Only Issue 2008, See Page 3

COMMON SENSE PEST CONTROL QUARTERLY

VOLUME XXIV, NUMBER 1-4, SPECIAL ISSUE 2008

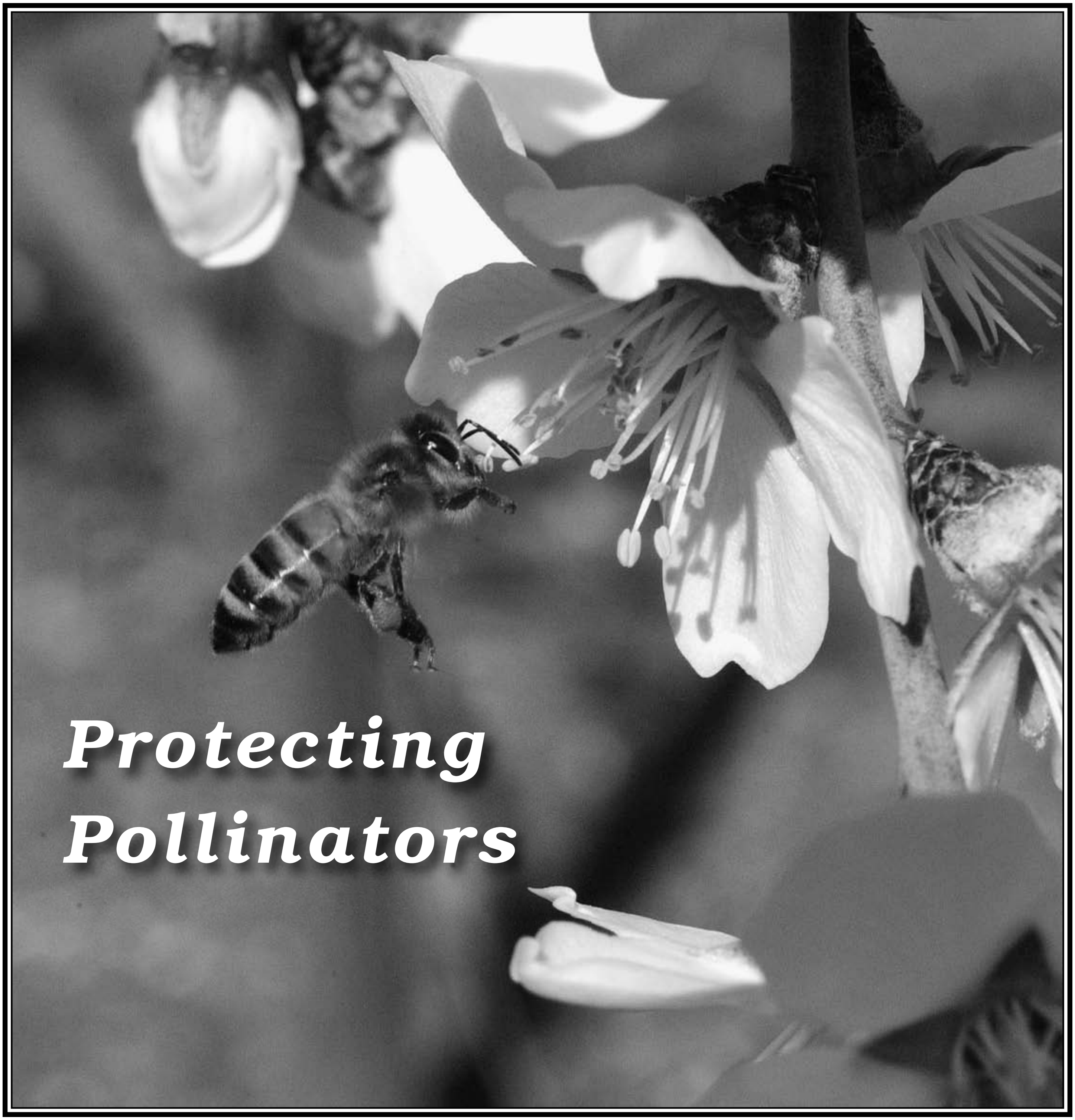


Photo courtesy of Kathy Keatley Garvey

An Invitation to Join

B · I · R · C

The Bio-Integral Resource Center

BIRC, A NON-PROFIT CORPORATION, WAS FORMED IN 1979 to provide practical information on the least-toxic methods for managing pests. The interdisciplinary BIRC staff and an international network of advisors and research associates have designed highly effective alternative solutions to a wide variety of pest problems throughout the world. This work has been based on the principles of 'Integrated Pest Management' or 'IPM'.

IPM IS A DECISION-MAKING PROCESS that considers the whole ecosystem in determining the best methods for managing pests. The objective of an IPM Program is to suppress the pest population below the level that causes economic, aesthetic, or medical injury. IPM strategies are designed to be the least disruptive of natural pest controls, human health, and the general environment. Horticultural, physical, mechanical, biological, least-toxic chemical, and educational tactics are integrated to solve pest problems with a minimal reliance on pesticides.

THE IPM APPROACH HAS GAINED FAVOR with government and business because it is cost-effective. Community groups and pest management professionals are enthusiastic about IPM programs because the use of toxic materials is reduced while better pest control is achieved.

BECOME A MEMBER OF BIRC! Membership in the Bio-Integral Resource Center supports our ongoing research program devoted to evaluating and disseminating alternative strategies for the many pest problems still being treated exclusively with pesticides. Membership support also enables BIRC's technical staff to continue to provide information and assistance to individuals and organizations endeavoring to change pest control policy and practices in their communities and places of work.

BIRC MEMBERS RECEIVE ONE OR BOTH OF OUR JOURNALS, the *Common Sense Pest Control Quarterly* and *The IPM Practitioner.* Members are entitled to consultations by phone or correspondence on an individual pest problem each membership year. Just write a description of the problem and send it to BIRC. Our technical staff will research the problem and provide you, if possible, with least-toxic solutions. BIRC memberships are tax-deductible to the extent allowed by law.

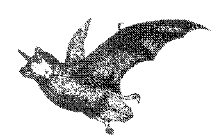
MEMBERSHIPS. Individuals can join BIRC for $30/yr and receive *Common Sense Pest Control Quarterly*, or they can pay $35/yr to receive the *IPM Practitioner.* Dual Members pay $55/yr and receive both journals. Institutional rates are $50/yr for the Quarterly, $60/yr for the Practitioner and $85/yr for both journals. Sustaining Members pay the Dual Membership fee and may also choose to donate to sustain BIRC activities. FEI# 94-2554036

FOREIGN POSTAGE. Professional and Associate Members from Canada and Mexico, add $15 for the *Practitioner* and $5 for the *Quarterly*; Dual Members, add $20 to cover postage for both journals. Professional and Associate Members from other countries, add $25 airmail for the *Practitioner*, $10 airmail for the *Quarterly*; Dual Members, add $35 to cover airmail postage for both journals.

Got A Pest Management Question?

If you have a specific pest management question, first check our website, www.birc.org. Often you will find a publication that covers your problem. If you do not find the solution on our website, you can write us with a description of the pest and the problem. Include scientific names of the pest. You can also email this information to birc@igc.org. We will respond as quickly as possible.

