On T.R.A.C.K.S.

Teaching Resource Activities and Conservation to Kansas Students

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Plight of the Pollinators

INSIDE...

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Pollinators

Worldwide there is disturbing evidence that pollinating animals have suffered from loss of habitat, chemical misuse, introduced and invasive plant and animal species, and diseases and parasites.

Many pollinators are federally "listed species," meaning that there is evidence of their disappearance in natural areas.

The U.S. has lost over 50% of its managed honeybee colonies over the past 10 years.

This issue of On T.R.A.C.K.S. is dedicated to creating an awareness of the "Plight of the Pollinators" and helping to empower us as educators to make changes in the world in which we live for the benefit of all living creatures.

Anything that moves pollen from one flower to another is called a pollinator. Wind, water, and even people can be pollinators, but the vast majority of pollinators are insects. Bees, wasps, moths, butterflies, flies, and beetles are the most common pollinators, but as many as 1,500 species of vertebrates such as hummingbirds, perching birds, flying foxes, fruit bats, possums, lemurs and even a lizard (gecko) are known to play roles in pollinating the 250,000 kinds of flowering plants on this planet.

Without the assistance of pollinators, most plants cannot reproduce. Nine times out of ten, pollination is the result of a happy accident. The bee or insect that visits the flower is usually after the sweet nectar (which the flower produces to attract and reward the pollinator) but in the process of walking on the flower, pollen collects on the body of the insect. When the insect visits a different flower of the same kind, some of the pollen falls off and lands on the stigma of the flower, thus beginning the process of reproduction. Pollination results when the pollen from the male part of the flower (stamen) is moved to the female part of the same or another flower (stigma) and fertilizes it, resulting in the production of fruits and seeds.

Over 75% of all flowering plants are pollinated by animals. Even more astonishing, is that every third bite you take is directly related to pollination. So thank a pollinator the next time you enjoy a crisp apple, toasted almonds, the season's first tomato, a juicy beefsteak or delicious milkshake. Wait a minute . . . beef and milk? One of the important hay crops we feed our dairy and beef cattle is alfalfa, which is pollinated by bees.

Apples, almonds, blueberries, chocolate, coffee, melons, peaches, potatoes, pumpkins, vanilla, and tequila are a few of the foods and beverages we enjoy due to pollination.Worldwide, roughly 1,000 plants grown for food, beverages, fibers, spices, and medicines need to be pollinated by animals in order to produce the goods on which we depend. In the United States pollination by honey bees directly or indirectly (e.g., pollination required to produce seeds for the crop) contributed to over $19 billion of crops in 2010. Pollination by other insect pollinators contributed to nearly $10 billion of crops in 2010.

Pollinators benefit more than just crops. Pollinators also support the maintenance of biodiversity in the ecosystems they inhabit and are known as keystone species in many terrestrial habitats. Biodiversity of pollinators in agricultural systems is critical to pollination, and likewise, pollination is critical to maintaining biodiversity in these systems.

Butterflies and Moths

Although not as efficient pollinators as bees, butterflies and moths are arguably the prettiest and most popular pollinators. Due to their spindly legs, butterflies do not accumulate as much pollen on their heads and bodies, usually picking up pollen on their tarsi, or feet.

Butterflies are attracted to large flat flowers that provide a sturdy landing platform, such as sunflowers, asters, cone flowers, zinnias, goldenrods, milkweeds and wild yarrow. Unlike bees, butterflies see red and are attracted by brightly colored flowers with faint but fresh odors.

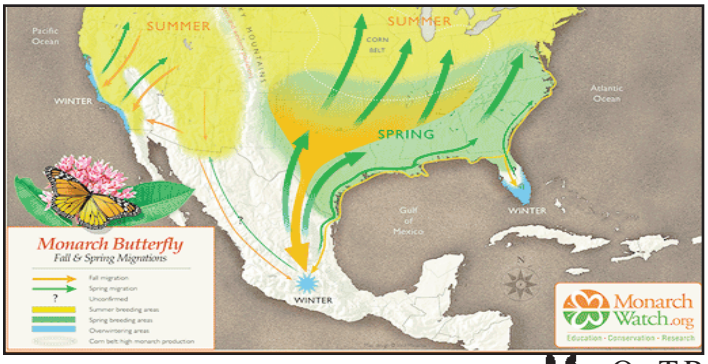
Butterflies also prefer nectar containing amino acids and lower sugar content than bees. The nectar, which is deeply hidden in butterfly flowers, is also in ample supply.

Moths prefer pale, white or pink flowers that bloom at night and exude strong, sweet scents. Many pollinating moths, like the white-lined sphinx, hover and extend their long tongue into the flower, hitting the flower's anthers and stigma with their head and thorax, where it sticks.

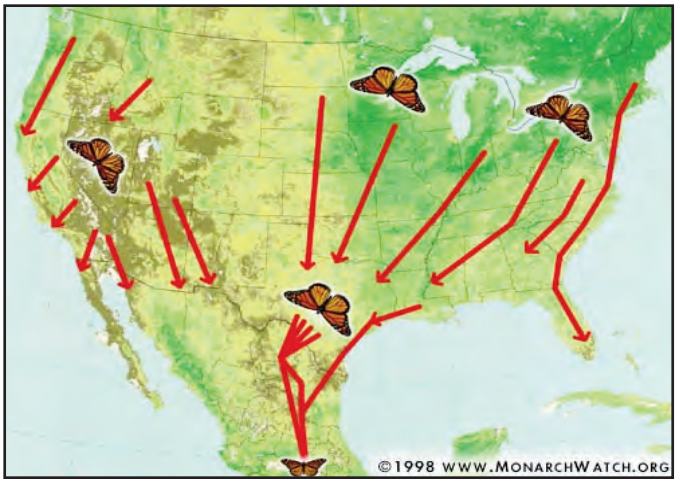
Monarchs: A migrating pollinator

One of the most well-known and beloved butterfly pollinator, the monarch butterfly with its bright orange wings trimmed in black and white, has captured our collective imaginations with its yearly migration. Monarchs, weighing less than 1/5th of an ounce, complete a migration that can exceed 2000 miles on wings 3 ½ to 4 inches wide.

Monarch butterflies begin leaving Central Mexico roost sites in February and March, flying into Texas and other Gulf States, where they mate, lay eggs and die. In about 30 days, a whole new generation of adult monarchs emerge and fly north again, moving into the Great Plains and Central Eastern U.S. The next generation goes through another life cycle, arriving in southern Canada and New England in June. They are following the caterpillar's food source – milkweed.



All adult monarchs live two to five weeks, except the late-summer generation that lives eight to nine months. Migrating monarchs are three to four generations removed from those that made the journey the previous year. In response to stimuli not yet fully understood, these monarchs do not mate and begin feeding heavily, drinking nectar and gaining weight in preparation for the migration south. Soon they begin flying south, facing many challenges along the way – predators, storms, cars, windows, towers and geographical barriers. The northernmost monarchs of Canada must cross the Great Lakes, and, in Mexico, all migrating monarchs face crossing the desert and Sierra Madre Mountains.



