COMMON SENSE
PEST CONTROL QUARTERLY

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Photo courtesy of Glenda Denniston, UW Madison Lakeshore Nature Preserve

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B · I · R · C

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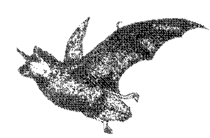

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Bringing Back the Monarchs

By William Quarles

The monarch butterfly, *Danaus plexippus*, is one of the best known environmental icons. But the migrating monarch is in trouble. Over the last 20 years, overwintering populations have dropped by 90%. Developing caterpillars of the monarch are dependent on milkweed, *Asclepias spp.* From milkweed they obtain the chemicals that give them a bad taste, and thus protect them from predators (Malcolm et al. 1989; Brower 1969). Milkweed in the Midwest has been destroyed by herbicide applications to fields of genetically modified (GMO) crops, and by herbicide management of roadsides (Pleasants 2015; Quarles 2012). Milkweed and nectar plants that remain are often treated with insecticides, killing monarchs by contact (Krischik et al. 2015; Oberhauser et al. 2006; Quarles 2014). Increased development has led to loss of flowering plants and nectar adult monarchs need to survive, and extreme weather caused by global warming has caused direct mortality. Without help, the migrating monarch may become a lost relic of the past (Brower et al. 2012). This article reviews monarch biology and suggests ways that we can make a difference. Working together, we can bring back the monarchs.

Monarch Migrations

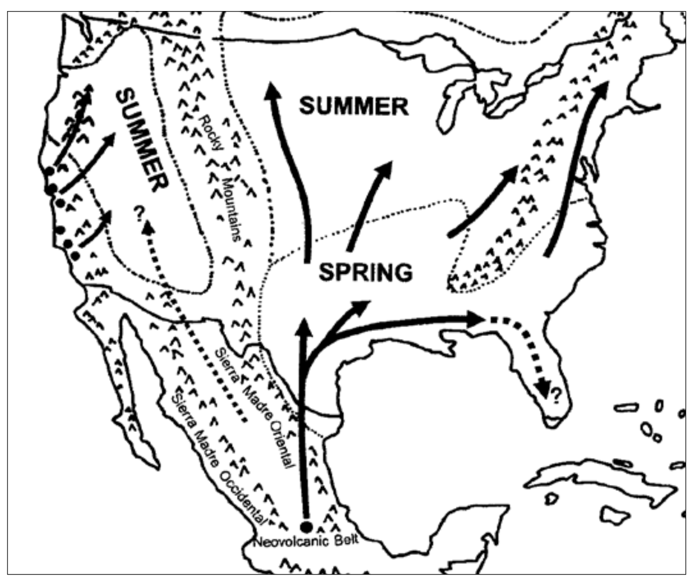
Butterflies evolved along with flowering plants about 100 million years ago (Ma). The monarch subfamily, Danainae, diverged about 90 Ma, and the cosmic event at 65 Ma that killed the dinosaurs had an impact on their evolution. The migrating monarch, *Danaus plexippus*, is a native of Mexico, and migratory behavior likely began about one million years ago. The northern range is limited by temperature and milkweed, and the journey north expanded and contracted during the ice ages. The current migrations began about 20,000 years ago (Zahn et al. 2014; Wahlberg et al. 2009).

There are two large populations of migrating monarchs in North America: the population east of the Rockies, and the Pacific population west of the Rockies. The eastern population breeds during the summer in the U.S. and Canada, then heads south when days get shorter and colder, temperatures fluctuate, and milkweed begins to die. Millions of butterflies travel up to 3,000 miles (5,000 km) to overwintering sites in the mountains of central Mexico. Monarchs were mysterious about their travels for some time, and the first Mexican overwintering site was not discovered until 1974 (Solensky 2004; Brower 1977; Urquhart 1976).

The eastern migration starts about mid-September. Populations move southward at about 20-25 mi/day (32-42 km/day) (Howard and Davis 2015). Monarch migration is marked by a single minded purpose. During the flight, all energy is channeled into the task. To conserve energy, monarchs stop mating and producing eggs, and they feed aggressively to fuel the flight and build up fat deposits for overwintering (Brower 1977).

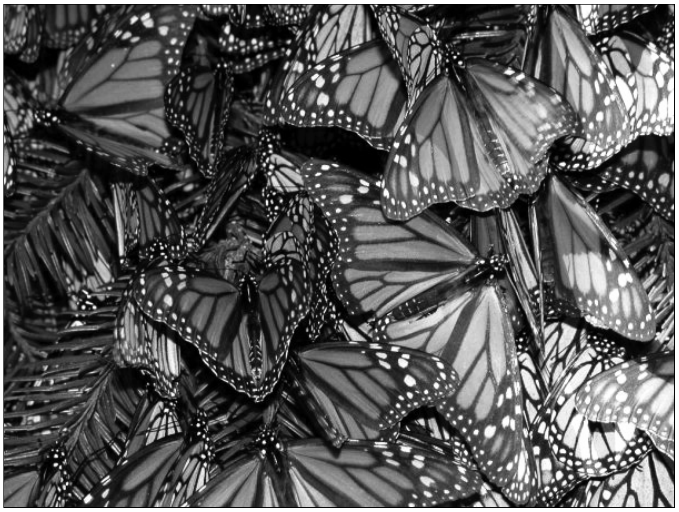
When they reach their destination in Mexico, overwintering populations form high density clusters on oyamel fir trees, *Abies religiosa*. The density of clusters in Mexico has been estimated at 10 million/ha (4 million/acre). Overwintering numbers are estimated by measuring total acres of clustering monarchs. The 1.19 ha (2.94 acres) measured in 2013 were the lowest on record (Brower 1977; Rendon-Salinas and Tavera-Alonso 2014).

In the spring, the overwintering monarchs engage in a vigorous mating ritual, then fly north into Texas and the southern U.S. laying eggs on milkweed such as *Asclepias viridis*. The eggs hatch into a spring generation that flies further north as southern weather becomes too hot. In the north, monarchs produce 2-3 summer generations, and the last summer generation migrates south in the fall. The spring and summer generations last about 3-5 weeks each, the migration and overwintering generation lasts about 8-9 months. Altogether, there are 4-5 generations each year (Malcolm et al. 1993; Malcolm and Brower 1989).



Courtesy of the University of Minnesota Monarch Lab

Monarchs migrate north and east during the spring, laying eggs on milkweed, producing at least four generations each year.



Courtesy Jim Lovett, www.MonarchWatch.org

Monarchs form overwintering clusters.