Common Sense Pest Control Quarterly is published four times per year by the Bio-Integral Resource Center (BIRC), PO Box 7414, Berkeley, CA 94707, 510/524-2567.



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 ISSN 8756-7881

On the Research Front

Vikane® is a Greenhouse Gas

Vikane (sulfuryl fluoride) is a fumigant gas commonly used to rid houses of drywood termites and other pests. It has supplanted methyl bromide, which depletes stratospheric ozone and is more hazardous. Unfortunately, sulfuryl fluoride has its own atmospheric problems. University of California, Irvine scientists have found that the chemical may persist in the atmosphere for up to 100 years. Atmospheric levels have nearly doubled in the last six years.

According to the study, sulfuryl fluoride is 4,000 times more potent as a greenhouse gas than carbon dioxide. Its effect on the climate each year in California is equal to the amount of carbon dioxide emitted from one million vehicles.

From: *Environmental Science and Techology*, Online January 21, 2009

Soap Solution Kills Cockroaches

Commercially available soaps and detergents have been shown to kill cockroaches. Because these formulations are proprietary and change frequently, University of Florida researchers tested pure salts of fatty acids (soaps) for their effects on cockroaches. Potassium and sodium laurate caused up to 95% mortality of German cockroaches, *Blattella germanica*; and up to 100% mortality of American cockroaches, *Periplaneta americana*. Dry salts and residues were not effective. Cockroaches had to be thoroughly wetted with 1-2% aqueous solutions of fatty acid salts. Spiracle penetration may be necessary to cause mortality.

Baldwin, R.W., P.G. Koehler and R.M. Pereira. 2008. Toxicity of fatty acid salts to German and American cockroaches. *J. Econ. Entomol.* 101(4):1384-1388.

Local Treatments for Drywood Termites

About 70% of California homeowners chose local chemical treatments to control drywood termites. Surprisingly little has been published on the field effectiveness of these chemicals, especially the newer ones (see *IPM Practitioner* 30(1/2) 2008). University of California Professors Mike Rust of UC Riverside and Vernard Lewis of UC Berkeley have published preliminary results of laboratory and limited field tests. Naturally infested boards were injected, then assayed for termites 3 months later. Termidor® (fipronil) killed 100%, Timbor® (borates) 99%, Boracare® (borates) 98%, XT-2000 (orange oil) 81%, Optigard (thiamethoxam) 81%, and Premise Foam (imidacloprid) 41%.

Lewis, V.L. and M. Rust. 2009. Drywood termite control. Preliminary laboratory evaluation of chemical local treatments for drywood termites. *PCOC* Spring:14-17.

Giant Knotweed Extract Registered in California

Extracts of the giant knotweed, *Reynoutria sachalinensis*, have been registered in California under the brandname Regalia® by Marrone Organic Innovations of Davis, CA. Regalia causes plants to produce natural proteins and other compounds that inhibit development of diseases such as powdery mildew, *Botrytis*, downy mildew, bacterial blight and others. See www.marroneorganicinnovations.com

Accuracy of Bed Bug Dogs

Bed bug sniffing canines are useful pest management tools. University of Florida Researchers tested their accuracy. Dogs were able to detect the difference between bed bugs, carpenter ants, cockroaches and termites with a 97.5% positive indication rate with no false positives. They were able to tell the difference between live bed bugs, viable eggs and dead bed bugs and eggs, cast skins and feces with a 95% positive indication rate and a 3% false positive rate on bed bug feces. They were 98% accurate in detecting live bed bugs in hotel rooms.

Pfiester, M., P.G. Koehler and R.M. Pereira. 2008. Ability of bed bug-detecting canines to locate live bed bugs and viable bed bug eggs. *J. Econ. Entomol.* 101(4):1389-1396.

Dear BIRC Members!

We are extremely proud of this issue of *Common Sense Pest Control Quarterly*, "Protecting Pollinators," as it provides a plan for pollinator conservation through pesticide reduction and landscaping choices. "Protecting Pollinators" complements, "Pesticides and Honey Bee Colony Collapse Disorder," which appeared in the *IPM Practitioner*.

These publications add to an impressive portfolio of work. BIRC's recent feature articles, "Feedlot Antibiotics Produce Pathogens," "Global Warming Means More Pests," and "Light Brown Apple Moth—Crisis of Trust" are invaluable resources for policy makers.

In recognition of thirty years of journalistic excellence, BIRC is receiving an IPM Lifetime Achievement Award at the 6th International IPM Symposium this March.

This award is especially meaningful since our recent editorial calendar was accomplished on the leanest budget we have faced in years. Due to the current recession, some of our contracts and grants have been frozen, with invoices unpaid. This has led to a reduction in staff hours, and lengthy delays in our publication schedule.

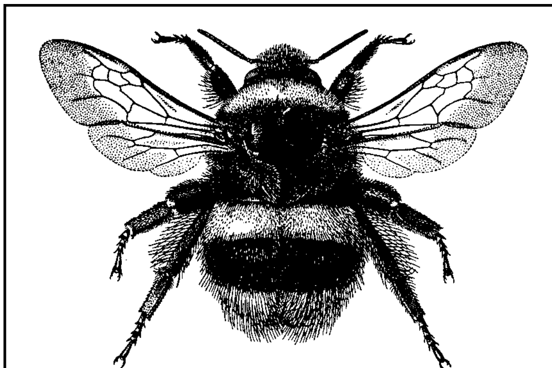
To catch up on our publication schedule, we are producing only one *Quarterly* issue for 2008. The next *Quarterly* you receive will have a 2009 publication date.

We apologize for this change, but financial circumstances leave us with no other choice. If you are able to make a donation at this time, please send a check to BIRC, PO Box 7414, Berkeley, CA 94707. You can also use your Visa or Mastercard. Your donation is tax deductible and your help is deeply appreciated. We hope the fortunes of BIRC will improve with the economy.

Sincerely,
William Quarles, Ph.D.
BIRC Executive Director

Protecting Native Bees and other Pollinators

By William Quarles



Bumble bee, *Bombus* sp.

From Nixon 1954

More than 75% of flowering plants need animal pollinators. Pollinators fertilize plants, and plants feed pollinators in a relationship that goes back more than 100 million years (see Box A). But during the past 60 years, pollinator numbers in North America and elsewhere have seriously declined. We have lost about 45% of our honey bees, and native bees, butterflies, bats, and hummingbirds are also affected (NAS 2007).

Causes for the decline include pesticides, parasites, diseases, development, habitat fragmentation, destruction of nesting sites, and lack of floral resources. For instance, flowering buckwheat acreage in New York State has dropped by 95% over the past 100 years. Wild native plant populations that fed native bees and butterflies have been destroyed by herbicides and development. Instead of the diverse crops that fed many pollinators, agriculture has shifted to large monocultures pollinated by honey bees. But even honey bees are at risk due to colony collapse disorder and other problems (Morse 1975; Allen-Wardell et al. 1998; NAS 2007; Quarles 2008). And global warming may also be affecting the synchronicity between the flowering plants and their pollinators, especially butterflies (Quarles 2007a; NAS 2007).