Averaging 25 to 30 miles per day, monarchs soar when they can, utilizing thermal air drafts like hawks and vultures, and resting when it is too cold, wet or windy to fly. Monarchs have been sighted 10,000 feet above the earth. The entire trip takes about two months. How they find their way, when they are three to four generations removed from the previous migrating generation, is still not understood. Scientists do have evidence they use a time-compen-

sated sun compass linked to their internal or circadian clock. They may also utilize the earth's magnetic field.

Overwintering sites are located in a 60 square-mile area of transvolcanic mountains at 10,000 feet, where they roost in oyamel fir trees. The tall firs act as heat sinks, providing warmth and canopy to protect them from rain and snow. At some sites, the weight of the monarch clusters break small branches.

And there, they wait, flying out in swarms to drink at streams periodically. In late February, the monarchs change internally and begin mating, starting the whole process over again.

Over the past 15 years, the number of eastern migrating monarchs has plummeted, raising fears the migration will be lost. No one knows the critical number of monarchs needed to continue the migration. Please see the article on milkweed to see how you can help "bring back the monarch".

Plant protection

Toxins (cardiac glycosides) within milkweed stems and leaves, build up within the monarch caterpillar's body and transfer to the adult, providing protection from predators. Due to the toxins, monarchs taste bad and may cause birds to vomit.

Cardiac glycoside levels vary by milkweed species, with some containing very little. Research has shown monarchs choose species with higher levels of the toxin if provided a choice.

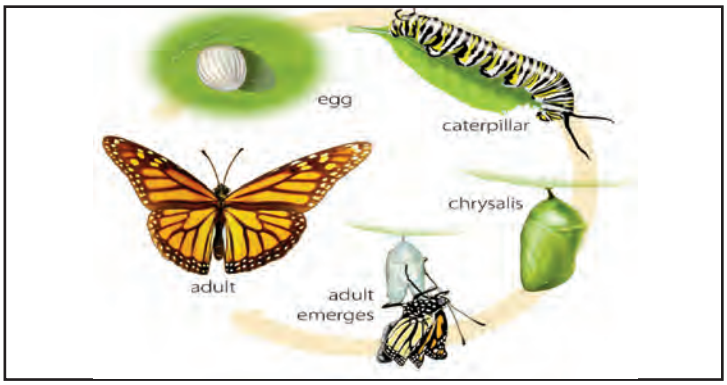
The monarch's bright orange and black coloration is thought to be a warning to would-be predators.

Life cycle

Monarch butterflies start out life rather inauspiciously, in a conical-shaped cream-colored egg about the size of a pinhead. Monarchs, like many butterflies, are host specific, their larva (caterpillar), eat only one particular type, or family, of plants. And for monarchs, that family of plants is the milkweed.

Get it wrong and the caterpillar will starve. Which is why female monarchs take so much time and care finding the correct plant. She locates milkweed plants through taste, using her shortened first pair of legs to tap plant leaves, a process called drumming.

She deposits the egg from her ovipositor located on



the tip of her abdomen, gluing the egg to the leaf. Laying an average range of 100 to 300 eggs, she usually lays one egg per milkweed plant for predator avoidance and insuring enough food for the growing caterpillar.

After four days, the tiny caterpillar hatches from its egg, turning around and eating its egg shell, which is protein rich. Soon the caterpillar moves to the leaf and begins to eat and grow – its sole purpose in life! Caterpillars are eating machines, increasing their body mass by as much as 1000 times or more.

As the caterpillar grows, its exoskeleton, made of chitin, becomes tight. To continue growing, the caterpillar must obtain a new exoskeleton by molting the old one. Monarch caterpillars go through 5 molts, called instars, with the fifth forming a chrysalis.

When the time is right, 10 to 14 days after hatching, the caterpillar becomes restless and leaves the plant, looking for the right spot to become a chrysalis. Spinning silk from glands along their mouths, they construct a silken pad, hooking their back prolegs (false legs) into the pad. And there they hang in the shape of a J for about a day. The actual change takes 10 to 20 seconds, as the exoskeleton splits behind the caterpillar's head and continues to open revealing the green chrysalis beneath.

After the chrysalis hardens, internal and external changes take place, and in 10 to 14 days, the adult but-

terfly is ready to emerge. The chrysalis opens at the bottom, leaking fluid, as the butterfly crawls out and hangs, swaying back and forth. Its wet, limp wings take about 20 minutes to unfold and reach their final size, as fluid is pumped from the adult's body into the wing's veins. In several hours, the wings are ready for flight.

This whole process, complete metamorphosis, from egg to adult, takes about 30 days.

Yucca moth: A life or death partnership

The little white yucca moth (species of Tegeticula moth) and the yucca plant (species of the Yucca plant), have formed a partnership that has made them so dependent upon one another; one cannot live without the other.

Every spring, this unique partnership unfolds. Yucca plants send up a tall stalk of white, bell-shaped flowers in late May, corresponding to the emergences of yucca moths from their cocoons. Male and female moths meet on the yucca flowers and mate.

Their lives are fleeting, with the adults' sole purpose of mating and producing a new generation. Neither male nor female yucca moths contain eating mouth parts but the female has modified mouth parts (palps) resembling tentacles used to collect pollen from the yucca flower.

She visits the flowers at night, scraping pollen into a ball and holding it against her thorax with her palps. Flying to another yucca plant to assure cross pollination, she carefully deposits her precious pollen ball on the stigma, the receptive part of the plant for pollination to occur.

Finding the flower's ovary, she checks to make sure another moth has not already visited and laid eggs. If not, she inserts her ovipositor and lays an egg. In this way, she ensures there is enough food for her young and enough seed for the plant to reproduce. The process of determining whether a flower has already been visited by another female moth is still not fully understood.

The female starts the process over again, continuing to transfer pollen and lay eggs in other yucca plant flowers. The caterpillar develops within the seed pod, emerging after it's fully grown, dropping to the ground and forming a cocoon and overwintering in that stage. In the spring, the whole process starts over again.

The two organisms have evolved so closely together that the yucca has no other way to reproduce by seed and the moth has no other host plant for its caterpillars. Yuccas can reproduce vegetatively, but the new plants are genetic copies, with no variation. If something were to happen to the yucca plant, wiping it out, so too would the moth disappear and vice versa – a classic case of co-evolution.

Nectar addiction

The sacred datura (*Datura wrightii*) is the name of a poisonous perennial plant and ornamental flower of southwestern North America. It has developed a unique way to keep pollinators at its flowers longer – drugs! Hawk moths (Sphingidae) visit the datura's flowers, which open at dusk to release a strong fragrance. Instead of hovering and extending its long tongue as hawk moths usually do, they land on the flower and then drink, fluttering their wings and picking up pollen.

