WINGS

ESSAYS ON INVERTEBRATE CONSERVATION

THE XERCES SOCIETY FALL 2023

CONTENTS

Moths are all around us. They share our natural areas and gardens, and sometimes they share our food crops, and even our clothes. Love them or despise them, moths play profoundly important roles in our environment—as pollinators; as food for songbirds, bats, and other wildlife; as part of the clean-up crew that recycles organic waste; and more—and they deserve our conservation attention.

Gardening for Good

Scott Black

Earlier this summer a friend on the East Coast asked me to describe our garden. That spurred me to spend a little time outside looking at what my wife and I have achieved over the last eight years. Our goals are to provide habitat for bees, butterflies, other insects, and birds, and to grow some good organic food. We want to minimize water use and maximize climate benefits, and also to have a place to relax and enjoy the sun, and for our dogs to enjoy as well. That is a lot to pack into one space.

I began cataloging what was blooming or seeding in the garden at that time, together with what fruits and vegetables we have harvested throughout the season. We picked more than six gallons of raspberries this spring, ate blueberries for much of the summer, and have had more tomatoes, squash, and basil than we can keep up with! In the fall, we get dozens of apples from our columnar apple trees and a lot of Italian plums.

We also have lots of flowering plants that provide sustenance for animals. The flower diversity and season-long bloom is achieved mostly with plants that are native or near-native, although non-invasive non-natives fill some gaps. At one point this summer I had eight plant species in bloom that were highly visited by bees and butterflies and three that were visited mainly by hummingbirds. I let my plants go to seed, which provides lots of food for birds well into the fall. Among my favorites are sunflowers. They provide pollen and nectar for bees and are host plants for moths, while birds eat both the leaves and seeds.

We love our space, and many people stop to tell us that they enjoy all of the

A wildlife garden may support hundreds of species of insects, and brings multiple benefits for our health and that of our environment. Photograph by Matthew Shepherd.

Scott Black takes a close look at what is in his garden. Photograph by Theo Black.

flowering plants—but, with such a small space, are these efforts really doing anything for the planet? Several studies have looked at this issue. A recent one, led by Luis Mata of Australia's University of Melbourne, titled "Large positive ecological changes of small urban greening actions" looked into the benefits of conservation in such small spaces. The researchers found that just three years after restoring a site with native plants there was a large increase in both the abundance and diversity of insects, and more interactions between insects and plants. They concluded that simple greening actions can have "real, quantifiable effects" on the richness and structure of ecological communities.

Our own experience mirrors this. When we moved in there was a lot of turf and many non-native plants that provided few resources for native insects or birds. Now most of that has gone (we retained a little lawn for the kids and dogs to run on), replaced with a diversity of plants to feed us as well as wildlife; as a result we have seen a remarkable increase in the variety of species and in the number of pollinating bees, flies, wasps, butterflies, and birds. Although native plants helped drive this increase, such non-natives as raspberries, blueberries, and apples are covered with pollinators. I have been impressed, for instance, with the profusion and diversity of insects on blooming mint: a short inspection revealed five kinds of bees, four kinds of flies, and seven kinds of wasps. As fall approaches, birds are eating seeds from sunflowers and brown-eyed Susans. I have found that a garden can be a place of beauty and abundance for both humans and animals.

Beyond these benefits, research shows that working in a garden can improve emotional and physical health. I know that when I am out in the garden, even just pulling weeds, I feel better in part because I am doing something meaningful. With all of the issues we are facing, a garden can be a refuge from the ongoing negative news of biodiversity loss and climate-related disasters.

Not everyone can garden or has the inclination to do so, and gardening alone will not save the planet. We need to push for strong climate and biodiversity legislation, protect natural areas, change the way we farm, and so much more. We must support conservation groups and elected officials that are pushing for change. But if one garden can help local biodiversity, then a hundred gardens can help rewild a neighborhood, and a million can help at the regional level. If we all work together, we can indeed change the world.