Both managed and wild pollinators are being killed by pesticides. Mosquito control programs, sprays for forest pests, lawn insecticides, and crop production chemicals are all part of the problem (Quarles 2008). In one well-known example, insecticides sprayed for forest pests in New Brunswick killed native bees that were pollinating blueberries. Loss of pollinators resulted in a 73% reduction of blueberry yields (NAS 2007; Buchmann and Nabhan 1996).

Yellow-faced bumble bee, *Bombus vosnesenskii*

Photo courtesy of Gary McDonald

Pesticide destruction of pollinators has also caused documented losses in alfalfa, pumpkins, and other crops. The crash of pollinator populations is often felt throughout ecosystems. Loss of food due to lack of pollination has impacts on birds and other wildlife (Allen-Wardell et al. 1998; Buchmann and Nabhan 1996).

Habitat Fragmentation and Decline

Because of widespread development, wild vegetation has been fragmented into islands of flowering plants, pollinators, and associated wildlife. Fragmentation disrupts both local populations and migrating species. Migratory species such as the Monarch butterfly, *Danaus plexippus*, need nectar corridors all along their route, so habitat fragmentation can reduce the numbers of migrating butterflies (NAS 2007).

Pollinator decline in the U.S. has been clearly established only for the honey bee and a few native pollinators. Decline of native pollinators in other countries has been documented through intensive monitoring programs. Longterm monitoring of native pollinator populations in the U.S. is needed to determine the extent of the problem here (see below) (NAS 2007).

But decline of pollinators in the U.S. has been tracked indirectly through plant surveys. One survey showed pollen limitation in 62% of the 258 species studied. Lack of pollination can lead to fewer seeds and reduced populations. Isolated stands of wildflowers with special pollination needs can go extinct. Fewer floral resources lead to fewer specialized pollinators and finally population collapse in an "extinction vortex" (Spira 2001; NAS 2007).

Food in the Garden

Farmers are concerned about the pollinator crisis because honey bee pollination costs are increasing. Wildlife biologists are concerned that some plant species may go extinct (NAS 2007). But home gardeners should also be concerned. If the food grown in your garden has shown a drop in quality or yield, you could have a pollinator problem. Fifteen of the 23 most commonly grown garden vegetables require pollination to increase yields and produce seeds. These include onions, cucumbers, peppers, lettuce, radishes, carrots, cabbages, squash, broccoli, egg plants, pumpkins, asparagus, herbs, and brussels sprouts. Fruit trees, citrus and berries also benefit from pollination (Moffett and Barclay 1984). Home gardeners should be protecting pollinators to improve yields and quality of food produced (NAS 2007). Another route to insure pollination is to become a keeper of honey bees (see Resources).

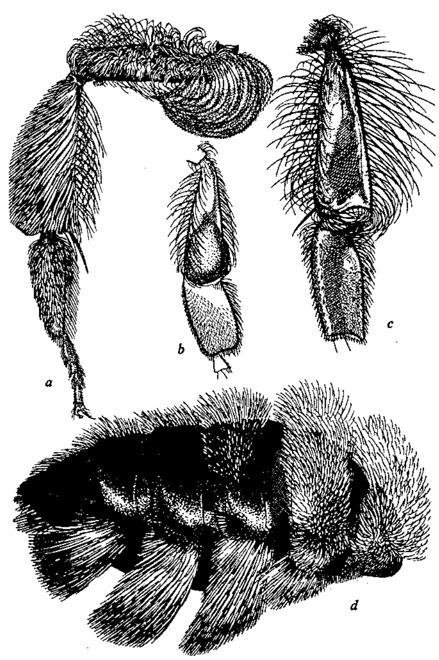
Protecting Pollinators

We can protect pollinators by avoiding pesticides and providing food, water, and nesting sites in our backyards and in crop production areas. Pollinator protection could easily be added to a number of existing wildlife conservation programs. The Humane Society and the Audobon Society both have Urban Wildlife Sanctuary Programs. There is also Bay Friendly Landscaping in the San Francisco Bay Area, the Backyard Wildlife Sanctuary Program in Washington State and others (see Resources). By making our backyards sanctuaries, we can improve the quality of life for pollinators, urban wildlife and ourselves (NAS 2007).

Avoid Pesticides

To protect pollinators, we can avoid pesticides. Pollinators such as bees, and other beneficial insects such as ladybugs, lacewings, and parasitic wasps are easily killed by insecticides. For a number of reasons, beneficials are more vulnerable to insecticides than are insect and mite pests (Croft 1990). Herbicides can destroy flowering plants that otherwise feed pollinators. Chemical fungicides are often synergistic with insecticides, and combinations are especially lethal to bees. Cultural methods and microbial fungicides are less damaging alternatives (Quarles 2008; Quarles 2005).

When possible, chemical pesticides should be avoided altogether by growing organic gardens, lawns, and landscapes, and switching to organic farm production. During the transition to organic, microencapsulated formulations, dusts, and longlasting toxic residuals

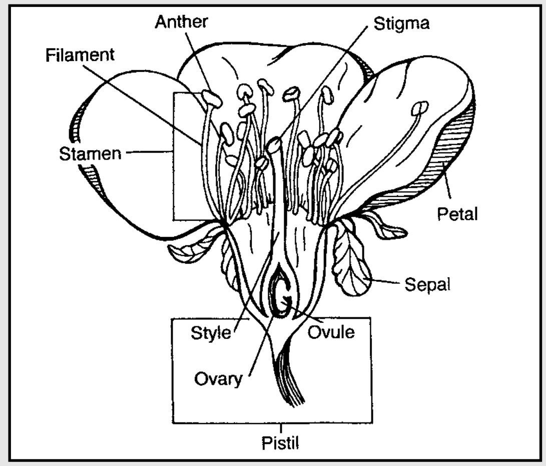


From Nixon 1954

Different species of bees carry pollen in different ways. (a) *Andrena* sp. carries pollen on leg hairs (b) and (c) Honey bees and bumble bees have pollen baskets on their legs and (d) *Megachile* sp. carries pollen beneath abdomen

Box A. Plant Pollination

More than 75% of our flowering plants require animal help with reproduction. Reproductive structures are found in flowers. The male part is called the stamen, the female part the stigma. Pollen secreted by male structures must be moved to female parts to permit seed formation (NAS 2007; Meeuse and Morris 1984; Lloyd and Barrett 1995; Frankie and Thorp 2003).



Flowers can be male (staminate), female (pistillate) or they can have both male and female structures. The easiest fertilization occurs when pollen can be moved from stamen to stigma in the same flower. These are called perfect flowers and more than 75% of flower species maintain perfect flowers. Because self fertilization could lead to inbreeding defects, plants protect themselves by physical separation of the parts or by maturation at different times. Slightly more difficult is movement from a male flower to a female flower on the same plant (monecious). The most difficult fertilization comes with a need to move pollen from plant to plant (dioecious).

Some plants need a specific pollinator. When that pollinator declines, the plant can be endangered. For example, two species of lobeliads have lost their moth pollinator, and now must be pollinated by hand. Plants with general pollination needs are less likely to disappear in the midst of a pollinator shortage. For instance, the hardy Geranium can be pollinated by at least 45 species of insects (NAS 2007).