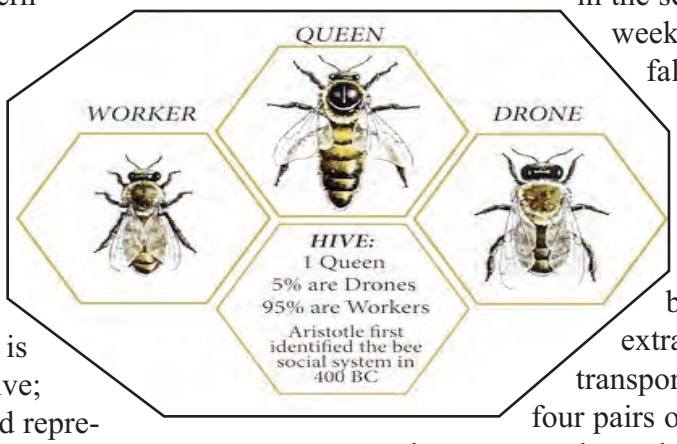
To increase the time the moth spends at the flower, and ensure pollination, the datura contains nectar spiked with a narcotic. Hawk moths appear to become addicted to the nectar, preferring the datura's flowers and arriving early, waiting for the flowers to open.

The pink-spotted hawk moth (*Agrius cingulata*) visiting a blossom of Datura at the Arizona-Sonora Desert Museum. Photograph by Dr. Robert Raguso.

Honeybees - Our State Insect

Maybe you remember from Kansas celebrations that the honeybee (*Apis mellifera*) was designated as the official state insect in 1976. Clearly, their important role in agriculture cannot be underestimated. In the United States pollination by honeybees directly or indirectly contributed to over $19 billion of crops in 2010. Beeswax and honey, often regarded as their most important contribution, are just surplus gifts we get from this tiny wonder of nature.

The first bees appear in the fossil record dating 40 million years ago and the honeybee has remained physically and socially unchanged for 30 million years. Spanish and English colonists brought honeybees with them to the New World where they quickly escaped into the wild and eventually populated the entire western hemisphere. Native Americans called the honeybee "white man's flies."



The Life of a Honeybee

Honeybee colonies are, in fact, a living organism, with each bee contributing to its incredible existence. The queen is the most important bee in the hive; she is the mother of the bees and represents the unity of the hive. Her role however is limited to producing eggs, as many as 2,000 a day. She does not "rule" over the other bees as romantic notions would have us believe. In a colony, it is the worker bees (all female as well) who "decide" how the hive is run; this is done through an intricate balance of pheromones in the hive and the bees' natural instinct.

Male bees, or drones, also have only one role: to mate with a queen and then die. Drones do not collect their own food, they are fed by the workers from their own hive or other hives they may visit. In order to ensure genetic diversity, during the first few days of her life, a queen will mate with over a dozen drones. The sperm will be stored and will allow her to lay fertile eggs until the end of her life.

Worker bees do all the different tasks needed to maintain and operate the hive. They make up the vast majority of the hive's occupants and they are all sterile females. When young, they are called house bees and work in the hive doing comb construction, brood rearing, tending the queen and drones, cleaning, temperature regulation and defending the hive. Older workers are called field bees. They forage outside the hive to gather nectar, pollen, water and certain sticky plant resins used in hive construction. Workers born early in the season will live about 6 weeks while those born in the fall will live until the following spring. Workers are about 12 mm long and highly specialized for what they do, with a structure called a pollen basket on each hind leg, an extra stomach for storing and transporting nectar or honey and four pairs of special glands that secrete beeswax on the underside of their abdomen. They have a straight, barbed stinger which can only be used once. It rips out of their abdomen after use, which kills the bee. http://www.gpnc.org/honeybee.htm

Making Honey

Honey is the only food source that contains all the substances necessary to sustain life! Honey bees make honey by taking nectar from flowers and mixing it with enzymes from glands in their mouths. This is then stored in hexagonal wax honeycombs until the water content has been reduced to around 17%. Once this happens, worker bees cap the combs with a wax seal until the bees need it for food in the winter.

A single worker bee produces about 1/12th of a teaspoon of honey in her lifetime. It takes tens of thousands of workers to produce the 60 lbs of honey made by an average hive in a good season. The colony will fly a total of about 55,000 miles to make just one pound of honey and visit about 2 million flowers!

Bee Communication

When scout bees find a good source of pollen or nectar, they return to the hive and “tell” the others through a series of movements, often referred to as the "waggle dance," to teach other workers the location. The honey bee first walks straight ahead, vigorously shaking its abdomen and producing a buzzing sound with the beat of its wings. The distance and speed of this movement communicates the distance of the foraging site to the others.

Communicating direction becomes more complex, as the dancing bee aligns her body in the direction of the food, relative to the sun. The entire dance pattern is a figure-eight, with the bee repeating the straight portion of the movement each time it circles to the center again.The honey bee dance was observed and noted by Aristotle as early as 400 BC.

The waggle dance of the honeybee

THE BUZZ ON HONEYBEES

- Honeybees are not native to America. They were brought over from Europe.
- It is the only insect that produces food eaten by man.
- Bees are cold-blooded, but can create heat through shivering.
- Honeybees have 170 odor receptors, compared with only 62 in fruit flies and 79 in mosquitoes. Their exceptional olfactory abilities include kin recognition signals, social communication within the hive, and odor recognition for finding food. Their sense of smell is so precise that it could differentiate hundreds of different floral varieties and tell whether a flower carried pollen or nectar from yards away.
- The honeybee's wings stroke incredibly fast, about 200 beats per second, thus making their famous, distinctive buzz. A honey bee can fly for up to six miles, and as fast as 15 mph.
- It takes one ounce of honey to fuel a bee's flight around the world.
- A colony of bees consists of 20,000-60,000 honeybees, a few hundred males, and one queen. Worker honeybees are female, live for about 6 weeks and do all the work.

The Forgotten Pollinators

Not all bees are honeybees. The drastic decline of honeybees, however, has highlighted the importance of the forgotten pollinators-native bees. There are an estimated 20,000 bee species worldwide with about 4,000 species native to the U.S. In contrast, there are only 4 species of honeybees with only the Western honeybee found in Europe and now the U.S. Native bees come in a wide range of colors and sizes, from tiny sweat bees less than a quarter of an inch long to bumble bees over an inch in length.

Native bees come in a wide range of colors and sizes. There are an estimated 20,000 bee species worldwide.

While some of these species may look like the familiar image of a bee with hairy yellow and black stripes, they may also be dark brown, black or metallic green and blue, with stripes of many colors. Most are solitary, with each female creating and provisioning her nest without the support of a caste system of workers. Most are unlikely to sting.

The common names for native bees often reflect their nest building habits: miner, carpenter, mason or plasterer. Other names depict behavioral traits. For example, sweat bees drink salty perspiration to acquire nutritionally important minerals.

About 70 percent of native bees excavate underground nests. Solitary bees dig narrow tunnels leading to a series of brood chambers, each one provisioned with a mixture of pollen and nectar and each holding a single egg.

A piece of a bisected tube to show the pollen ball, *Osmia lignaria* egg, and the mud plug separating each cell. Photograph by USDA-ARS.

About 30 percent of bees nest in wood tunnels, usually pre-existing holes such as those made by wood-boring beetles, but some will chew out the center of pithy twigs (Michener, 2000). Females of these wood-nesting bees create a line of brood cells, often using materials such as leaf pieces or mud as partitions between cells.