The Glorious Diversity of Moths

Eric Lee-Mäder

In general, moths have a bad image. To many gardeners, they are seen only as pests: hornworms, cutworms, webworms, earworms, and more. Other people may picture drab, nighttime insects battering against a streetlight. And yet, these insects are essentially just nocturnal butterflies, which often rival their daytime relatives in beauty. Indeed, some moths are boldly colored and day-active—seeing them, you may think they are butterflies—while conversely many butterflies are small and brown and, well, mothlike in appearance. There should be no surprise that butterflies and moths are so similar, as together they form the order Lepidoptera, a group that encompasses more than a hundred and eighty thousand species worldwide. Of these, approximately a hundred and sixty thousand are moths, vastly more than the roughly twenty thousand butterfly species identified globally. Maybe we should be thinking of butterflies as daytime moths.

North America's moth diversity is represented by more than three dozen families. While many of these families may be present in your garden or neighborhood, a few of them are more common and obvious than others. Sphinx and hawk moths (family Sphingidae) are a particularly striking group that you might well see visiting plants such

The white-lined sphinx (family Sphingidae) usually flies at dusk and dawn, but is also seen in broad daylight. Like other hawk moths, it is large—with a wingspan of up to three and a half inches (nine centimeters)—and is adept at hovering. Photograph by Bryan E. Reynolds.

as bee balm and morning glory. Many are active during the day, and their large size and habit of hovering in front of flowers to feed often leads to them being mistaken for hummingbirds—a few species are actually larger than hummingbirds—and places them among the most obvious and accessible moth groups.

Sphinx and hawk moths are among the fastest flying insects known, with some species capable of speeds of more than thirty miles per hour. Like hummingbirds, these moths use rapidly beating wings to hover above flowers. While doing so, they can extend their very long proboscises deep into the blossoms without landing. Those quick-beating wings also allow them to fly sideways, in addition to hovering or flying forward. This provides a handy advantage when they are trying to access hard-to-reach flowers or evade predators.

The tiger moths (subfamily Arctiinae) are another group that includes commonly encountered day-active species, although many of us may primarily know them because of their caterpillars. The well-known woolly bear will transform into the Isabella tiger moth (*Pyrrharctia isabella*), and the caterpillars of many other tiger moths are similarly hairy.

While some adult moths rely on camouflage to protect themselves from predators, many members of the tiger moth family flaunt bright colors and make no effort to disguise themselves. Among them are some species that produce chemical defenses, making them toxic to those who might see them as potential food. As in the case of the monarch butterfly, the bright colors of these moths are a warning to potential predators. The cinnabar moth (*Tyria jacobaeae*) is a good example. The orange-and-black-striped caterpillars are noticeable enough, but the adults are perhaps even more striking, with bright red warning stripes imposed on sleek bluish-black forewings. The cinnabar moth is not native to North America but was introduced to control its larval host plant, tansy ragwort, an invasive, non-native weed.

Other tiger moths seem to cheat. Their bright colors suggest that they are toxic, but they're actually harmless, relying on mimicry for protection. Moths

Caterpillars of the cinnabar moth (subfamily Arctiinae) on tansy ragwort. Introduced into North America, the moth is largely restricted to the Pacific Northwest. Photograph by Matthew Shepherd.

The luna moth (family Saturniidae) is a treat to see in eastern North America. Its caterpillars feed on foliage of hickory, walnut, sweet gum, and other trees. Photograph by Bryan E. Reynolds.

in the genus *Ctenucha* manifest this strategy with metallic-blue-green bodies and wings that are sometimes complemented with patterns of red or yellow around the head. While adult *Ctenucha* moths may be found visiting flowers, their caterpillars tend to feed on grasses.

One of the better-known night-flying tiger moths is the arge tiger moth (*Grammia arge*). Found in gardens, roadsides, and meadows of eastern regions of both Canada and the United States, this species stands out for its white, orange, or sometimes bright pink wings, which are crisscrossed with black stripes and angular dots. As an adult the arge tiger moth doesn't eat, but its caterpillars readily feed on a wide range of plants, including sunflowers, prickly-pear cactus, and lamb's quarters.

Other colorful and relatively common tiger moth visitors include the great leopard moth (*Hypercompe scribonia*) and the milkweed tussock moth (*Euchaetes egle*). The latter, like the monarch butterfly, feeds on milkweeds to acquire poisonous cardiac glycosides to protect themselves from predators. The very hairy caterpillar of the milkweed tussock also has the curious habit of dropping to the ground and curling into a ball when disturbed.