Mason bee, *Osmia* sp.

Photo courtesy of Gary McDonald

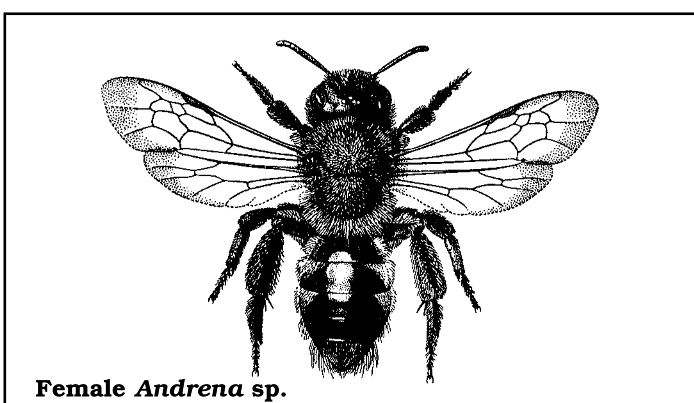
should be avoided, as these are especially destructive. (Note: There are many articles about alternatives to pesticides listed on the BIRC website at www.birc.org). Insecticides should not be applied while a crop is in bloom or while bees are foraging. Some application times are better than others. Night applications are best, as bees are not foraging.

However, favorable application times depend on the species. Early morning applications that spare honey bees will kill bumble bees out for a morning snack. Bumble bees and other ground nesters (see Box B) are also more at risk from pesticides such as imidacloprid and clothianidin applied to lawns and turf for grub control (NAS 2007; Schacker 2008).

Many microbial pesticides can be used safely with bees. Microbial pesticides have such low toxicity, that honey bees have been used to apply *Bacillus subtilis* and *Beauveria bassiana* in organic cropping situations. Targeted insecticides such as *Bacillus thuringiensis* (BT), and least toxic insecticides such as soaps, oils, or quickly degraded botanicals minimize damage to pollinators. Though BT might have an impact on the larval form of butterflies, it is usually applied to crops that butterflies do not utilize (NAS 2007; Quarles 2004; Quarles 2006).

Monitoring Bees

Monitoring programs can establish the extent of a pollinator problem. Since most pollination is done by bees, monitoring programs should concentrate on them (see Box B). We can monitor them by catching and collecting specimens or by just observing them visit flowers over time. There are websites that aid in identification of bees (see Resources). Books can also be helpful (O'Toole et al. 1991; Michener 2007; Michener et al. 1994). One of the simplest ways to monitor bees is with a pan trap. This is a small, shallow bowl containing soapy water. Yellow bowls are the most attractive. Bowls are placed at least 5 m (16.4 ft) apart (NAS 2007). Collection and identification of a few specimens makes it easier to visually identify species as they visit backyard flowers (see Resources for more on monitoring bees).



Female *Andrena* sp.

From Nixon 1954

Bees on flowers can be monitored with sweep nets (see Resources). Or we can just watch flowers and count the numbers and kinds of bees over time. To make individual efforts more powerful, citizen groups can be formed and encouraged. A model for this is Monarch Watch, which collects monitoring data through a website (see Resources).

A squash bee, *Peponapis pruinosa*, sips nectar.

Photo courtesy James Cane, USDA

Making Bee Gardens

To increase pollinator populations, we can increase floral resources. According to Cane et al. (2008), "in our cities and towns where most of the native plant communities have been displaced by pavement, buildings and lawns, our flower gardens can become important cafeterias of native bees." Since bees are major pollinators, we should give them what they need. Generally, bees need floral sources of nectar and pollen, nesting sites, water, and a pesticide free environment (Black 2008). Bees like flowers, sunlight, warm temperatures, and open spaces. Most species prefer to forage when soil and air temperatures are greater than 55°F (12.8°C). Some limit activity to one, or a few species of flowers, while others such as the honey bee have a wide range of hosts (Linsley 1958).

Forage Constantly Available

Social bees such as honey bees have perennial colonies. When foraging plants are not available, they

Box B. Common Kinds of Native Bees

Most of the 17,000 known species of bees are solitary (NAS 2007; O'Toole et al. 1991; Michener 2007; Michener et al. 1994; Linsley 1958). This means that a female collects pollen and nectar which is used to provision a solitary nesting site, which is often a simple hole in the ground. Females add pollen and nectar to the nest, then go looking for a male. [Note: Sometimes they mate before nest building.] Males usually do not have nests, but often reside in flowers. After mating, the solitary female goes back and lays an egg in a richly provisioned nest.

Some solitary bees nest in isolation, others are more gregarious. Gregarious bees have solitary nests, but they like a lot of companionship. So several bees may establish nests close together. Examples of gregarious bees are alkali bees, *Nomia* spp. and carpenter bees, *Xylocopa* spp. Finally, large numbers of bees may choose to live in a single nest. For instance, bumble bees, *Bombus* spp. have a solitary queen and many foragers that live in a single annual nest. Over the course of a year, foragers from the same nest actively pollinate crops and wildflowers (NAS 2007).

Most of the solitary bees in North America are natives. Native bees are also called pollen bees, since they specialize in pollination, not production of honey. There are several common native bee families. Bumble (Bombinae), sweat, alkali (Halictidae), digger, squash (Anthophoridae), and polyester (Colletidae) bees live underground. Mason, leafcutters (Megachilidae), and carpenter bees (Xylocopinae) live in wood or in plant stems (Greer 1999).

Bee Families

Andrenidae (dig nests in soil)

Andrenids are short-tongued bees that nest in the ground. They are black, reddish, blue, greenish or brown. They are smaller than a honey bee, and are very abundant. Some are gregarious (AAPA 1999).

Anthophoridae (dig nests in soil)

These are as big or bigger than honey bees. They are long-tongued, hairy, black, yellow, brown, or gray. Squash bees, *Peponapis* sp. are very important pollinators of squash and cucumbers. Others in the family are sunflower bees, *Diadasia* sp., and blueberry bees, *Habropoda* sp. (AAPA 1999; NAS 2007).

Bombinae (family Apidae) (soil nesters)

These are large, hairy, black and bright yellow, white or red. There are about 50 species of bumble bees, *Bombus* spp., in the U.S. and 26 species native to California. Bumble bees live in colonies in the ground that may contain several hundred bees. Annual colonies are established in springtime by a single overwintering queen in existing holes in the ground. Often, these are abandoned rodent burrows in sunny, well drained soil (AAPA 1999; Thorp et al. 2002).

The queen digs out an area about the size of a tennis ball to establish her nest. Wax is used to construct a cell for egglaying and a honeypot. Eggs are laid in the cell on top of pollen. The honeypot is used to store collected nectar. She lays 8-14 eggs that hatch in about 3 days. Development to adults takes 3-4 weeks, and about 50% of the eggs survive to become adults. Bumble bees forage at lower temperatures than honeybees (Kearns and Thomson 2001; Thompson 2001).