In the case of both ground-nesting and wood-nesting bees, once the nest is complete, the mother bee generally dies. Her off spring will remain in the nest, passing through the egg, larva and pupa stages before emerging as an adult to renew the cycle.

For some species this life cycle may progress over a matter of weeks, resulting in a second generation of bees in a single season. A few species may remain dormant for over a year. Most solitary bees, however, complete this life cycle over the course of a full year.

Native bees often only live for a few weeks as actively flying adults. They mate immediately upon emergence and the females begin nesting. They lay relatively few eggs compared to other insects, with a single female often laying less than 50 eggs before she dies. Male bees do not live long beyond mating, they do not collect pollen and have little value as pollinators.

While most of these wood-nesting and ground-nesting bees are solitary, some are gregarious, preferring to nest near others, a behavior that allows large aggregations to develop in favorable locations. Only a few tunnel and ground-nesting bee species ever develop truly social colonies, and often such behavior is environmentally dependent with some bees being social in one situation and being solitary in another.

Common Native Bees

Globally, bees are grouped into seven families. Six of these have species in North America, although only five, the Colletidae, Andrenidae, Halictidae, Megachilidae and Apidae, are commonly encountered.

Colletidae: Polyester Bees

Bees in the family Colletidae are highly varied in appearance and have few common features. One feature consistent to all colletid bees is that their tongue has a branched tip. Colletids secrete a plastic-like substance

(hence the family's common name) that they use to waterproof their brood cells. This allows the bees to nest in periodically flooded areas such as stream banks. This bee family is not represented in Kansas.

Andrenidae: Mining Bees

With just over 1,400 hundred species in North America, Andrenidae is the most diverse family of bees on the continent. Andrenidae are abundant in the spring and, as their common name indicates, excavate nests in the ground. The huge majority of species in this family are solitary. A small number of species are communal, with several females sharing a nest entrance but each excavating and provisioning their own brood cells. They generally nest in flat or gently sloping sites and may form aggregations with tens of thousands of bees nesting in a small area. This bee family is not represented in Kansas.

Halictidae: Sweat Bees

Halictidae are among the most frequently encountered bees during summer. Although this family includes brightly colored metallic bees, the majority of halictids are drably colored and small. Most Halictidae excavate nests in the ground, though some nest in rotting wood. The genus Lasioglossum includes the whole gamut of social behaviors from solitary to semi-social (nests constructed by a group of bees in which one is the egg-laying queen). The bright green Agapostemon is communal; a dozen or more females may share a nest entrance, but underground each bee creates her own brood cells.

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Megachilidae: Leafcutter and Mason Bees

Megachilidae is one of the easiest families to recognize because its members don't carry pollen on their legs. Instead, they have rows of stiff hairs on the underside of their abdomen into which they pack for transport back to the nest. The great majority of megachild bees nest in existing cavities above ground (beetle tunnels in snags, crevices in rocks) and collect items such as leaf pieces or wet soil to divide the nesting tunnel into brood cells.

Apidae: Bumble, carpenter and other bees

The Apidae is an immensely diverse family that includes bumble bees *(Bombus)* as well as a wide range of less well-known yet frequently encountered groups such as the digger (Anthophora), squash (Peponapis) and sunflower (Svastra) bees. Given the diversity of its genera, it will come as no surprise that the Apidae displays the full range of nesting behaviors from solitary to social and has species that nest in the ground, in wood and in old rodent burrows.

Bumble Bees

The one group of strictly social bees native to the United States is the group of approximately 45 bumble bee species. Bumble bees live in a colony with a caste system of workers, males and a single egg-laying queen. Within this social structure, bumble bees share the labor of foraging and rearing their young.

Similar to honey bees, bumble bees construct a wax comb; however, this comb is not a symmetrical series of hexagonal cells, but rather is an abstract configuration of round wax pots, some containing brood and some containing small amounts of pollen or nectar.

Bumble bees nest in cavities such as abandoned rodent burrows, brush piles and grass tussocks. The colony grows through three or four generations and, depending on the species, may have several hundred workers at the peak in mid-summer. Unlike honey bees, bumble bee colonies do not survive over the winter.

Used with permission
Alternative Pollinators: Native Bees
By Eric Mader, Mace Vaughan, Matthew Shepherd and Scott Hoff man Black
The Xerces Society for Invertebrate Conservation
www.xerces.org. Published 2010
www.attra.ncat.org/attra-pub/PDF/nativebee.pdf

Threats to Insect Pollinators

Determining the causes of insect pollinator declines and potential threats to pollinator populations are rather challenging feats. Invertebrates can be harder to study than vertebrate animals for many reasons, such as their size or lifespan, or our lack of knowledge on their behavior and biology. Many times, the causes for decline in insect pollinator populations are due to several different factors, instead of just one.

In honeybees, the term Colony Collapse Disorder (CCD) is used to describe a mass disappearance of worker bees from a hive, resulting in a breakdown of the colony when there are no longer enough workers to maintain that colony. The cause is largely unknown because the workers disappear, leaving no bodies to study. Scientists believe CCD is caused by several factors including pesticide residues, habitat loss, pathogens, parasitic mites, diseases, pollution, viruses and other stressors (U.S. Dept. of Agriculture 2012 CCD Progress Report). The U.S. has lost over 50% of its managed hives over the last 10 years.

The most evidence for population declines are seen in honey bees, but we will also take a look at factors which do or can affect other insect species.

Parasitic Mites and Noxious Pests

One of the biggest threats to western honeybees (*Apis mellifera*) is the parasitic mite called the Varroa Mite (*Varroa destructor*). This Asian mite is an external parasite of the larvae, pupae and adult honeybee and was first reported in the United States in 1987. The parasite can cause weight loss in adult bees, wing deformity, impair development in the larval and pupal stages, shorten bee lifespan, and can kill an entire colony if left untreated. If that wasn't enough, the Varroa mite can also affect honeybee reproduction (unhealthy males do not produce healthy sperm) and pass on viruses to their honeybee host. Unfortunately, this mite has become resistant to pesticides used to eradicate it, and is therefore one of the most expensive threats to the commercial honey bee industry.

Small hive beetles (Aethina tumida) were first detected in the United States in 1998. Native to South Africa, these beetles live and reproduce in honeybee hives, damaging the hive as they go from larva to adult form. Larvae cause the most damage by burrowing into combs where they defecate, which causes honey to ferment and leak from the combs. So far, small hive beetle infestations can be managed with chemical and biological control agents.

Bumble bees and honeybees can both suffer from Tracheal Mite (Locustacris buchneri) infestations. This mite is an internal parasite that reproduces inside the airways of bees, blocking oxygen and eventually killing them. Bees with Tracheal mites have trouble flying and are often seen crawling with their wings in a "disjointed" position. Some treatments are available, but are costly for beekeepers.

http://www2.ca.uky.edu/entomology/entfacts/ef012.asp

Pathogens and Pathogen Spillover

Pathogens are agents (bacterium, virus, or fungus) that cause diseases. Organisms such as bees, living in large groups in close quarters, are highly susceptible to pathogen outbreaks. One pathogen in honey bees is *Paenibacillus larvae* which causes a disease in larval bees called American Foulbrood (AFB). AFB can be particularly problematic because it is resistant to antibiotics and its spores can persist on beekeeping equipment for 80 years!