Pacific Population Smaller

The Pacific population is about 100 times smaller than the eastern one. The Pacific monarchs arrive on the California coast for overwintering in October. Overwintering butterflies prefer to cluster in pine, cypress, and especially eucalyptus within 1.2 miles (2 km) of the ocean. Sites are chosen to protect from wind and cold temperatures. Sites can have up to 200,000 monarchs, and the maximum Pacific population has been estimated at about two million. Over the last 20 years, average numbers at each overwintering site have declined by 90% (Frey and Schaffner 2004; Leong et al. 2004; Jepson and Black 2015; Solensky 2004).

In February and March the monarchs mate, then fly inland looking for milkweed. Migrating monarch populations are constrained by the amount of milkweed in breeding areas, and by availability of overwintering sites. At every point in its lifecycle, this iconic butterfly is under constant attack from natural enemies, weather, and humans (Oberhauser and Solensky 2004).

Why Migrate?

Monarchs constantly migrate between milkweed and overwintering shelter. The milkweed family Apocynaceae evolved in the Old World about 45-53 million years ago (Ma). The subfamily Asclepiadoideae diverged about 40 Ma, and ancestral milkweed in the genus *Asclepias* arrived in North America by dispersal about 20 Ma. Most North American species such as *A. syriaca* evolved after this time, and are thus native (Wikstrom et al. 2001; Rapini et al. 2007).

Milkweed had likely dispersed to Mexico by 7 Ma. At some point in the stretch between 7 Ma and 1 Ma when migrations began, monarchs became addicted to milkweed (Rapini et al. 2007; Zahn et al. 2014). Steroids (cardenolides) ingested with the milkweed protected them against vertebrates and protozoan parasites (see below). Monarch populations that adapted to milkweed successfully expanded, and the journey north in search of milkweed began. Once in colder climates, they had to retreat south in the fall to keep from freezing (Wikstrom et al. 2001; Rapini et al. 2007; Altizer and deRoode 2015).

One viewpoint is that monarch migrations are driven by their protozoan parasites (see below). Steroids (cardenolides) in milkweed protect monarchs against the parasite. Monarchs find milkweed to medicate themselves, but in the process they infest the plant with protozoan spores (Sternberg et al. 2012). Monarchs migrate to leave infested plants behind. Those weakened by the parasite die during migration, and do not spread the pathogen into overwintering areas. Evidence for this is that overwintering monarchs in Mexico have very low (9.3%) infection rates, and the infection rate in summer breeding areas is about 14.1% (Satterfield et al. 2015; Altizer and deRoode 2015; Bartel et al. 2011).

Protozoan purification by migration may be true of the eastern population, but overwintering populations of the Pacific migration have infection rates of 53-68%. This less strenuous migration does not free the Pacific population of infection, but infection has no effect on monarch mortality at the temperature (10.1°C; 50°F) and humidity (78%) of the overwintering sites (Leong et al. 1992; deRoode et al. 2008; Glassberg 2014).

Monarchs have some characteristics of social insects, such as bees. Though they do not live in colonies, clusters give added protection against bird predation, additional warmth and shelter. In the spring, large numbers make it easy to find a mate. And because of the migration, genetic information has been optimized for fitness (Tuskes and Brower 1978).

Milkweed Protects Them

There are more than 100 species of milkweed in North America, and monarchs are known to use about 27 of them (Malcolm and Brower 1989). Milkweed contains steroids called cardiac glycosides (cardenolides) that are toxic to many vertebrate, and some invertebrate, predators. The amount of cardiac glycosides varies according to milkweed species, and each species has a characteristic chemical fingerprint (see Table 1). The amount sequestered in the butterfly is independent of concentration in the plant (Brower 1969; Malcolm and Brower 1989; Malcolm 1991).

The best milkweed for monarchs contains intermediate levels of toxins. Too little does not protect them, too much retards their growth. Concentrations of toxins are higher in younger plants, and those on the edge of milkweed patches. Monarchs typically concentrate the plant toxins by about 5x. For instance, the most common host, *A. syriaca*, contains about 0.5 mg/g, and monarchs that feed on it contain about 2.3 mg/g. Female monarchs contain larger concentrations of toxins than males (Malcolm et al. 1989).

The amount of toxin per butterfly varies with each generation. Much of the toxin is lost during the fall migration, and lowest levels are in overwintering monarchs, making them more vulnerable to birds (see below). In the spring, eggs are laid on Southern U.S. milkweed sources such as *A. viridis* that are rich in toxins, producing a maximum amount in each butterfly. So spring and summer butterflies have the maximum protection (Malcolm and Brower 1989; Martin et al. 1992).

Table 1. Native Milkweeds for Monarchs

Common name	Scientific Name	Native Area	Description	Cardenolides (micrograms per gram dry wt.)	Reference
Butterfly weed	*A. tuberosa*	Southeast, California, Arizona	Well drained soil. Bright orange flowers.	30	MJV 2015a, Malcolm 1991
Swamp milkweed	*A. incarnata*	Northeast	Damp areas. Pink flowers.	140	MJV 2015a, Malcolm 1991
Narrowleaf milkweed	*A. fasicularis*	California and West	Dry climate. Gray-pink or white flowers.	170	MJV 2015a, Malcolm 1991
Purple milkweed	*A. purpurascens*	Northeast	Purple flowers.	350	MJV 2015a, Agrawal et al. 2015
Common milkweed	*A. syriaca*	Northeast	Aggressive in gardens. Well drained soil. Purple-pink to green-white flowers.	500	MJV 2015a, Malcolm 1991
California milkweed	*A. californica*	California	Grassy areas. Pink to purple flower	660	MJV 2015a, Malcolm 1991
Showy milkweed	*A. speciosa*	California	Grassy areas. Pink or white flowers.	900	MJV 2015a, Malcolm 1991
Green milkweed	*A. viridis*	Texas, South Central	Dry areas. Flowers green-white to red-purple.	2450	MJV 2015a, Malcolm 1991
Sandhill milkweed	*A. humistrata*	Southeast	Dry sandy areas. Pink flowers	3890	MJV 2015a, Malcolm 1991
Tropical milkweed	*A. curassavica*	Not native, but can grow in U.S.	Cut back in spring and fall. Reddish orange flowers.	10550	Malcolm 1991

Milkweed species most frequently utilized by the eastern monarchs are *A. viridis* and *A. humistrata* that support spring monarchs in the south, and *A. syriaca* that supports summer and fall monarchs in the north. Studies show that about 92% of overwintering monarchs in Mexico have developed on *A. syriaca* (Malcolm and Brower 1989).

Humans as Enemies

Humans are major enemies of monarchs due to development and overuse of pesticides. Glyphosate application to Roundup Ready® GMO corn and soybeans in the Midwest has destroyed about 99% of the milkweed growing in the fields, leading to a 64% milkweed reduction in the landscape, and an 88% loss of Midwest monarchs (Pleasants and Oberhauser 2013; Hartzler 2010; Pleasants 2015). Since most of the monarchs overwintering in Mexico originate in the Midwest, the Midwest massacre can explain the 90% drop in overwintering populations (Wassenaar and Hobson 1998).