The title for the largest North American moths probably goes to the family Saturniidae, referred to as wild silkmoths, royal moths, or imperial moths. Numerically the family is small in the United States and Canada, with perhaps forty-some species north of Mexico. Many, however, are intensely patterned,

Almost matching the colors of its host plant, the painted schinia (family Noctuidae) blurs the commonly accepted line between drab moth and colorful butterfly. Photograph by Bryan E. Reynolds.

colorful, and huge (some equal in size to an average adult human's hand).

Because wild silkmoths have no digestive system as adults and do not feed, they don't visit flowers. Instead, their short adult lives consist of seeking out mates while living off of the energy reserves they stored as caterpillars. In eastern North America, some well-known members of this family include the luna (*Actias luna*), cecropia (*Hyalophora cecropia*), io (*Automeris io*), rosy maple (*Dryocampa rubicunda*), royal walnut (*Citheronia regalis*), imperial (*Eacles imperialis*), and polyphemus (*Antheraea polyphemus*) moths. In the West, the enormous ceanothus silkmoth (*Hyalophora euryalus*) and Glover's silkmoth (*Hyalophora gloveri*) are two of the largest and most well-known family members.

For all their glory, wild silkmoths tend to be distinctly nocturnal. Thus, aside from occasionally sighting members of those silkmoth species that are attracted to porch lights, most of us don't get to see them. Nonetheless, they are a captivating group of moths that leave an indelible memory if you have the good fortune to encounter one.

Owlet moths (family Noctuidae) form a large and very common group of flower visitors. In a typical garden, this group is often represented by various cutworm and plusiine moths—small, heavy-bodied moths that usually hover while feeding. The cutworm moths are typically drab in color, while the plusiines are distinguished by silvery marks on their forewings. One plusiine, the green-patched looper (*Diachrysia balluca*), is notable for its striking brassy metallic-green forewings. Another green-colored owlet is the deceptive sallow (*Feralia deceptiva*), which has delicate black and white markings across its pale green wings.

Less common among owlets are the flower moths (*Schinia*). This group, which includes many rare species, are perhaps the most strikingly colorful moths in North America. These moths also tend to have very specific flower associations, sometimes nectaring on the same plant that they fed on as caterpillars. The painted schinia (*Schinia volupia*) and the gaillardia flower moth (*Schinia masoni*) both have orange markings that almost exactly match the flower petals of their host plant, blanketflower. Rivaling them for color intensity is the bleeding flower moth (*Schinia sanguinea*). Its bright pink wings blend in with the flower buds of its host plants, the blazing stars. The cotton-candy-pink primrose moth (*Schinia florida*) is perhaps the most abundant and well-known example of owlet flower moths. Many gardeners in the eastern United States and Canada are amazed by their first glimpse of this otherworldly looking moth when they spot it perched among the bright yellow flowers of its host plant, common evening primrose.

The largest owlet in North America is steeped in folklore. With a wingspan reaching more than six inches (fifteen centimeters), an attraction to nighttime lights, and a unique striped and dotted pattern on a brown background, the black witch (*Ascalapha odorata*) makes an immediate impression on those who see it. This moth is most common in the southern United States, where it feeds on leguminous trees and bushes such as Kentucky coffeetree and mesquite. In Mexico and Jamaica, it is associated with ghosts or a pending death in the family, while, conversely, in the Bahamas, its sudden appearance is associated with good fortune and future wealth. In Hawai'i (where the moth was introduced), it is believed to be a deceased loved one coming back to say goodbye.

The muted gray and brown but intricately patterned forewings of underwing moths (family Erebidae) offer them

Notwithstanding its six-inch wingspan, the black witch (family Noctuidae) is not North America's largest moth, but it has probably given rise to the most extensive body of folklore. Photograph by Alan Schmierer.

excellent camouflage and protection from predators. When they are startled, however, these moths may suddenly expose the striking bands of red, orange, or yellow on their underwings. One species common in the western United States, the Aholibah underwing (*Catocala aholibah*), which feeds on oaks as a caterpillar, has such colorful orange underwing patterns that at first glance in midflight it might be mistaken for the similarly sized painted lady butterfly. Underwing caterpillars usually feed on the leaves of such trees as willows, aspens, oaks, hickories, and hawthorns, underscoring the value of native trees for landscaping and gardening.

