia capitata* and other *Gilia spp.*, *Phacelia spp.* (Caterpillar & Lacy Phacelia), *Collinsia spp.* (Chinese Houses), native clovers such as Owl’s Clover, *Jensia spp.*(Common & Ramm’s Madia), *Helianthus spp.* (Common & Bolander’s Sunflower) *Mimulus spp.* (annual monkeyflowers).
Informative websites on pollinators and pollinator-friendly gardening and agroforestry:

https://xerces.org

https://anrcatalog.ucanr.edu/pdf/8498.pdf


https://www.plants.usda.gov/pollinators/Enhancing_Nest_Sites_For_Native_Bee_Crop_Pollinators.pdf


http://www.helpabee.org/common-bee-groups-of-ca.html

http://butterfly.ucdavis.edu/doc/garden/foothills

http://www.laspilitas.com/wildlife/California_Bumble_bees.html