Bumble bees are highly susceptible to a number of different pathogens, such as deformed wing virus. Alfalfa leaf-cutting bees can contract a fungal disease called Chalkbrood. It is caused by the *Ascosphaera aggregate* fungus and turns the body of a bee chalk-white.

Pathogen spillover occurs when "domestic" bees used in commercial growing operations (i.e. greenhouses) escape and spread diseases to wild populations. Because many growers get bumble bees or honey bees from other countries, the potential for the spread of diseases to native populations that do not have immunity is greater.

Pesticides

Pesticides are designed to get rid of pests, many of which are insects. Pesticide related die-offs of bees, butterflies, moths, beetles and wasps, all important pollinators, is typically the result of carelessness. Someone doesn't follow label instructions, sprays too much, or sprayed during the wrong time of year. Insecticides and other pesticides (i.e. herbicides) can impair a pollinator's navigational and foraging skills, or even kill them.

Transgenic Crops

Transgenic crops are genetically altered, to make them Round-Up© resistant or pest resistant or for other reasons. Monarch butterflies may be vulnerable to the transgenic crop, Bt Corn. Some studies have shown monarch caterpillars that ingest Bt Corn pollen have a high mortality rate. The effects of transgenic crops on other pollinators are not known.

Invasive Species

The number of invasive species which cause problems is very long. Two examples that could be detrimental to pollinators are the Africanized honey bee and red brome grass.

Africanized honey bees are more aggressive than western honey bees, and they reproduce faster. This causes competition with western honey bees and other pollinators. Africanized bees also do not fly as far to collect pollen so they are not as helpful as pollinators.

Red brome is an example of an exotic plant that has taken over native plant habitat. It chokes out native flowers, reducing the available food sources for many pollinator species.

Habitat Loss

Pollinators require nesting habitat as well as food habitat. Monarchs have at least a two-fold habitat loss problem. In their over-wintering grounds of Mexico, deforestation threatens their population. Loss of milkweed habitat along their migration/egg-laying habitat also threatens them. Several bee species, like some of the bumble bees, are ground nesters and require drier grassland habitat. Much of our grasslands are turned into agriculture or have become more forested. Our mowing practices can have detrimental effects on many pollinators when we mow yards, roadsides, etc. during pollination season.

Climate Change

Not much is known yet of the effects climate change may have on pollinators. Some species may see less food sources due to drought conditions, while others may see increases due to longer pollination seasons. A better understanding of the relationship between pollinator and plant, and how climate change can affect that relationship would reveal more clues.

One thing is clear when it comes to pollinator population declines: Humans are the main culprit. But, we have the capability to help pollinators! The more we learn about these fascinating and important creatures, the better we can understand how to help their populations.

Plant It And They Will Come

While it may not be possible to get out to rescue sea turtles, or save polar bears right at the moment, concerned citizens can help support and conserve another threatened group of animals right in our own yards. Insect pollinators are vital to the health and wellbeing, not only of the environment, but of our own food supply as well.

There are over 4000 different kinds of bees and wasps native to North America. Together with butterflies, moths, beetles, and flies, these insects make up an army of invaluable plant pollinators. Over 1300 different food crops in the world depend directly on pollination. It is said that one in every 3 bites of food we eat and drink can be linked directly to pollinators. But genetically modified seeds, insecticides and other chemicals have drastically reduced the numbers of pollinators in the wild. European honey bees were imported to North America to help pollinate food crops and fruit trees. Sadly, managed honey bee colonies have decreased by almost 50% over the last 10 years due to disease, parasites and pesticides.

Pollinators come in a wide variety of sizes, with wings and mouthparts designed to exploit the different shapes and sizes of flowers. Native plants and pollinators evolved together to develop mutually beneficial adaptations that allow for effective reproduction. Native bees are best adapted to pollinating native plants, but will make use of horticulture varieties as well.

The conservation minded gardener can contribute a great deal to pollinator survival by selecting plants that enhance habitat for them. How can this be done? Open a pollinator restaurant right in your own yard. By landscaping your yard with pollinator friendly plants, the average person can become a pollinator conservationist. In return, there will be rewards in enjoying a lovely garden alive with busy insects all through the growing season.

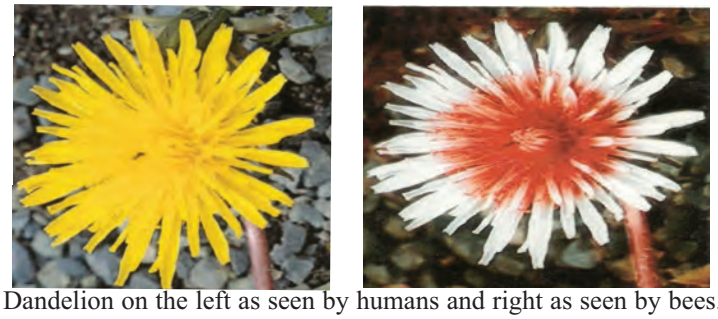
To create a five star pollinator restaurant, gardeners need to follow a few simple guidelines for selecting and planting:

1. Select plants for continuous blooming from spring to fall.
2. Select a variety of flower shapes, sizes and heights to accommodate the foraging habits of different kinds of pollinators.
3. Select a variety of colors, as different pollinators are attracted to different colors.
4. Plant in clumps. This allows insects to feed and pollinate without long distance travel.
5. Eliminate the use of pesticides, replacing weed control chemicals with less toxic options.
6. Provide a water source.

Shapes and Sizes

Butterflies prefer flatter flower surfaces for landing and feeding like asters, sunflowers, and milkweeds. Bees, on the other hand, are capable of extracting nectar from a variety of flower shapes. The shape of the insect's mouthparts will determine which flowers have nectar available to them. Some flowers, like beardtongues, are adapted specifically to large bee pollination, while others, like beebalm, are magnets for a wide variety of pollinators. Large butterflies can reach into long tubular flowers like honeysuckles and pentas. By planting a variety of sizes and shapes of flowers, the gardener will attract a greater diversity of hardworking pollinators.

Most insects see in a limited light spectrum which may include ultraviolet light. Bees in particular like blue, purple, violet, white, and yellow. The lines and patterns on flowers are important to helping insects navigate to the nectar source on the flowers. These patterns appear quite different to an insect's eye than they do to ours. Planting a variety of colors will insure more effective pollination.



Dandelion on the left as seen by humans and right as seen by bees.

Natives vs. Cultivated Plants

While native insects will usually show a preference for native plants, both can be used effectively in a pollinator garden. Native perennials will have a shorter flowering period than most cultivated annuals. The gardener can select from both kinds best suited to the conditions of light and soil available.