Resembling small, drab butterflies, geometer, or geometrid, moths (family Geometridae) are frequent nighttime flower visitors. Their common and scientific names come from the Latin and Greek words for "earth-measurer," a reference to the distinctive movement of their "inchworm" caterpillars.

Some of the more colorful and thus noticeable geometers include the white slant-line (*Tetracis cachexiata*) and the infant (*Archiearis infans*), both of which feed on forest trees and are found across most of temperate North America. One of the larger members of the group is the large maple spanworm (*Prochoerodes lineola*), which prefers maples and oaks; its caterpillar resembles a brown twig, while its adult stage roughly resembles a brown leaf. The wavy-lined emerald (*Synchlora aerata*) uses similar camouflage, as a caterpillar attaching bits of flowers or leaves to its body to blend in with its host plant, and resembling a pale green leaf as an adult. You can attract the wavy-lined emerald with its preferred host plants: various asters, blazing stars, black-eyed Susans, goldenrods, and other members of the sunflower family.

The clearwing moths (family Sesiidae) are notable for looking almost nothing like other moths. Lacking the heavy bodies, muted colors, and fuzzy appearance of many other moth families, the clearwings tend to be distinctly wasplike in appearance, complete with transparent wings and metallic coloration or striped patterns of yellow and black that discourage birds and other predators from attacking them. This appearance works in their favor, since most clearwings are active in the daytime and frequently visit flowers to feed on nectar. In contrast, the larvae of clearwings tend to hide away within the stems, bark, or roots of host plants, boring and tunneling as they feed. A butterfly garden rich in native wildflower diversity might attract the eupatorium borer (*Carmenta bassiformis*), which as a caterpillar feeds within the stems of ironweed and Joe Pye weed, and Riley's clearwing (*Synanthedon rileyana*), a moth whose yellow and black stripes make it look at first glance deceptively like a yellowjacket wasp.

The slug moths (family Limacodidae) are so called because many of the caterpillars in this family have a uniquely sluglike appearance. While slug moth adults tend to be chunky and brown, a few stand out with bright green color patterns on their forewings. One that you might encounter is the hag moth (*Pheobetron pithecium*), a squat species that resembles a bee as an adult but as a caterpillar has a hairy, branched appearance like the shed exoskeleton of a spider. Its relative the stinging rose caterpillar moth (*Parasa indetermina*) looks

Riley's clearwing (family Sesiidae) is another moth that challenges expectations. Its wings lack scales, which, along with its striped coloration, results in a close resemblance to a wasp. Photograph by Katja Schulz / CC BY 2.0.

like a green and brown folded leaf; the caterpillars are bright yellow and orange and covered with stinging, fleshy projections. The caterpillar of a third species, the spiny oak-slug moth (*Euclea delphinii*), is bright green and protected by stinging orange projections. As an adult this dark brown moth with two bright green wing patches feeds on various trees across the eastern United States.

Countless other interesting moths can make an appearance in gardens, parks, and other neighborhood greenspaces, offering an opportunity to explore a remarkably diverse world into which we typically get only a glimpse. There is evidence that, like so many other insects, moths are declining as our environment changes. Older readers may recall the "moth snowstorm" in the headlights when driving at night, now just a distant memory. There are steps you can take to make your garden better for moths—provide an abundance of native plant habitat, structure for egg laying and overwintering, and protection from pesticides—but the first step, and maybe the most important one, is to get to know your local moths. I encourage you to get outside and take time to find out what's out there. Moths need a public relations makeover, and each of us can help that happen.

This article is adapted from the Xerces Society's *Gardening for Butterflies: How You Can Attract and Protect Beautiful, Beneficial Insects* (Timber Press, 2016)

Eric Lee-Mäder directs the private-sector side of Xerces' Pollinator Conservation Program, supporting a team of ecologists that is focused on partnerships with the food-industry and renewable-energy sectors; collaborations with the native-plant nursery industry; and research and development of methodologies for the restoration of pollinator habitat.