Monarchs are also being killed by garden pesticides and mosquito sprays (Oberhauser et al. 2006; Krischik et al. 2015). Permethrin and other mosquito sprays contaminate milkweed, killing larvae that eat it, and adults that contact it (Oberhauser et al. 2006).

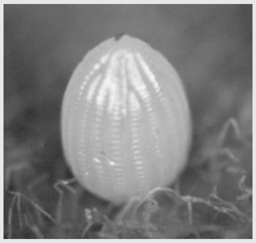
Neonicotinoid insecticides have drastic effects on bees, and may affect monarchs. Milkweed leaf concentrations of 1 part-per-billion (ppb) of the neonic clothianidin slow larval development, and concentrations of 15 ppb can kill half of an exposed larval population (Pecenka and Lundgren 2015).

Neonic use in corn growing areas can have an impact on larval growth and survival. Milkweeds are exposed to the insecticides through pesticide drift. One study showed milkweed plants about 1.5 m (5 ft) from cornfields contained an average neonic concentration of about 1 ppb. About 50-80% of monarch eggs laid on exposed plants did not hatch or led to dead larvae (Pecenka and Lundgren 2015).

Neonics are applied to gardens, parks, and other non-agricultural areas through foliar sprays and soil drenches. Neonics are systemic, appearing in leaves, pollen and nectar. Garden soil drenches of flowering plants may expose adults to toxic nectar. Concentrations of 10-50 ppb and more are often obtained in nectar (Goulson 2013; Quarles 2014). For instance, eucalyptus trees, *E. rudis*, treated with soil drenches of imidacloprid at label rates had 660 ppb of imidacloprid and its toxic metabolites in the nectar five months after the application (Paine et al. 2011).

Neonics applied as soil drenches in gardens can have an effect on monarch mortality. Monarch larvae died within 7 days after they were fed leaves of tropical milkweed, *A. curassavica* that had been treated with 1x and 2x label soil application rates of the neonic imidacloprid. Adults exposed to flowers did not die, but may have experienced some sublethal effects (Krischik et al. 2015).

Box A. Monarch Biology



A monarch egg. Actual size is 1 mm.
Photo courtesy of Michelle Solensky

Each monarch female lays 300-400 eggs during her lifetime. Large numbers are needed because of the high death rate. Eggs are laid on the underside of milkweed leaves, and small seedlings are preferred to mature plants. An egg weighs about 0.5 mg, a female about 500 mg. Yellowish white 1 mm eggs hatch into small caterpillars, reaching about 3-4 mm in length (0.1 in) before they molt. Caterpillars molt through 5 instars, and the largest is about 55 mm long (2 in). The 1st instars have a black head and a grey body. Further stages are the familiar white, black and yellow-striped environmental icons (Heppner 2005).

The larval stage lasts 9-14 days, and more than 90% die before pupation. They are killed by bad weather, pesticides, disease, and natural enemies. The 5th larval instar forms a pupal stage that lasts 9-15 days. Larvae either pupate on the underside of milkweed leaves or in sites nearby. They spin a silk footpad, hanging from their tails as the green and gold-spotted pupa develops. Adults emerge from the pupal stage in the mornings. Adults have wingspans of about 9-10 cm (3.5-4 in), and have two pairs of wings with the familiar orange and black multicolored pattern reminiscent of stained glass. Adult males have one black spot on each rear wing, females do not. The bright colors advertise that the monarch might be poisonous (Brower 1969; Urquhart 1987).

From egg to adult takes about 3-4 weeks. Adults not in diapause mate 3-8 days after emerging and start laying eggs. Summer adults live 2-5 weeks, the overwintering generation lives 9 months. There are 4-5 generations per year (Oberhauser 2004).

Temperature is an important part of monarch biology. Low temperatures of 11-12°C (52-54°F) stop larval development. Continuous exposure to 36°C (97°F) causes larval mortality, and 44°C (111°F) kills all larvae exposed. No larvae survive -20°C (-4°F), and no eggs are hatched at -30°C (-22°F) (Nail et al. 2015).

Monarchs have several flight modes. They glide leisurely when approaching a plant for nectar or to lay eggs. They cruise at about 10 mi/hr (17 km/hr), and fastest flight is about 22 mi/hr (37 km/hr). Monarchs rely on their bright colors to warn predators. Males approach females at their fastest speed, if receptive, she flies in an ascending spiral. Migrating monarchs cover about 3.2 km/hr (2 mi/hr) by combining gliding with cruising flight (Urquhart 1987).

Photo courtesy of Jaap de Roode

A late stage monarch caterpillar.

Photo courtesy www.MonarchWatch.org

A green and gold monarch pupa.

Photo courtesy Glenda Denniston, UW Madison

Adult male monarchs have two distinct spots on their rear wings.

Natural Enemies

Monarchs have an important ecological role because they feed large numbers of beneficial insects and spiders. More than 90% of monarchs are killed in the egg, larval, and pupal stage. Natural enemies include spiders, ants, ladybugs, lacewing larvae, paper wasps, parasitoid wasps, and tachinid flies. In many cases, more than 98% are dead before they become 3rd larval instars. About 10-20% of late stage larvae and pupae are killed by parasitoids such as the tachinid, *Lespesia archippivora.* Typically, each female lays about 300-400 eggs, producing after attrition about 3-7 adults (see Biology Box A). Losses are less after monarchs become adults, as their sequestered toxins protect them from vertebrate predators. But because monarchs metabolize or excrete some of their toxins during migration, about 9% of overwintering adults in Mexico are killed by birds or mice (Prysby 2004; Oberhauser et al. 2007; deAnda and Oberhauser 2015; Oberhauser et al. 2015b).

Attack by Protozoan

As mentioned above, monarchs are also attacked by a protozoan parasite, *Ophryocystis elektroscirrha.* The major route of transmission is through infected females that spread spores onto milkweed and eggs during egglaying. New infections start when larvae eat the spores. During the pupal stage, spores from the parasite invade epidermal tissues of developing adults. Wings and abdomens of emerging monarchs are covered with spores, and a high spore load can lead to deformity and death during metamorphosis. About the same number of males and females are infected (Altizer 2001; Leong et al. 1992).

The most serious infections start with the 1st instar (see Box A). One ingested spore is enough to cause an infection. Larvae do not infect each other by contact, and spores that pass through the larval intestine are not infectious. Spores that sit in the environment for a year are about 1/5 as active as fresh spores (Leong et al. 1997a).

Spore-covered adults can spread the spores to other adults, primarily by mating. Females infected during mating or metamorphosis transmit the spores while egg laying. Spores spread by males infected during mating is a less important route of transmission. Passive transmission between adults in clusters is possible, but transfer quantities are low. For instance, the percentage of clustering individuals with detectable infections did not change over a 6-mo period in California. Immune responses and sequestered plant toxins protect monarchs from the parasite. Monarchs are either killed outright or become debilitated, making migration difficult (Leong et al. 1992; Leong et al. 1997ab; Altizer 2001; Altizer and deRoode 2015).