Many plants will have the added bonus of being good host plants to larval insects. Milkweeds, parsley, dill, fennel and rue will attract butterfly larvae as well as adults.

Spring

Foxglove beardstongue *Penstemon digitalis*
Common milkweed *Asclepias syriaca*
Purple prairie clover *Dalea purpurea*
Blue wild indigo *Baptisia australis*
Plains wild indigo *Baptisia bracteata*
Plains larkspur *Delphinium carolinianum*
Western Wallflower *Erysimum capitatum*

Summer

Butterfly milkweed *Asclepias tuberosa*
Joe Pyeweed *Eupatorium maculatum*
Beebalm *Monarda fistulosa*
Purple coneflower *Echinacea augustifolia*
Culvers root *Veronicastrum verginicum*
Prairie blazing star *Liatris pycnostachya*
Baldwins Ironweed *Vernonia baldwinii*
Slender mountain mint

Fall

Pitcher sage *Salvia azurea*
Rough blazing star *Liatris aspera*
Stiff Goldenrod *Solidago rigida*
Sunflower *Helianthus* species
New England Aster *Symphyotrichum novae-angliae*

Bushes

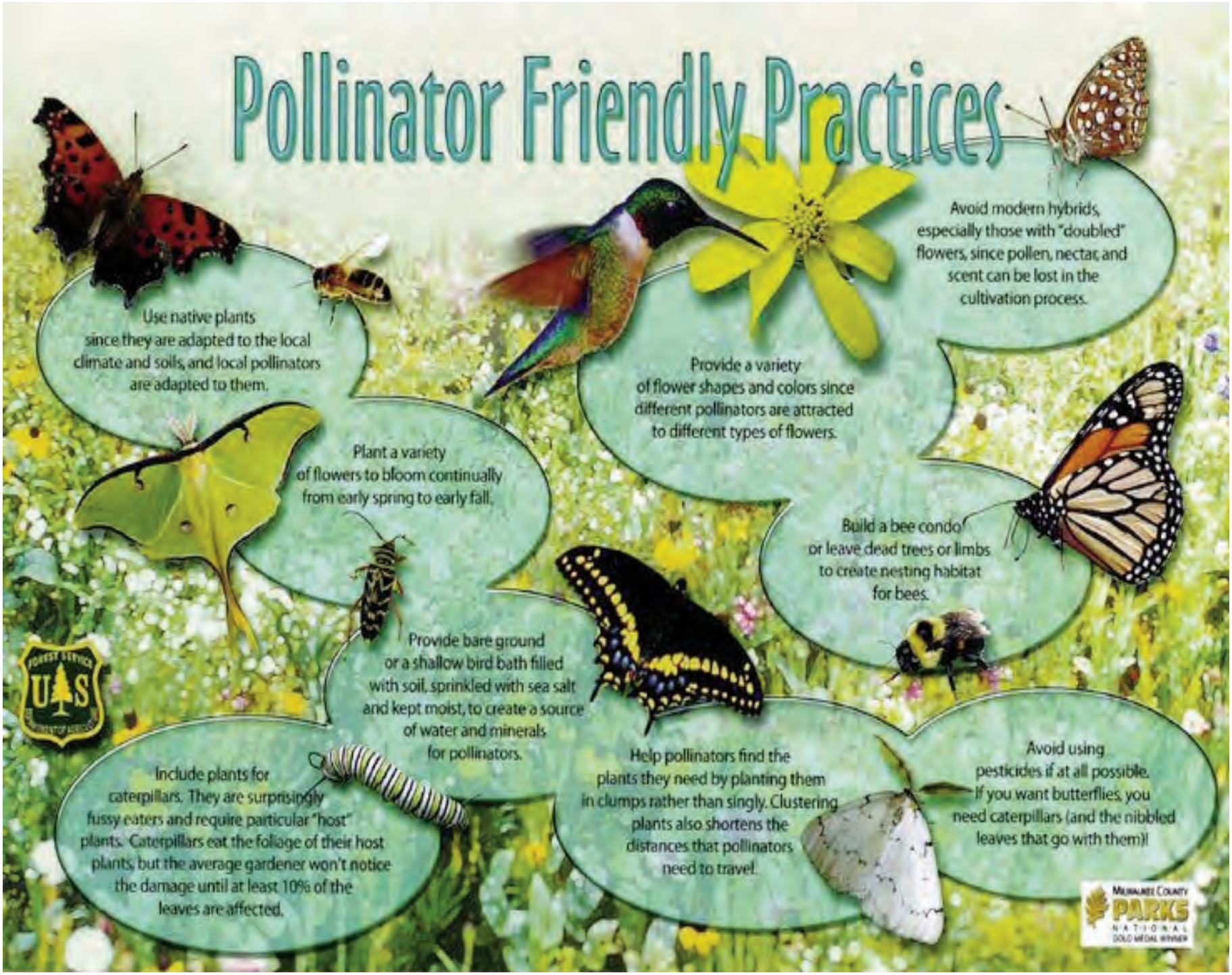
Button bush *Cephalanthus occidentalis* summer
Butterfly bush *Buddleia davidii* summer
Golden currents *Ribes aurem* spring
New Jersey Tea *Ceanothus hervaceus*
St. John's Wort *Hypericum perforatum* summer

Annuals

Basil *Ocimum*
Cotoneaster *Cotoneaster*
English lavender *Lavandula*
Giant hyssop *Agastache*
Hyssop *Hyssopus*
Pentas *Pentas lanceolata*
Zinnia *Zinnia varietal*
Globe thistle *Echinops*
Marjoram *Origanum*
Rosemary *Rosmarinus*

Basic pollination syndrome character table.

FLOWER	bats	bees	beetles	birds	butterflies	flies	wind
color	dull white, green, purple	bright white, yellow, blue	dull white, green	orange, red, white	orange, red, purple	pale and dull to dark brown or purple, often veined	dull green or brown
odour	strong, fruity	fresh, mild, pleasant	fruity, spicy	none	spicy, none	putrid	none
shape	regular, bowl-shaped, closed during day	shallow, landing platform, tubular	large, bowl-like	large, funnel-like, no landing platform but strong perch support	narrow tube, wide landing pad	shallow, funnel-like or trap-like	regular, small, stigmas exerted, petals absent or reduced
bloom time	night	day	day	day	day	day and night	anytime
nectar	abundant, somewhat hidden	usually present	sometimes present, not hidden	ample, deeply hidden	ample, deeply hidden	usually absent	none


Pollinator Friendly Practices
Use native plants since they are adapted to the local climate and soils, and local pollinators are adapted to them.
Avoid modern hybrids, especially those with "doubled" flowers, since pollen, nectar, and scent can be lost in the cultivation process.
Provide a variety of flower shapes and colors since different pollinators are attracted to different types of flowers.
Plant a variety of flowers to bloom continually from early spring to early fall.
Build a bee condo or leave dead trees or limbs to create nesting habitat for bees.
Provide bare ground or a shallow bird bath filled with soil, sprinkled with sea salt and kept moist, to create a source of water and minerals for pollinators.
Include plants for caterpillars. They are surprisingly fussy eaters and require particular "host" plants. Caterpillars eat the foliage of their host plants, but the average gardener won't notice the damage until at least 10% of the leaves are affected.
Help pollinators find the plants they need by planting them in clumps rather than singly. Clustering plants also shortens the distances that pollinators need to travel.
Avoid using pesticides if at all possible. If you want butterflies, you need caterpillars (and the nibbled leaves that go with them)!
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Monarch Waystations

What is a Monarch Waystation?