Bumble bees are good pollinators of wildflowers, watermelon, cucumbers and tomatoes. They prefer perennial flowers to annuals. Some species are in decline, and the Franklin bumble bee, *Bombus franklinia* has almost disappeared (Thorp et al. 2002; NAS 2007).

Colletidae (dig nests in soil)

Some species (*Colletes* spp.) secrete shiny polymers to line their holes, and are called polyester or membrane bees (AAPA 1999).

Halictidae (soil nesters)

Sweat bees, *Halictus* spp.; alkali bees, *Nomia melanderi*, and other salt loving bees are members of the Halictidae. These are small bees, black with metallic blue, green, brass, or copper sheen. Sweat bees are very common, and you may have seen one land on your arm to sample the perspiration. Alkali bees are groundnesting solitary bees that live in alkaline soil and are efficient pollinators of alfalfa. They are gregarious and large numbers of nests are built close together. One alfalfa site had more than 5 million nests (AAPA 1999; Cane 2008).

Megachilidae (wood and plant stem nesters)

This family includes leafcutting and mason bees. They mostly nest in holes in wood, stems of plants, but occasionally in the ground. Mason bees, *Osmia* spp., live in wood and line their nests with mud. Leafcutters, *Megachile* spp. line their nests with leaf cuttings. Mason bees are usually medium sized, shiny black bees. The blue orchard bee, *Osmia lignaria*, which is dark blue, is sometimes managed for pollination of fruit trees (AAPA 1999; Delaplane and Mayer 2000).

Leafcutter bees are shiny, black bees with white hairs for carrying pollen. They can be grey with striped abdomens. The alfalfa leafcutting bee, *M. rotunda*, is one of the few non-native bees. *M. rotunda* is sometimes raised commercially to pollinate alfalfa in 3/16 inch (5 mm) holes, 3 and 1/2 inches (9 cm)deep (Greer 1999; AAPA 1999; Delaplane and Mayer 2000).

Xylocopinae (family Apidae, wood nesters)

Small carpenter bees, *Ceratina* spp., nest in plant stems. They are green purple blue or black. Large carpenter bees, *Xylocopa* spp., often make holes in wood for nesting. These large, black or blue-black bees sometimes can be pests, as they make holes in wooden structures (AAPA 1999).

feed on stored honey and pollen in the hive. Native bees are driven by the seasons. Solitary bee queens overwinter, then establish a nest in the spring (See Box B). Because they do not have extensive food stores, forage must be constantly available. Floral resources must

California poppy, *Eschscholzia californica*

Photo courtesy Br. Alfred Brousseau

have overlapping flowering periods, so that something is constantly in bloom. For instance, of 32 bee species observed visiting plants in Berkeley, CA flower gardens, 17 needed full season flowers, 7 were early season, 8 were late season bees (Wojcik et al. 2008). Wildflower seed mixes are commercially available that can provide forage in open areas. Perennials and annuals in planting beds should be chosen with flowering periods in mind. When restoring habitat, native plants are preferable because native bees generally prefer native plants (see below) (NAS 2007; Frankie et al. 2002; Black 2008).

High Density Planting

Monitoring bees is the best way to find which floral resources they prefer, then these flowers can be planted to feed them. For instance, bees in the urban gardens of Berkeley and Albany, CA were monitored by Frankie et al. (2002). Flowering plants were identified and their bee visitors were checked twice a week. They observed about 700 flowering plant species and cultivars. About 75% were exotics, and about 25% were natives. Only about 5-10% of the flowering plants attracted measurable bee numbers. Frequency of bee visits "varied from one flower patch to the next." Attraction was increased when large numbers of flowering plants were growing in close proximity. Flowering areas need to be about 1 meter (3.2 ft) in diameter to draw in diverse species of bees. Bees most often seen were the honey bee, *Apis mellifera*; bumble bees, *Bombus* spp., and leafcutter or mason bees (*Megachile* spp. and *Osmia* spp.). (see Box B)

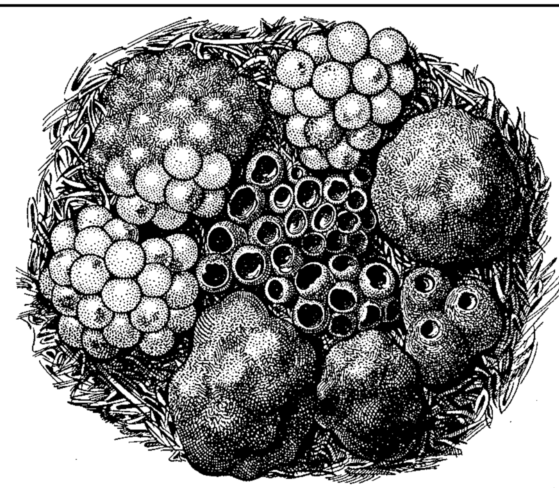
Native Bees, Native Plants

Native bees tended to visit native plants (Schmidt 1980; Frankie et al. 2002; Schindler et al. 2003). This may have been because exotics generally produce less pollen and nectar than natives. Or perhaps, coevolution of the native bees and plants caused the preference. Bees attracted varied with the flowers. Bumble bees and sweat bees (Halictidae) were seen on California poppy, *Eschscholzia californica*. Blackberries "attracted a wide variety of leafcutter bees, bumble bees, and honey bees. Dusty Miller, *Centaurea cineraria*, attracted megachilids. Cosmos attracted "large anthophorid bees of the family Apidae." The USDA, and a number of private organizations have produced lists of flowering plants that function as attractive bee gardens (see Resources). A list of plants attractive to native bees can be found in Tables 1 and 2.

Provide Nesting Sites

Most North American native bees nest in the ground (see Box B). Sweat bees (Halictidae) and the Andrenidae family dig holes in the ground; bumble bees, *Bombus* spp., like to nest in abandoned rodent burrows. Sunny open horizontal areas of well drained soil are preferred, but some species nest vertically in banks of soil. Any sunny area in your backyard can be converted to a nesting site by removing vegetation and mulch (NAS 2007; AAPA 1999).

About 10% of native bees, such as carpenter bees, *Xylocopa* spp., mason bees, *Osmia* spp., and some leafcutters, *Megachile* spp. nest in wood (see Box B). Just having wooden fences can provide sites for twig nesting bees. You can make nests also by drilling 3/16 to 5/16 inch (5 to 8 mm) diameter holes about 4 to 6 inches (10 to 15 cm) deep in a 4x4 inch (10 by 10 cm) or 4x6



Nest of a bumble bee, *Bombus* sp. The spheres are cocoons. True honeypots are to the right. Open cocoons in the center are being used for temporary honey storage.