Ecological Interactions

Monarchs are involved in complex ecological interactions. Infections of milkweed by vesicular arbuscular mycorrhizae (VAM) fungi can increase plant nutrition and the concentration of cardenolides. As the amount of cardenolides sequestered by monarchs increases, monarchs become more resistant to the parasite, *O. elektroscirrha* (Tao et al. 2015).

Photo courtesy of Jim Lovett, www.MonarchWatch.org

Spores can be transmitted while mating.

Milkweed infested by aphids is not good for the monarchs. Aphid feeding reduces toxins secreted by the milkweed, increasing the parasite load of monarchs feeding on the plant. Though aphids reduce monarch predation by lady beetles, monarchs are more likely to die on aphid infested plants, as aphids attract ants that feed on monarch eggs and larvae (de Roode et al. 2011; de Roode 2015).

Milkweed aphids should be controlled with insecticidal soap. Allowing populations to grow could impact monarch populations. Care should be taken not to kill monarch eggs and caterpillars (deRoode et al. 2011).

What do they Need?

Since monarchs are at risk, what can we do to help them? To survive, monarchs need water, milkweed, nectar sources, and trees on which to overwinter. Milkweed provides food for caterpillars, and nectar sources for adults. Adults can also utilize many of the nectar plants that sustain bees, biological controls, and other butterflies. Trees needed must be in critical climate zones that provide moisture and shelter monarchs from storms and other disturbances (Oberhauser et al. 2015a).

Monarch Way Stations

Monarch restoration is the goal of several environmental groups. Bringing Back the Monarchs is a project of Monarch Watch. Monarch Watch encourages home gardeners to plant milkweed and nectar plants, and in return will register the garden as a Monarch Way Station (see Resources). Recommendations include an area of at least 100 ft^2, six hours of sun a day, low clay soils with good drainage, at least ten milkweed plants, preferably from different species, and at least four species of nectar plants. Nearly 13,000 Monarch Way Stations have been registered. Other organizations with pollinator and butterfly garden certification programs include the Xerces Society, Monarch Joint Venture, the North American Butterfly Association, and Wild Ones (see Resources) (Popkin 2014).

Photo courtesy Geoff Hall, Sentient Landscape

Lawns can be sheet mulched to establish milkweed and nectar plants.

Make your Lawn a Way Station

If your garden is already overplanted, consider converting your lawn to a Monarch Way Station. There are 40 million acres (16.2 million ha) of irrigated lawns in the U.S. (Milesi et al. 2005). Lawns can be at least partly replaced with milkweeds for monarchs, pollen and nectar sources for bees. Many public agencies have made lawn replacement a priority (www.stopwaste.org). We can help monarchs by making sure monarch friendly plants are part of these lawn replacement programs (Bay Friendly 2008).

The best way to replace a lawn is through sheet mulching. Sheet mulches are built in layers like lasagna. Layers such as paper or cardboard that are rich in carbon are alternated with material high in nitrogen such as grass clippings and manure. Sheet mulching combines composting in place with surface mulching. It provides an easy way to turn a lawn into a garden (Bay Friendly 2006).

To sheet mulch a site, existing vegetation is knocked down or mowed so it lays flat. Compost or manure is added at about 50 lbs/100 ft^2 (2.5 kg/m^2). The site is soaked with water, and large plants are added. The next step is to add a weed barrier of cardboard or layers of paper. Rolls of recycled cardboard can be purchased. Cardboard sections are overlapped about 6 inches (15.2 cm) to prevent weed penetration. With sheet mulching, restraint is a good idea. Two layers of cardboard are enough for weed control. If cardboard is layered too thickly, the soil could become anaerobic and plants could die.

The cardboard should be wet thoroughly with water to keep it in place. About two inches (5 cm) of compost should be layered on top. To improve weed control and add aesthetic value, a top layer of shredded yard waste, leaves, straw, wood chips or other organic material 2-5 inches (5.1-12.7 cm) deep is added. Small plants can be transplanted by punching holes in the cardboard. To prevent disease, mulch should not be in contact with plant stems (Bay Friendly 2006; 2008; Olkowski et al. 1991; Quarles 2008).

Monarchs Along the Roadside

There are 10 million acres (4 million ha) of roadsides in the U.S. Conversion of these from herbicide management to integrated vegetation management (IVM) and native plants could bring back needed habitat for bees, birds, and monarchs (Quarles 2003). For instance, conversion from herbicide management to IVM and native plants increased the number of roadside milkweed sites in Iowa by about 64% (Hartzler 2010).

The Obama administration as part of the "National Strategy to Promote the Health of Honey Bees and Other Pollinators" has proposed establishing milkweed and nectar plants along federal highways, especially along Interstate 35, the corridor from Mexico to the Midwest. State governments might also consider this approach.

Laws and Regulations

We should raise awareness of laws crafted to help the monarchs. California AB559 allows the California Fish and Wildlife Department to partner with non-profits, federal agencies, and private landowners to conserve monarch habitat. The Department can plant native nectar and milkweed sources, and restore trees in overwintering habitat. It can use residential and institutional landscaped areas, agricultural noncropped lands, transportation corridors, and other areas.

Photo courtesy www.MonarchWatch.org

Tropical milkweed, *Asclepias curassavica*

Photo courtesy laspilitas.com

California milkweed, *Asclepias californica*

Photo courtesy of University of Minnesota Monarch Lab

Common milkweed, *Asclepias syriaca.*

Environmental groups have petitioned the federal government to give protection to monarchs under the Endangered Species Act, and a decision is expected soon.

Which Milkweed Species to Plant?

Key to bringing back the monarchs is restoration of milkweed. As mentioned earlier, migratory monarchs do best on native species with intermediate cardenolide concentrations (see Table 1). Caterpillars on plants such as *A. syriaca*, with low latex and cardiac glycoside concentrations, can weigh up to 10x more than those on plants such as *A. californica* or *A. asperula* with higher latex and cardenolide concentrations (Agrawal et al. 2015).

Lack of native seeds has hampered milkweed restoration efforts. But 15 species of milkweed are native to California, and the Xerces Society Project Milkweed has now made seeds of narrowleaf milkweed, *A. fascicularis*; and showy milkweed, *A. speciosa*, available in California (Xerces 2011) (see Resources).

If you cannot obtain locally sourced seeds, and you are in the Eastern U.S., it is better to buy commercially available *A. syriaca* seeds than to not plant milkweed at all (see Resources). About 92% of the overwintering Eastern population feeds on *A. syriaca* (Malcolm and Brower 1989).