A Monarch Waystation is simply a garden that has both milkweed plants which Monarchs feed on as caterpillars, and nectar plants that they feed on as adults.

Milkweed, as you know is critical as it is the only plant Monarchs lay their eggs on. In addition, the adults need nectar plants. They can't reproduce without nectar, they can't go through migration without nectar, and they can't survive the winter without having a very large amount of lipid stores which they aquire from nectar during migration.

How Big Does a Waystation Need to Be?

A waystation can be as small or as large as you want to make it. You can grow it on a deck with containers, in a garden or as way of maintaining large acreage. The minimum recommendation is to have at least 10 milkweed plants (preferably 2 species of native milkweed) and an assortment of at least 4 native nectar plants.

A good rule of thumb is to plant 2 nectar plants for every milkweed plant. Milkweed will also serve as a nectar plant so you may want to err on the high side for milkweed.

The best location is a sunny spot. Space plants 12" to 18" apart. For a 10' x 10' planting, you will need 36-49 plants (depending on the plant size). The following is a rough estimate of cost:

Milkweed plants: need 15-20 at $3.00/plant. Try to have at least two kinds of milkweed. These are available through the Monarch Watch Milkweed Market ***http://monarchwatch.org/milkweed/market*** or a local nursery. Be sure to purchase pesticide free milkweed.

Nectar plants: need 24-32 at $5-$7 each. Ask for pesticide free. *See The Waystation Recipe*

Compost or topsoil: enough for 100 sq.ft.~ $30. You may not need if you have good soil.

Leaf Mulch: There is a product called Karbon which is very good. Plan for 100 sq. ft. ~ $25.

Monarch Waystation Certification: $41 includes sign. Contact monarchwatch.org.

The Waystation Recipes

Here is a basic waystation plant list that you can use to get started. It includes milkweed and nectar plants. You will want to select at least 1-2 varieties of milkweed in addition to nectar plants.

Native Host and Nectar Plants for Monarch Waystations

*Common Milkweed, *Asclepias syriaca* [the #1 choice by Monarchs]
*Swamp Milkweed, *Asclepias incarnata* [the #2 choice]
*Butterfly Weed, *Asclepias tuberosa* [the #3 choice]
Joe-Pye Weed, (e.g. *Eupatoriadelphus fistulosus, Eupatorium maculatum*)
Boneset, *Eupatorium perfoliatum*
**Goldenrod (e.g. Rough-stemmed Goldenrod, *Solidago rugosa*; Missouri Goldenrod, *Solidago missouriensis*)
**Aster (e.g. New England Aster, *Symphyotrichum novae angliae*;Heath Aster, *Aster ericoides*)
Blazing Star, *Liatris spicata*
Bergamot, *Monarda fistulosa*
Blackeyed Susan, *Rudbeckia hirta*;
Purple Coneflower, *Echinacea angustifolia*
Common Sunflower, *Helianthus annus* (also other Helianthus sp.,)
Sneezeweed, *Helenium autumnale*
*Necessary host plant for Monarch caterpillars --if you don't have milkweed, you will not have Monarchs
**Key nectar (food) plant for adults. Goldenrods & asters are critical -especially in the fall

Please Certify Your Waystation

It's important to certify your waystation so that the impact can be measured and recognized by others what the garden signifies: Bringing Back the Monarch! In this way, you are communicating to others the plight of the Monarch and the need to restore habitat. Providing an example of what a waystation can look like makes it easier for others to follow in your footsteps. Go to **monarchwatch.org** for more information.

Milkweed Planting and Care

Species	Planting Tips	How it spreads
Common Milkweed *Asclepias syriaca*	30-100% sun. Grows well in open areas or tree lines. Moist or dry soils. Height: 3-5’	Primarily spreads by rhizomes. Seed germination is low. To transplant, dig a hole at least 8” around, getting the lateral rhizome. Soak plant in water for ~2 days, then plant OR plant immediately. Keep soil saturated for 4-5 days. The plant will go into shock but should regrow.
Swamp Milkweed *Asclepias incarnata*	Full sun. Grows well in typical gardens. Also good in moist areas. Height: 4’	Spreads by seeds.
Butterflyweed *Asclepias tuberosa*	Best in full sun but withstands shade for part of the day. Prefers drier soils. Height:1-2’	Spreads by seeds.

Oleander Aphids and Milkweed Tussock Moth Caterpillars are commonly seen on milkweed. They typically do not bother Monarch caterpillars or eggs. Aphids are eaten by lady bugs so when enough aphids appear, lady bugs should also appear to eat the aphids. Buying lady bugs typically does not work as the lady bugs released are not native and fly away. You can physically squish the aphids with your fingers or you can use a steady stream of water to remove (check for Monarch caterpillars or eggs first). This method may destroy lady bug and lacewing eggs/larvae in the process. Letting nature take its course is often the best approach. The tussock moth caterpillars are native and part of a healthy ecosystem, however, if you have just a few milkweed plants, you may want to move the tussock caterpillars to a larger patch. They can eat a single plant quickly.

Citizen Science Monitoring Programs

A variety of programs engage citizen scientists in monitoring monarchs during their migratory, breeding, and overwintering seasons. Monarch-focused citizen science programs include Correo Real, Journey North, Monarch Alert, Monarch Health, the Monarch Larval Monitoring Project, the Monarch Monitoring Project, Monarch Watch, the Southwest Monarch Study, the Western Monarch Thanksgiving Count, and World Wildlife Fund–Mexico’s surveys of the Monarch Butterfly Biosphere Reserve. In addition, other butterfly programs gathering data on a broad variety of species allow individuals to contribute data on monarchs, including the North American Butterfly Association’s Fourth of July count, statewide butterfly monitoring networks, and online projects such as eButterfly and Butterflies and Moths of North America. Despite the diversity of existing programs, efforts are still needed to monitor the monarch migration in key regions, such as areas of Kansas, Missouri, Arkansas, and Oklahoma directly south of the monarch’s core breeding area and in Texas.

Classroom experiments*

Feeding a butterfly

The simple process of feeding butterflies can be used for classroom demonstrations and experiments.