From Nixon 1954

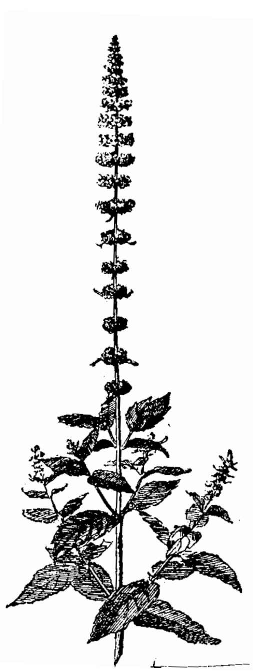
inch (10 by 15 cm) block of wood. Holes should be 1/4 inch (6 mm) apart. Nest blocks should be attached to posts and trees three to six feet off the ground in areas shaded from afternoon sun. Or you can just fill a coffee can, milk carton, or PVC pipe other container with drinking straws 1/4 to 3/8 inches (6 to 9.5 mm)diameter. Entrance holes should be placed horizontal, and

Table 1. Flowering Plants Attractive to Native Bees*

Common Name	Genus	Family
Bachelor's button	*Centaurea cyanus*	Asteraceae
Blackeyed susan	*Rudbeckia hirta*	Asteraceae
Bluebells, scorpion weed	*Phacelia* spp.	Hydrophyllacea
Blueberry, cranberry, huckleberry	*Vaccinium* spp.	Ericaeceae
Borage	*Borago officianalis*	Boraginaceae
Bush clover	*Lespedeza* sp.	Fabaceae
Catmint	*Nepeta cataria*	Lamiaceae
False heather	*Cuphea hyssopifolia*	Lythrraceae
False indigo	*Baptisia fruticosa*	Fabaceae
Goldenrod	*Solidago* spp	Asteraceae
Mexican sunflower	*Tithonia rotundifolia*	Asteraceae
Mints	*Mentha* spp., *Salvia* spp.	Lamiaceae
Purple coneflower	*Echinacea purpurea*	Asteraceae
Redbud	*Cercis* spp.	Fabaceae
Sedum, stonecrop	*Sedum* spp.	Crassulaceae
Squash, gourd, pumpkin	*Cucurbita* spp.	Cucurbitaceae
Sunflower	*Helianthus* spp.	Asteraceae
Tansy or Fever Few	*Tanacetum* spp.	Apiaceae
Yarrow	*Achillea millefolium*	Asteraceae

*From Cane et al. 2008 and Greer 1999.

Flowering buckwheat, *Eriogonum* sp.

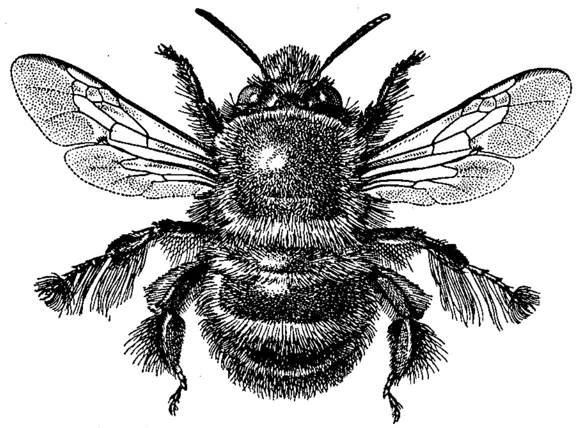


Spearmint, *Mentha* sp.

Table 2. California Native Plants that Attract Bees*

Common Name	Scientific Name	Color	Notes
Bird's eye	*Gilia tricolor*	Purple, yellow	Blue pollen
Buckwheat	*Erigonium fasciculatum*	White, pink	Also attracts butterflies and other beneficials
California gilia	*Gilia achillefolia*	Blue	Plant in dense clumps
California poppy	*Eschscholzia californica*	Yellow, orange	Plant in large patches
Chinese houses	*Collinsia heterophylla*	Purple	Large patches
Coyote mint	*Monardella villosa*	Purple, white	Limit summer water
Elegant clarkia	*Clarkia unguiculata*	Purple, pink	Plant in dense clumps
Elegant madia	*Madia elegans*	Yellow	Flowers open morning and afternoon
Globe gilia	*Gilia capitata*	Blue, purple	
Gumplant	*Grindelia*	Yellow	Attractive megachilids
Hedgenettle	*Stachys ajugoides*	Pink	Spring plant
Lindley Blazing Star	*Mentzelia lindleyi*	Yellow, orange	Needs little water
Phacelia grandiflora	*Phacelia grandiflora*	Blue	Lots of pollen
Sunflower	*Helianthus gracilientus*	Yellow	Large bees
Tansy phacelia	*Phacelia tanacetifolia*	Purple, blue	Attracts diversity

*From Frankie et al. 2008



Male *Anthophora* sp.

From Nixon 1954

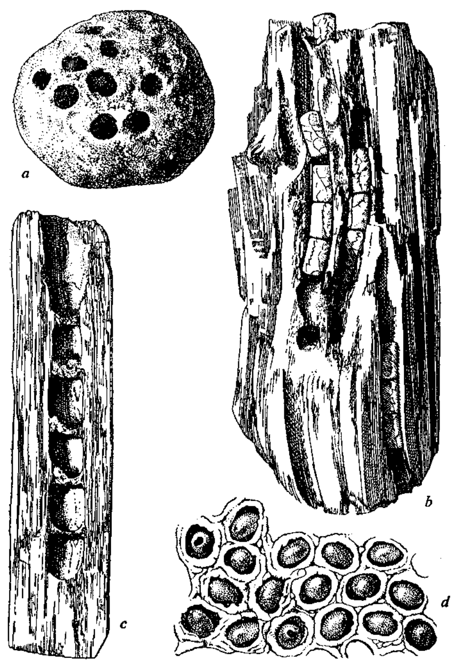
the nests should be protected from rain (NAS 2007; AAPA 1999; Greer 1999).

How About Bee Stings?

Generally, foraging bees are not likely to sting. Greatest risk of a sting comes from social bees such as honey bees and bumble bees that are protecting their nest sites. Native bees are generally not aggressive, and males have no stingers at all (Frankie et al. 2008; Cane et al. 2008). However, if you, or someone in your family has a special sensitivity to bee stings, perhaps you should let someone else establish the much needed bee gardens.

Bees and Biocontrol

Protecting pollinators has many rewards. Many of the same plants that feed pollinators such as bees, birds

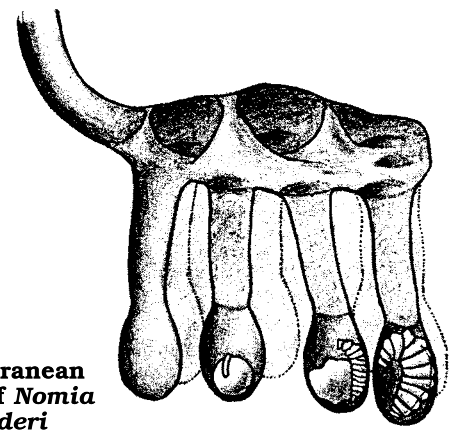


Different bee species nest in different ways (a) Mason bees use clay to form or line nests (b) Leafcutters nest in wood or plant stems and line their nest with leaves (c) Carpenter bees excavate wood for nesting (d) Mason bee cocoons in clay cells

From Nixon 1954

and butterflies will also provide refuge for biocontrol agents such as ladybugs and lacewings. You can have both better pollination and fewer pests feeding on your garden. Insectary plants used to conserve beneficial insects include native annual wildflowers such as California poppy, *Eschscholzia californica*; buckwheat, *Eriogonum*; tansy leaf, *Phacelia tanacetifolia*; umbelliferous herbs such as coriander, chervil, and fennel, garden flowers such as sweet alyssum, *Lobularia maritima*; yarrow, *Achillea millefolium*; baby blue eyes, *Nemophila* and tidy tips, *Layia platyglossa* (Quarles and Grossman 2002). Sweet alyssum and phacelia have so much pollen, they are planted in organic lettuce fields to attract syrphid flies for aphid control (Chaney 2007).