Although *A. syriaca* is the best adapted to monarchs, many gardeners do not like to plant it because it is aggressive in gardens, spreading from root buds. Growing in raised beds will minimize this, but there are other native milkweeds such as butterfly weed, *A. tuberosa*, or purple milkweed, *A. purpurascens* that may be more appropriate in some gardens (Popkin 2014).

Box B. Milkweed Biology

The milkweed family Apocynaceae evolved in the Old World about 45-53 million years ago (Ma). The subfamily Asclepiadoideae diverged about 40 Ma, then spread to North America about 20 Ma. Milkweed was likely in Mexico by 7 Ma (Wikstrom et al. 2001; Rapini et al. 2007). Milkweed gets its name from the milky sap that the plant secretes when it is damaged (Gaertner 1979). Biological details vary with the species, but the biology of most is similar to *A. syriaca*, which is given here. Milkweeds grow either from seeds or by vegetative reproduction. Seedlings are characterized by a central stem with opposite leaves and a flower head at the top of the stem. Flowers are complex and have an umbel like structure. Flowers must be pollinated to produce seeds, and pollinators are mostly wasps and bees (Bhowmik and Bandeen 1976; Wyatt and Broyles 1994).

For *A. syriaca*, aerial shoots emerge in the spring. Plants like to grow in sunny, well drained soil. Stems grow to heights of about 60-120 cm (2-4 ft). Leaves can be narrow or broad, hairy or smooth according to species. *A. syriaca's* leaves are broad (5-15 cm; 2-6 in) and 7-20 cm long (2.7-7.9 in). Leaves are short stalked, "prominently veined, smooth margined, green on the upper surface, but light colored and hairy on the lower surface." At the end of its life cycle, each stem produces 4-6 pods containing 150-425 seeds. Seed pods split open early in the fall, revealing seeds. These have silky strands called floss attached to them that help them disperse in the wind (Bhowmik and Bandeen 1976; Wyatt and Broyles 1994).

A. syriaca and many other species are native to North America, growing wild along roadsides, fencerows, wastelands, river basins and in agricultural fields. What looks like a colony of milkweed is often many stems growing from roots of the same plant. *A. syriaca* grows best at 27°C (80.6°F) and 16 hr photoperiods (Bhowmik and Bandeen 1976).

Tropical Milkweed Controversy

Many gardeners have planted non-native tropical milkweed, *A. curassavica*, because seeds are readily available, it is aesthetically pleasing and less aggressive than some of the native milkweed species. Monarchs like it, and thrive on it. In fact, monarchs may have been breeding on *A. curassavica* in Mexico a million years ago when the migrations likely began (Ripini et al. 2007; Zahn et al. 2014).

Migratory monarchs use plant senescence as a cue to start migrating south. In northern areas, winter freezes kill *A. curassavica* along with other milkweeds. In areas of Florida, California, Arizona, and along the southern border of the U.S., it grows throughout the year, and monarchs may be tempted not to migrate.

Photo courtesy of Tony Morosco

Monarchs are fond of sunflowers, *Helianthus spp.*

In fact, there are non-migrant monarch populations in Florida, Arizona, and in Southern California. Native milkweed that dies back during the winter is a better choice, especially along the southern border (Batalden and Oberhauser 2015; Popkin 2014). But some experts question this concept, and think tropical milkweed along the border is not significantly interfering with migration (Glassberg 2014).

If you already have tropical milkweed, cut it back drastically in the fall and spring, and migratory behavior will be maintained. In areas that already have non-migratory monarchs, tropical milkweed can be maintained year round to support these populations. The plant has high levels of cardenolides, and may actually help monarchs that are infested with parasites (Altizer and deRoode 2015; deRoode et al. 2008; Malcolm 1991).

Growing Milkweed

Milkweed should be planted in raised beds, as it can aggressively spread throughout a garden. Plants can grow from seeds or root cuttings. When growing milkweed outdoors from seeds, planting in the fall primes seeds for germination. Seeds are best planted about 1-2 cm (0.4-0.8 in) deep, then protected by a thin mulch (Landis and Dumroese 2015).

If you want to plant outside in the spring, seed stratification will aid their germination. Seeds are mixed with an equal volume of moist sand or vermiculite, then held in a refrigerator (4-5°C; 40-41°F) for about 4-6 weeks (Borders and Lee-Mader 2014).

Seeds can also be planted directly into shallow germination trays (flats), and seedlings can then be transplanted later into the garden. Seeds are pressed gently into the growth medium, then covered with a very thin layer of peat moss or perlite. Flats can be maintained moist, but not wet by misting, and are kept at about 65-70°F (18.2°C-21.1°C) (Landis and Dumroese 2015).

For vegetative propagation from root cuttings, rhizomes should be collected in late fall to early spring. They can be planted outdoors in raised beds or in large containers filled with a well drained growth medium. When the plant matures, pruning dead flowers will bring new ones and extend the flowering period (Landis and Dumroese 2015).

Nectar Plants

Monarch adults need nectar to survive, and the migrating generation consumes nectar to build fat reserves for overwintering. Some of the nectar can come from milkweed, but other sources are necessary. When planting, choose natives when possible. Fall nectar sources are important, and these include *Ageratina hvanensis, Bacharis neglecta, Helianthus maximiliani, Liatris mucronata, Solidago nemoralis,* and especially *Vebesina virginica* (Brower et al. 2015). Other good nectar plants are *Lupinus, Senecio, Stevia,* and *Bidens* (Brower 1977). Native nectar sources in the spring include violets, *Viola spp.* and serviceberries, *Amelanchier spp.* In the summer, sumacs, *Rhus spp.*; coneflower, *Echinacea purpurea*; and blazing stars, *Liatris spp.* can provide nourishment. And in the fall, asters, *Symphyotricum spp.* and witch hazels, *Hamamelis spp.* can provide nectar (Popkin 2014). Organizations such as Monarch Watch, Wild Ones, and Monarch Joint Venture have online lists of monarch friendly plants (MJV 2015abc; Xerces 2013)(see Resources).

If natives are not available, plants attractive to butterflies include butterfly bush, *Buddleia davidii*; yarrow, *Achillea millefolium*; aster, *Callistephus sp.*; lavender, *Lavendula sp.*; lilac, *Syringa sp.*; Mexican sunflower, *Tithonia diversifolia*; burning bush, *Dictamnus sp.* and others. Much information on butterfly gardens is available on the internet and in classic books on the subject (Xerces 1990; 2016).

Conflicting Issues

Milkweed feeds monarchs, bees, and biocontrol agents such as lady bugs. Establishing milkweed for monarchs will also help support their natural enemies. So should you establish milkweed or other plants that encourage biocontrols? Yes. Monarch populations have adapted to the natural rate of loss, and the natural enemies will provide pest control for your garden. Some of the biocontrol agents fed by milkweed might attack monarchs, but without milkweed, monarchs would not survive at all (Oberhauser and Solensky 2004).