Demonstration:

Make a 5 % sugar water solution by mixing 1 teaspoon of sugar in 1/2 cup of distilled water.
Wrap a small ball of cotton around the end of a wooden skewer.
Saturate the cotton ball in the sugar-water solution.
Holding the butterfly firmly with wings held together, place its feet on the cotton. Its proboscis should uncoil and the butterfly should start feeding if it's hungry. You may want to withhold food for a day before the demonstration so the butterflies are hungry – this will not hurt the butterflies as long as they've been feeding regularly.
A piece of watermelon also works well for this experiment

Experiment 1:

Have students touch different body parts with the saturated cotton ball and observe when the proboscis extends to determine where the taste receptors are located

Antenna Abdomen Thorax Edge of wing Proboscis Each pair of feet

Experiment 2:

Five 8-oz. cups
Water
Sugar
Cotton swabs
Measuring cups
Measuring spoons
Eyedropper or pipette

Make several sugar water concentrations, marking each cup so you know concentrations but students do not. Use separate spoons to stir the solution:
Half cup distilled water with no sugar
¼ tsp. in half cup distilled water (1 %)
½ tsp. in half cup of distilled water (2.5 %)
1 tsp. in half cup distilled water (5 %)
2 tsp. in half cup distilled water (10 %)

Test each solution by holding butterfly firmly with wings held together, place its feet on the cotton. Its proboscis should uncoil and the butterfly should start feeding if it's hungry. You may want to withhold food for a day so the butterflies are hungry.

Record each butterfly's reaction.

Use a pipette to squirt a small amount of nectar in each of the "test" students, rinsing between each taste. Have students rank the sweetness of each solution.

Humans can detect sweetness at levels as low as a 2 % sugar solution, whereas butterflies can't detect concentrations lower than 4 % or greater than about 7 %.

*From the Live Butterfly Activity Book by Robert Drake

Milkweed:A Special Pollination

Famous for its association and importance to the monarch butterfly, milkweed plant species exhibit some of their own interesting features involving flower structure and pollination.

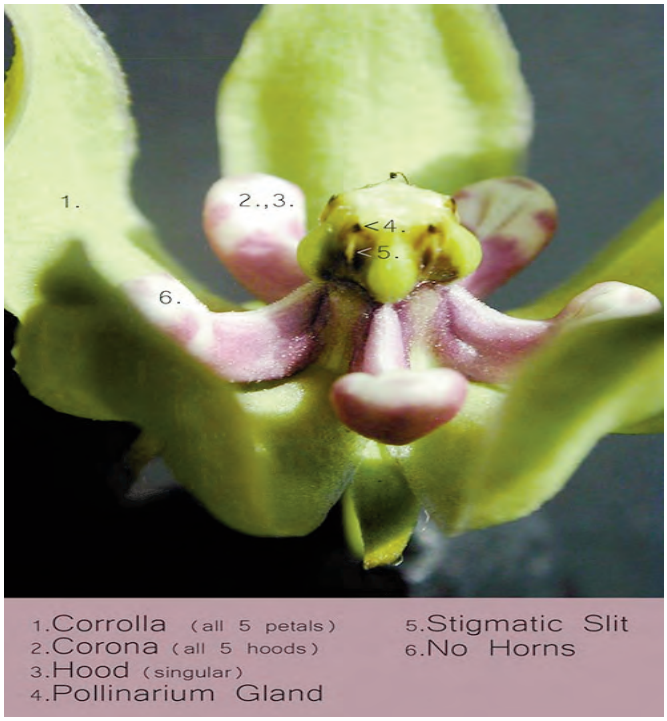

Photo Monarch Watch

Individual milkweed flowers are arranged in clusters on the plant. Each flower contains five sepals, modified leaves that hold the petals and other flower parts. The flower itself contains five petals, collectively called the corolla, which open back from the flower's center. The upper part of the flower has five hood-shaped structures, containing the nectar. In some species, the hoods also have horn-like appendages.

The flower's unusual shape continues to its pollination strategy. Milkweed flowers contain unique structures, the pollinarium, that contain small waxy sacs (pollinia), which hold the pollen grains. The pollinarium, located within five vertical grooves in the flower, attach to insect legs, tongues or mouthparts. When the insect searches for nectar it unknowingly inserts a leg or tongue in the vertical slit and the pollinarium attach. As the insect visits other milkweed flowers it again inserts a leg or tongue in the slit, leaving behind pollinarium from other flowers of the same species, thus completing pollination.

Milkweed flowers are pollinated by butterflies, moths, bees, ants and wasps – any insect large enough to remove and carry the pollinarium. Due to its rich nectar, it is an important food source for many bee and wasp species.

Plant it and they will come

Due to a sharp decline in monarch butterfly numbers over the past 15 years, the insect's epic migration is in danger. Habitat loss (reduction in milkweed plants) in North America appears to be one of the major factors in this decline. Thus a national effort has begun to replace lost milkweed by planting milkweed in gardens, school yards and wherever else possible.

Butterfly milkweed *(Ascelpias tuberosa)* is a popular addition to flower gardens, attracting monarch butterflies and other pollinators.
Photo Monarch Watch

Help is needed gathering native milkweed seed from specific areas, increasing the resulting seedlings chance of survival. In Kansas, contact Monarch Watch for information on how to help gather seeds and plant milkweed species.

Resources for obtaining and growing Kansas Milkweed species
Monarch Watch – www.monarchwatch.org
The Xerces Society for Invertebrate Conservation – www.xerces.org
Dyck Arboretum of the Plains – arboretum@hesston.edu

Milkweed's Role in WWII

A 4-H group proudly points to milkweed seed pods collected for the WWII war effort.

Milkweed's flossy seed saved many soldier's lives during WWII. In 1943, the U.S. Department of Agriculture started harvesting milkweed seed as a substitute to kapok, a fiber used to fill life vests until Japan seized control of the Dutch East Indies where kapok was grown.

Just 28 ounces of the white fluffy milkweed fiber buoyed a person for 140 hours. The waxy coating on the fiber also made it rot-resistant under most conditions.

Boy Scout Troops and 4-H Clubs throughout the Midwest were encouraged to collect milkweed seed to contribute to the war effort. Pickers were paid 20 cents per 50-pound mesh bag. In Michigan, the government operated buying stations and drying yards. By war's end, more than 2 million pounds of milkweed floss had been used to fill life vests.

On TRACKS is published by the Kansas Department of Wildlife & Parks several times during the school year.

The purpose of On TRACKS is to disseminate information and educational resources pertaining to the natural, historic, and cultural resources of the prairie, emphasizing Kansas ecology. Information is presented from the perspective of current scientific theory.

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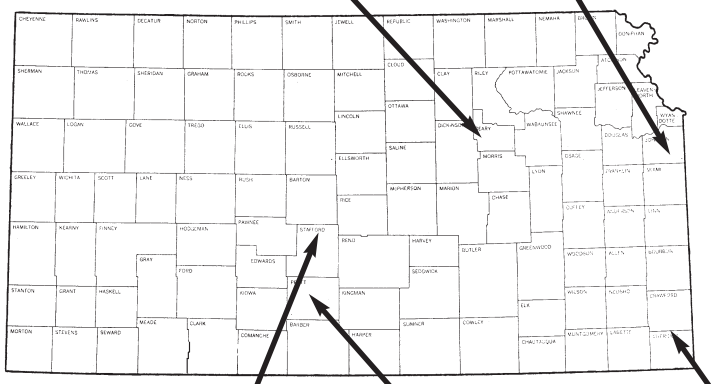

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