Perennials such as California lilac, *Ceanothus* spp.;



Subterranean nest of *Nomia melanderi*

From Stephen et al. 1969

yarrow, *Achillea millefolium*; coyote bush, *Baccharis pilularis*; and perennial grasses are also good food sources. These plantings have something in bloom all year, so native bees and beneficials have a constant food supply (Long 1998).

Roadside Restoration

Seed mixes containing native plants such as black-eyed Susan, *Rudbeckia hirta*; butterfly weed, *Asclepias tuberosa*; bergamot, *Monarda* sp., and similar plants compete with weeds along roadsides, reducing herbicide applications. Wildflowers used in these mixes also increase biocontrol and provide forage for migrating butterflies (Quarles 2003). For instance, roadside native plantings in Iowa showed a 5-fold increase in butterfly abundance. Native plants also crowded out weeds and reduced the number of corn borers, *Ostrinia nubilialis* in nearby cornfields (Quarles 2003; Harper Lore and Wilson 2000; Ries et al. 2001).

Roadsides restored with native plants in Iowa had greater numbers of native bees and greater bee diversity. Nearby traffic did not bother the bees. Most important were the floral resources and availabilty of ground nesting sites. There are millions of acres along roadsides that could be used to support native bees. The vegetation planted could also improve roadside weed management (Harper Lore and Wilson 2000; Hopwood 2008).

Habitat Restoration and Cultural Practices

Habitat restoration and cultural practices can encourage pollinators. In grasslands, mowing can encourage successional plants that butterflies use for food. Mowing, for example, synchronizes the endangered Karner blue butterfly, *Lycaeides melissa samuelis*, with its lupine host plant, *Lupinus perennis* (NAS 2007).

In farming situations, habitat restoration for pollinators should be a key priority. When possible, field margins and other areas should be planted with floral resources. Establishing hedgerows, diverse plantings, no-till agriculture and other practices can conserve pollinators (See Box C). Money for restoration can be obtained through already existing government programs such as the Conservation Stewardship, Wildlife Habitat Incentives, Environmental Quality Incentives, and the Conservation Reserve Programs (NAS 2007).

Photo courtesy of Tony Morosco

Wild sunflower, *Helianthus* sp.

Native Bees and Crop Pollination

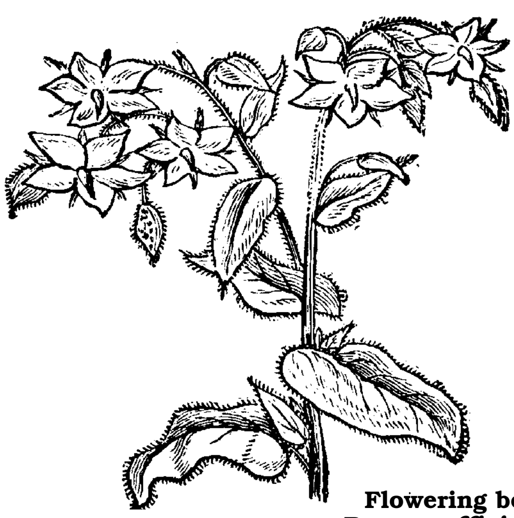
For crop production we have come to rely on the honey bee, which is suited to large acreages of monocultures. Since the honey bee is in trouble, this problem has generated increased interest in other pollinators, especially native bees (Quarles 2008; NAS 2007). Currently, seven crops worth about $1.25 billion annually are pollinated by wild insects and vertebrates. About 73% of the pollination is done by bees, 19% by flies, 6.5% by bats, 5% wasps, 5% beetles, 4% birds, and 4% butterflies and moths. One estimate of the total pollination value provided by these animals is $4.1 billion per year (Buchmann and Nabhan 1996).

Alfalfa is one crop that benefits from wild bees. Groundnesting alkali bees, *Nomia melanderi*, are such efficient pollinators that 2,500 bees can pollinate 100 acres. Alfalfa leafcutter bees, *Megachile rotunda*, nest in alfalfa fields. Alfalfa provides all the nectar and pollen they need. *M. rotunda* is one of the few wild bees that is non-native. It can be managed for alfalfa production (Bohart 1972).

When alfalfa is grown for seed, wild bees can increase the yields by a factor of four. Many nesting sites of alkali and leafcutter bees have been destroyed, but when their populations were thriving, 85% of alfalfa seed production was concentrated in areas where these bees were located (Buchmann and Nabhan 1996).

Though managed honey bees can be used to pollinate crops such as squash, the native gourd or squash bee, *Peponapis pruinosa*, is three times more efficient. Honey bees require three visits to do the job of one squash bee visit (Buchmann and Nabhan 1996).

Farms in Ohio raising crops such as strawberries, blueberries, and raspberries extensively benefit from native bees. Though there is variation from site to site, native bees often provide more than 80% of the pollination (Williams 2008).



Flowering borage, *Borago officianalis*

Native Bees and Farming Practices

Adjustment of farming practices, including farmscaping, may provide crops with free pollination from native bees. Farmscaping includes planting floral resources and insectary plants (see Box C). No-till agriculture can protect groundnesting sites. For instance, the squash bee nests in the fields near the growing crops. Conversion from tillage to no-till cropping practices results in three times more squash bees and improved pollination (Shuler et al. 2005). Conversion to organic agriculture or modification of pesticide applications may be necessary (see Box C).

Preserve Natural Habitat

Generally, native pollinators thrive in natural habitat and pollinate crops that are nearby (Kremen et al. 2004). More abundant bee communities are found on farms close to wild areas. For example, flower visitation rates by bees near wild refuges are twice those about 0.6 km away (Ricketts et al. 2008; Kim et al. 2006).

When nests of blue orchard bees, *Osmia lignaria*, were placed on conventional farms, organic farms and in "seminatural riparian habitats," survival and reproduction initially decreased with distance from natural habitat. But bees on organic farms were able to switch to local resources (Williams and Kremen 2007).

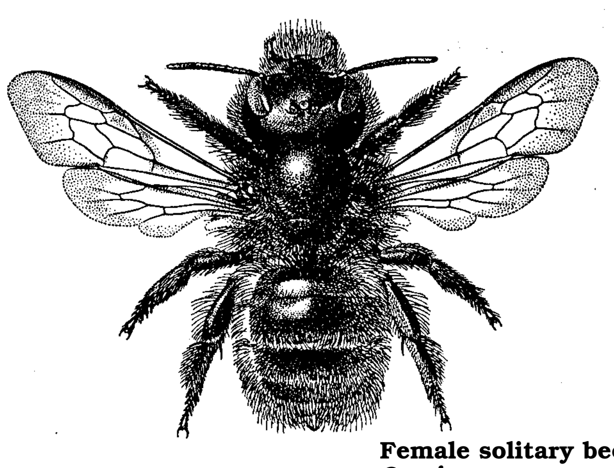
Kremen et al. (2002) found that watermelons grown on organic farms near native bee habitats had sufficient pollination, and did not need managed honey bees. Bee populations dropped off with distance from natural habitat and with pesticide use.