In general, native plants should be encouraged because they are adapted to the landscape. If your garden already has non-native nectar plants such as buddleia, zinna, lilacs, sweet alyssum, and marigolds that are feeding monarchs, keep them until you have good native replacements (Popkin 2014).

California monarchs primarily use non-native eucalyptus trees to overwinter. There is a contingent of native plant experts that would like to remove all eucalyptus. Eucalyptus was first planted in California in 1848, and presumably the monarch used another species before then. But in any of these restoration schemes, other trees such as pines and cypress should be established before eucalyptus is removed so that overwintering monarchs will not be displaced (Frey and Schaffner 2004).

Conclusion

We can help bring back the monarchs by planting milkweed and nectar plants, sheet mulching our lawns to make monarch way stations, reducing garden applications of pesticides, and using what influence we have to reduce aerial glyphosate applications in the Midwest. We should promote awareness of helpful legislation. The Obama administration has proposed planting milkweed along federal highways as part of the National Pollinator Health Strategy, and this strategy should be encouraged. Overwintering areas such as the forests of Central Mexico and coastal areas of California should be protected. Monarch butterflies survived the dinosaurs and have probably been migrating for a million years. We should not let pesticide pollution and human activity destroy them. Working together, we can bring back the monarchs.

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Resources

Organizations

Bio-Integral Resource Center (BIRC), PO Box 7414, Berkeley, CA 94707; 510-524-2567; www.birc.org

California Native Plant Society, 2707 K St., Suite 1, Sacramento, CA 95816; 916-447-2677; www.cnps.org

Golden Gate Audubon Society, 2530 San Pablo Ave., Suite G, Berkeley, CA 94702; 510-843-2222; www.goldengateaudubon.org

Monarch Joint Venture, 135 Skok Hall, 2003 Upper Buford Cir., St. Paul, MN 55108; 612-624-8706; www.monarchjointventure.org

Monarch Watch, University of Kansas, 1200 Sunnyside Ave., Lawrence, KS 66045; 785-864-4441; www.monarchwatch.org

North America Butterfly Association, 4 Delaware Rd., Morristown, NJ 07960; www.naba.org

Sierra Club, 85 2nd St., Suite No. 2, San Francisco, CA 94105; 415-977-5500; www.sierraclub.org

Wild Ones, PO Box 1274, Appleton, WI 54912; 920-730-3986; www.wildones.org

Xerces Society, 628 NE Broadway, Suite 200, Portland, OR 97232; 855-232-6639; www.xerces.org

Seeds and Plants

Applewood Seed, 5380 Vivian St., Arvada, CO 80002; 303-431-7333; www.applewoodseed.com

Educational Science, PO Box 747, League City, TX 77574; 281-554-9783; www.educationalscience.com

Hedgerow Farms, Winters, CA; 530-662-6847; www.hedgerowfarms.com

Ion Exchange, 1878 Old Mission Dr., Harpers Ferry, IA 52146; 563-535-7231; www.ionxchange.com

Pacific Coast Seed, Livermore, CA; 925-373 4417; www.pcseed.com

Prairie Moon Nursery, 32115 Prairie Lane, Winona, MN 55987; 800-585-2788; www.prairiemoon.com

Roundstone Native Seed, 9764 Raider Hollow Rd., Upton, KY 42784; 888-531-2353; www.roundstone-seed.com

S&S Seeds, Carpinteria, CA; 805-684-0436; www.ssseeds.com

Sierra Seed Supply, Greenville, CA; 530-284-7926; www.sierraseedsupply.com

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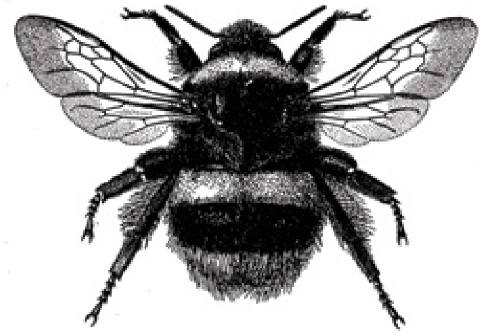
Bringing Back the Birds and Bees



By William Quarles

As we saw in the first article, monarchs are imperiled and need our help. But bees and many bird species are also in decline. Many of the causes are the same: habitat destruction, global warming, and pesticide pollution (NAS 2007). Some of these vast environmental disasters may be beyond our influence. But we can act locally within our own gardens to encourage and restore wildlife such as birds, bees, and monarchs. If enough of us do this, our aggregated gardens can become part of the larger ecosystem that wildlife needs for survival.

Bees are Threatened

Pollinators of all kinds in the U.S. are in decline (NAS 2007). This is especially true of honey bees. Over the past five years, overwintering colonies of honey bees have been averaging losses of about 30%. From April 2014 to April 2015, honey bee colony losses were about 40%, the highest on record (USDA 2015). Major causes are mites, loss of habitat, and pesticide pollution. Pesticides, and especially neonicotinoids, are a major problem. For instance, Mullin et al. (2010) analyzed a large number of commercial honey bee hives for pesticides. Wax, pollen, and bees were highly contaminated. There were 121 different pesticides and metabolites in 887 wax, bee, and pollen samples, averaging about 6 pesticides per sample.

Honey bees are extremely sensitive to neonicotinoid pesticides, which are extremely persistent and exposure is widespread. Neonics are applied as seed treatments in agricultural fields, and as soil drenches or foliage sprays on trees, ornamental plants, and lawns in gardens, parks, and nurseries (Quarles 2014; Goulson 2013).

Photo courtesy of Gary McDonald

Yellow faced bumble bee, *Bombus vosnesenskii*

Neonicotinoids are systemic, appearing throughout the plant, including the pollen and nectar. Honey bees readily consume pollen and nectar containing neonics, sometimes causing death (Kessler et al. 2015). Sublethal effects include impaired foraging, damaged immune systems, and reduced reproduction (Wu et al. 2011; Yang et al. 2008; Pettis et al. 2012; Lu et al. 2011; 2014).

Neonics and other pesticides also have an effect on wild bees. Mosquito control programs, sprays for forest pests, lawn insecticides, and crop production chemicals are all part of the problem (Hladik et al. 2016). For instance, neonic seed treatments have been shown to reduce the number of foraging bumble bees in canola fields, and lawn sprays decreased reproduction and increased mortality (Rundlof et al. 2015; Whitehorn et al. 2012; Larson et al. 2013).

Wild Bees

Most of the 17,000 known species of wild bees are solitary (NAS 2007; O'Toole et al. 1991; Michener 2007; 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.

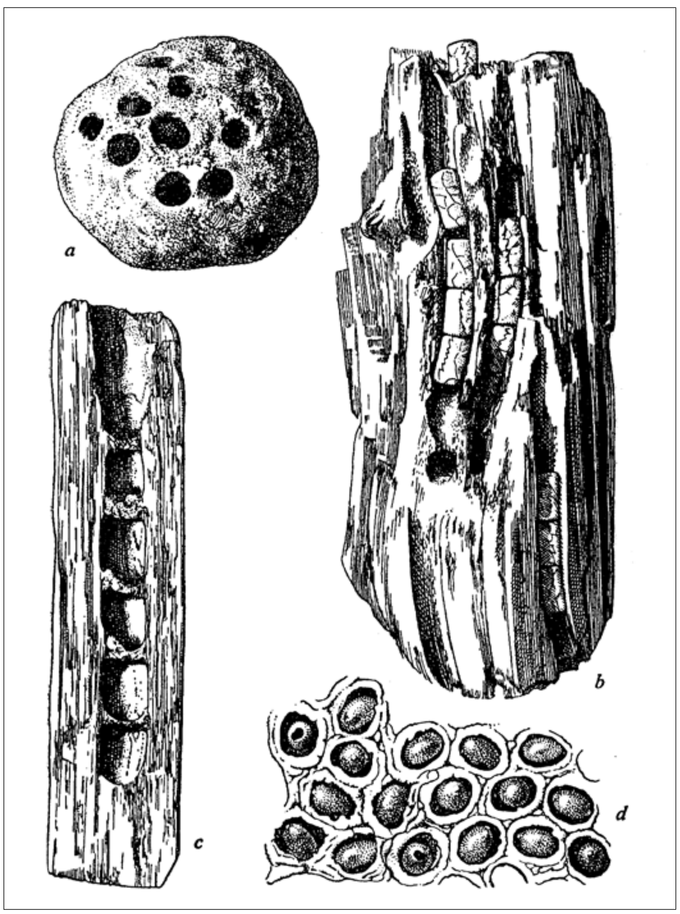
Some solitary bees nest in isolation, others are more gregarious. Gregarious bees have solitary nests, but they like a lot of companionship. So several bees may establish nests close together. Examples of gregarious bees are alkali bees, *Nomia spp.* and carpenter bees, *Xylocopa spp.* Finally, large 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).

Provide Nesting Sites

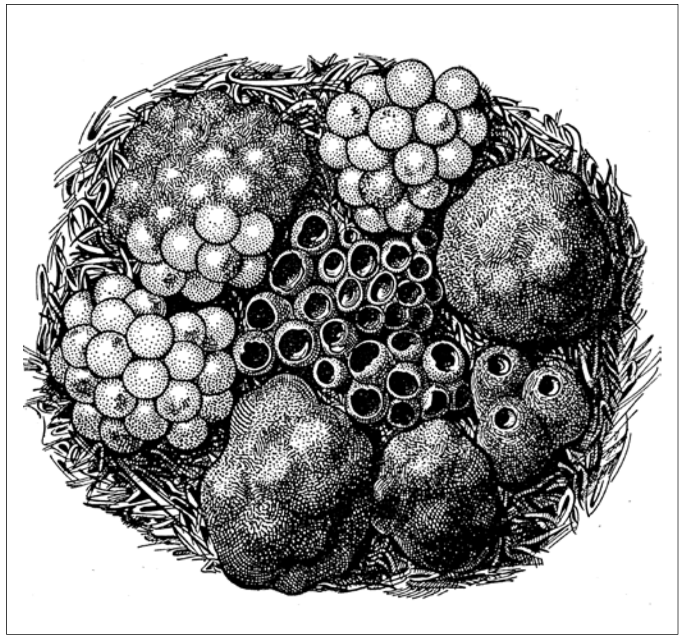
We can help bring back the bees by providing nesting sites. Most North American native bees nest in the ground. Sweat bees (Halictidae) and the Adrenidae family dig holes in the ground; bumble bees, *Bombus spp.*, like to nest in abandoned rodent burrows. Sunny, open horizontal areas of well drained 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. Use of drip irrigation can reduce the flooding that kills nests in soil (NAS 2007; AAPA 1999; Quarles 2008a).

About 10% of native bees, such as carpenter bees, *Xylocopa spp.*, mason bees, *Osmia spp.*, and some leafcutters, *Megachile spp.* nest in wood. 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 15cm) deep in a 4x4 inch (10 by 10cm) or 4x6 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 the nests should be protected from rain (NAS 2007; AAPA 1999; Greer 1999).



From Nixon 1954

(a) Mason bees nest in tubes lined with clay (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

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.

Avoid Pesticides

To bring back birds and bees, we should 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 2008ab; 2004ab; 2005ab; 2013).

When possible, chemical pesticides should be avoided altogether by growing organic gardens, lawns, and landscapes, and switching to organic farm production. (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 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), *Chromobacterium sp.*, 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 plants that butterflies do not utilize. It should not be applied to milkweed (NAS 2007; Quarles 2004ab; Quarles 2006; Quarles 2013).

Floral Resources

To increase bee populations, we can increase floral resources. Many of the same nectar plants that feed monarchs (see the first article) will also feed bees and hummingbirds. 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).

Plantings for bee gardens include attractive plants such as scorpion weed, *Phacelia spp.*; sunflower, yarrow, mints, borage, bachelor's button, blackeyed susan and others (Quarles 2008b). Bee plants can also provide nectar for adult monarch butterflies, *Danaus plexippus*, that are endangered due to herbicides and destroyed habitat (Quarles 2011a).

Forage Available

Social bees such as honey bees have perennial colonies. When foraging plants are not available, they 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. Because they do not have extensive food stores, forage must be constantly available. Floral resources must have overlapping flowering periods, so that something is constantly in bloom (Wojcik et al. 2008). Wildflower seed mixes are commercially available that can provide forage in open areas (see Resources). Perennials and annuals in planting beds should be chosen with flowering periods in mind (NAS 2007; Frankie et al. 2002; Black 2008).

Photo courtesy of James Cane, USDA

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

Photo courtesy of Gary McDonald

Mason bee, *Osmia sp.*

High Density Planting

With flower plantings, high density is best for bees. Frankie et al. (2002) found 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.*).

Native Bees Native Plants

When restoring habitat, native plants are preferable because native bees generally prefer native plants (Schmidt 1980; Frankie et al. 2002; Schindler et al. 2003). This may be because exotics generally produce less pollen and nectar than natives. Or perhaps, coevolution of the native bees and plants caused the preference. Bees attracted vary with the flower species. Bumble bees and sweat bees (Halictidae) often frequent California poppy, *Eschscholzia californica*. Blackberries attract "a wide variety of leafcutter bees, bumble bees, and honey bees." Dusty Miller, *Centaurea cineraria*, attracts megachilids. *Cosmos* attracts "large anthophorid bees of the family Apidae" (Frankie et al. 2002). 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.