But native bees can also provide pollination in disturbed conditions. Winfree et al. (2007) found 46 species of native bees visiting watermelon crops in New Jersey. Native bees were responsible for "62% of pollen grains deposited on female watermelon flowers." Native bees fully pollinated the watermelon crop at 91% of the farms studied. These New Jersey bees were thriving in a fragmented, disturbed landscape and were "abundant on multiple crops." So even disturbed areas in cities and suburbia could be successfully managed to encourage native bees.

Pollinator Competition

Generally, pollinators share resources and are even complementary. For instance, roadside restoration can encourage both butterflies and bees, but some flowers and habitats are more preferred by bees, others by butterflies (Davis et al. 2008). There may be some competition between native bees and honey bees. But this has not been well studied (NAS 2007). Because pollinators prefer undamaged plants with adequate soil mycorrhizae and proper nutrition, there is some competition between pollinators and plant pests. Proper soil and pest management is part of pollinator protection (Cahill et al. 2008; Lehtila and Strauss 1997).

Argentine ants, *L. humile*, can compete with pollinators for floral resources. The ants provide no pollination, but steal nectar to make flowers less desirable to bees and other pollinators. Ants should also be controlled to reduce plant damage from pests such as aphids (Lach 2008; Quarles 2004; Quarles 2007b).



Female solitary bee, *Osmia* sp.

From Nixon 1954

Box C. Encouraging Native Pollinators in Agriculture

In urban and suburban situations native pollinators can be encouraged by avoiding pesticides, planting bee gardens, providing water and nesting sites. A similar approach can be used in agriculture. Pesticides can be avoided by converting conventional fields to organic production. Or pesticides can be mitigated by choosing less toxic products and bee friendly application schedules. Nesting sites, water, and floral resources should be provided and:

- Monocultures should be avoided and replaced by diverse plantings whenever possible;
- Weeds can provide floral resources for bees and butterflies and should be tolerated whenever possible;
- Insectary crops can provide resources for beneficial insects that provide pest control. Bees and butterflies can also harvest nectar and pollen from insectary strips planted on unused field margins or within crops;
- Cover crops on fallow fields, orchard understories, and other areas should be allowed to bloom before plowing them under;
- Planting wildflower mixes in unused fields will create meadows that provide pollinator forage;
- Planting permanent hedgerows of native perennial forbs and shrubs provides nest sites and preferred pollen and nectar sources. Hedgerows also act as windbreaks and provide erosion control;
- When possible, restoration areas should be established. Areas around ditches, streams, utility poles, and difficult to farm hillsides can provide habitat for pollinators and beneficial insects;
- Drip irrigation prevents flooding that kills groundnesting bees;
- No till agriculture preserves ground nesters. Squash bees are three times more numerous in no till squash plantings;
- Some native bees, such as the blue orchard bee, can be raised in managed colonies.

From: (NAS 2007; Quarles and Grossman 2002; Altieri 2004, Schuler et al. 2005; King and Olkowski 1991; Delaplane and Mayer 2000; Bugg et al. 1998)

Hummingbird feeders can give much enjoyment. But providing free resources can also reduce hummingbird pollination efforts. Fortunately, wild bees may provide alternate pollination. Feeders placed near *Salvia mexicana* reduced hummingbird foraging on this plant, but the plant was pollinated by wild bees (Maria del Coro et al. 2007).

Conclusion

More than 75% of flowering plants need animal pollination, and many pollinators are in decline. We can help restore pollinators by choosing production strategies that reduce or eliminate pesticide applications. A widespread switch to organic methods in our gardens, landscapes, and in agriculture would protect pollinators.

Since bees do most of the pollination, they deserve special attention. Honey bees are in trouble due to colony collapse disorder and other problems. We should help them recover, and we should encourage native bees. Native bees need floral resources, water, and nesting sites that we can provide. By planting bee gardens, and farmscaping in rural areas, we can protect bees, butterflies and other pollinators, and at the same time provide resources for insect biocontrol agents.

Resources for pollinators can be incorporated into native plant restoration programs along roadways. These programs can provide weed control and refuges for biocontrol agents as well. We should view the pollinator crisis in America as an opportunity for change. By making things better for pollinators, we can also improve our gardens, our roadsides, and our quality of life.

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Resources

Flowering Plant Lists

Urban Bee Gardens, University of California, Berkeley, http://nature.berkeley.edu/urbanbeegardens/

Plants Attractive to Native Bees, USDA, http://www.ars.usda.gov/research/docs.htm?docid=12052

Selecting Plants for Pollinators, Pollinator Partnership, http://www.pollinator.org

Organizations

American Association of Professional Apiculturists, http://entomology.ucdavis.edu/aapa

Humane Society, Backyard Sanctuary Program, www.hsus.org

North American Butterfly Association, www.naba.org

North American Pollinator Protection Campaign, www.nappc.org

Pollinator Partnership, www.pollinator.org

Xerces Society, www.xerces.org

Monitoring and Identifying Pollinators

Bee Identification, http://www.discoverlife.org/20/q?search=Apoidea

Monitoring bees, http://online.sfsu.edu/~beeplot/

Monitoring butterflies, www.monarchwatch.org, www.bfly.org/

Monitoring birds, Audobon Society Christmas Bird Count, http://audubon2.org/birds/cbc/hr/graph.html; Breeding bird survey, http://www.mbr-pwrc.usgs.gov/bbs/bbs.html

Bees and Equipment

Sweep Nets, Bee Collection Materials—**BioQuip Products**, 2321 Gladwick Street, Rancho Dominguez, CA 90220; 310/667-8800, Fax 310/667-8808; www.bioquip.com

Beekeeping Equipment—**Dadant & Sons**, 51 S. 2nd St., Hamilton, IL 62341-1399; 888/922-1293, 217/847-3324, Fax 217/847-3660; www.dadant.com

Honey bees—Brushy Mountain Bee, 610 Bethany Church Rd., Moravian Falls, NC 28654; 800/233-7929; Draper's Super Bee Apiaries, RR#1, Box 97, Millerton, PA 16936; 800/233-4273; Glorybee, 120 N. Seneca Rd., Eugene, OR 97402; 800/456-7923

Bumble bees—**Hydro-Gardens, Inc.**, PO Box 25845, Colorado Springs, CO 80936; 800/634-6362, 719/495-2266, Fax 719/495-2266; www.hydro-gardens.com; **The Green Spot, Ltd.**, Dept. of Bio-Ingenuity; 93 Priest Rd., Nottingham, NH 03290; 603/942-8925, Fax 603/942-8932; www.greenmethods.com

Mason bees—Knox Cellars, 25724 NE 10th St., Redmond, WA 98053; 425/898-8802; www.knoxcellars.com;

Mason bees and leafcutters—International Pollination Systems, 16645 Plum Road, Caldwell, ID 83605; 800/990-1390; www.pollination.com.

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