Lose the Lawn

Lawns eat up resources. They are water hogs, and they require large amounts of fertilizers and pesticides. We can bring back monarchs, birds and bees by converting our lawns to Monarch Way Stations, and habitat for bees and birds. This approach is outlined in the first article and also in the BIRC publication, *Rethinking the American Lawn* (Quarles 2009).

One alternative is mowed pathways in native meadowgrasses and wildflowers. America is blessed with a number of strikingly beautiful wildflowers such as California poppy, *Eschscholtzia sp.*; black-eyed susan, *Rudbeckia spp.*, purple blazing stars, *Liatris spp.*, and others. Seed mixtures are available to suit the needs of your climate

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*	Fabaceae
False indigo	*Baptisia fruticosa*	Blue, purple
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.

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	Southeast
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**

Spearmint, *Mentha* sp.

(Daniels 1999). Mowed, gravel, or flagstone pathways can be integrated with strategically placed raised beds containing vegetables and herbs. Sheet mulching can be used to convert your lawn to milkweed and nectar plants for monarchs, and pollen and nectar plants for bees and hummingbirds (Quarles 2008a).

If you need to keep part of your lawn, there are cultural methods and least toxic pesticides to deal with most lawn pests. Common pests are grubs, billbugs, chinch bugs, cutworms, mole crickets, and sod webworm. Cultural controls such as proper fertilization and watering; physical controls, such as traps; and biological controls such as nematodes, *Bacillus thuringiensis* (BT), and beneficial fungi, can be integrated with least-toxic chemical controls such as neem, insecticidal soap, natural pyrethrins, and spinosad (Quarles 2006).

Birds are In Decline

Many bird species are in decline. In 2014 the North American Bird Conservation Initiative found that 33 of the most common bird species such as sparrows, warblers, cuckoos, and blackbirds are in steep decline. The Audubon Society has found that 10 common bird species have declined by about 70%, and the bobwhite has declined by about 82%. Major causes are loss of habitat due to agricultural intensification and development, and pesticide pollution (Goulson 2013; Hallman 2016).

Pesticide Destruction

Grassland birds are in decline, and about 25% of species protected by the Migratory Bird Treaty Act are in trouble. At least 72 million birds are directly killed by pesticides in the U.S. each year, and sublethal effects are probable in 10 times that many. So pesticides may be affecting nearly a billion birds a year (USFWS 2002; Mineau and Palmer 2013).

Organophosphate and carbamate insecticides often had disastrous and dramatic effects on birds. In 1992, when these were in widespread use, lethal toxicity from insecticides was the best predictor of grassland bird decline (Mineau and Whiteside 2013).

Neonicotinoid seed treatments can kill seed eating birds. One imidacloprid treated corn seed, 3-4 cereal seeds, or 4-5 canola seeds can be lethal. About 1/10 of a lethal dose can cause chronic and reproductive effects (Mineau and Palmer 2013).

Neonic and other pesticides can also reduce the food supply of insectivorous birds. Neonics are water soluble and applications finally end up in surface water. Hallman et al. (2014) showed that as concentrations of the neonic imidacloprid in the surface water increased beyond 20 ng/liter (1ng is a billionth of a gram), the number of insectivorous birds declined by 3.5% a year. The pesticide depleted the insects they were eating.

Garden Birds

Grassland birds are being impacted by agricultural intensification, and forage areas are being destroyed. We may have no influence over these trends, but we can act locally to increase populations of garden birds. Birds often seen in gardens include sparrows, jays, robins, mockingbirds, mourning doves, towhees, and hummingbirds (Adams 1998).

Photo courtesy of Br. Alfred Brousseau

California poppy, *Eschscholzia californica*

Garden birds generally eat seeds, insects and nectar. Some seed eating birds, such as mourning doves and sparrows can be encouraged by birdseed feeders. Nectar rich plants can encourage hummingbirds, and hummingbird feeders can help maintain them in winter. Insectivorous birds that provide biocontrol include bluebirds, chickadees, nuthatches, phoebes, sparrows, purple martins, vireos, and wrens. These can be encouraged by providing water, trees, shrubs, and nesting boxes (Roth 1998).

Sunflower, *Helianthus sp.*; *Cosmos sp.*, purple coneflower, *Echinachea sp.*, manzanita, *Arctostaphlos sp.*, crabapple, *Malus sp.*, elderberry, *Sambucus sp.*, cotoneaster, and blackberry are attractive to birds. Extensive lists can be found on the internet and helpful advice can be found at your local horticultural nursery (Roth 1998).

Garden Harmony

Can we really bring back bees, birds, and monarch butterflies at the same time? Yes. Plantings do not have to be extensive, because some of the same nectar rich plants will simultaneously encourage bees, butterflies, biocontrol insects, and hummingbirds. Insectivorous birds are not generally interested in eating monarchs or bees. They will eat some beneficial insects, but pest insects predominate, and birds will mostly eat those. Beneficial insects will consume eggs and larvae of monarchs, but monarchs compensate by laying a large number of eggs. The overall effect will be a balanced garden with increased pollination, and increased biocontrol, providing food for wildlife and for you.

Conclusion

We can encourage bees by avoiding pesticides and providing water, nesting sites, and floral resources. Birds will respond to food, water, trees and shrubs for shelter. We may not be able to reverse the losses from development and agricultural intensification, but we can have birds, bees, monarchs and biocontrols in a harmonious garden providing us with food and continuous pleasure. If enough of us do this, our aggregated gardens can become part of the larger ecosystem that wildlife needs for survival.

Resources

Organizations

American Bird Conservancy, www.abcbirds.org

Audubon Society, www.audubon.org

American Association of Professional Apiculturists, www.masterbeekeeper.org

Backyard Wildlife Sanctuary Program, http://wdfu.wa.gov/living/backyard

California Native Plant Society, www.cnps.org

Golden Gate Audubon, www.goldengateaudubon.org

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

National Wildlife Federation, www.nwf.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

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.hydrogardens.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.

Wildflower Seed Mixes and Plants

Annie's Annuals—740 Market Ave., Richmond, CA 94801; 510/215-3301; www.anniesannuals.com

Berkeley Horticultural Nursery—1310 McGee Ave., Berkeley, CA 94703; 510/526-4704; www.berkeley-hort.com

Cornflower Farms—9811 Sheldon Rd., Elk Grove, CA 95624; 916/689-1015; www.cornflowerfarms.com

Native Here Nursery—101 Golf Course Drive, Berkeley, CA 94708; 510/549-0211; www.nativeherenursery.org

Pacific Coast Seeds—533 Hawthorne Place, Livermore, CA 94550; 925/373-4417; www.pcseed.com

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Thank you,
William Quarles, Ph.D.
Executive Director

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