The Bogong Moth, An Icon Driving Insect Conservation in Australia

Kate Umbers

Insect conservation is a significant global challenge of great consequence, but it is hampered by our constrained understanding of biodiversity. In Australia the situation is dire, with the vast majority of the estimated two hundred thousand species of insects on the continent undescribed, under-researched, and unrepresented in conservation programs, a result of the under-resourcing of Australian entomology. This neglect is problematic because it is at odds with the importance of insects: they constitute the majority of Australia's animal diversity and almost half of Australia's total biodiversity, and are critical to the functioning of all terrestrial agricultural systems and ecosystems. The state of Australia's insects is largely unknown, but many are certainly at risk due to climate change, pesticide use, and the fact that land clearance continues largely unchecked: Australia is the only developed country included in a list of the world's deforestation hotspots.

The bogong moth (*Agrotis infusa*) is of profound meaning to Australians. These moths have deep cultural resonance for many First Nations Australians, are critical to the nutrient cycle

The bogong moth (family Noctuidae) is of great significance for Australians, and for First Nations people in particular. Photograph by Reiner Richter / CC BY-NC-SA 4.0.

Bogong moths migrate up into the Australian Alps, where they shelter in crevices and caves for summer hibernation. They "tile" tightly, with their heads tucked under the wings of other moths. Photograph by Eric Warrant.

in the Australian Alps—a mountain range in the southeastern part of the country—and are economically significant pests of wheat and barley. They also provide spectacular interactions with wildlife: stealing the show at the opening ceremony of the Sydney 2000 Olympics, famously covering Parliament House in swarms, and conjuring fond childhood memories of visitors to veranda lights in spring.

Bogong moths are notable for their remarkable annual migration of more than a thousand kilometers (six hundred and twenty miles) to Australia's highest mountains, including Kunama Namadji / Mount Kosciuszko. The marvelous work of Professor Eric Warrant of Lund University in Sweden and colleagues shows that in spring the moths leave their breeding grounds in Queensland, New South Wales, and Victoria, and possibly as far as Perth on the western coast; they then use the stars, the Earth's magnetic field, and visual landmarks to guide their flight to the Alps. Once there, they undergo a summer hibernation (aestivation), packing together in large numbers within cool cracks and crevices among giant granite and basalt boulders.

Studying these aggregations in the 1950s, Dr. Ian Common of CSIRO, the Commonwealth Scientific and Industrial Research Organisation, found that bogong moths can be at astonishing densities of up to seventeen thousand individuals per square meter (approximately fourteen thousand per square yard). Come autumn they return to the vast surrounding lowlands to mate, lay eggs, and die. Unlike monarch butterflies, which in North America take three or four generations to complete their migration, individual bogong moths are thought to complete their entire return journey in their lifetime.

The migration is important for First Nations Australians whose Country—the lands and waterways to which they

The Australian Alps provide the cool conditions sought out by the bogong moths. Climate change means the area of suitable boulderfields is shrinking. Photograph by Lois Padgham / CC BY-NC-ND 2.0.

are connected via knowledge, history, cultural practices, and spiritual beliefs—includes Australia's highest peaks. First Nations Australians from across the Alps and beyond, including the Gundungurra, Ngunnawal, Ngarigo, Wiradjuri, Jaithmathang, Taungurung, Gunaikurnai, Bidwell, and Yuin peoples, gather in spring for major ceremonies and feasts related to the extraordinary numbers of arriving moths.

The moth migration also benefits the Alps' wild inhabitants, which are adapted to the huge influx of nutrients that the moths bring, with threatened species like the mountain pygmy-possum (*Burramys parvus*, a hibernating marsupial) dependent on their arrival. These moths are important pollinators, feeding on nectar as they migrate and thereby transferring pollen among flowering species across the landscape.

Historically, roughly four billion moths migrated each year, but in 2017 their numbers plummeted, and since then less than 5 percent of the usual number of moths have arrived at monitored alpine sites. This has raised major concerns not only for the bogong moth's survival, but for Australia's entire alpine ecosystem and its already threatened plants and animals.

The total area of cool boulderfields suitable for bogong moth aestivation is shrinking due to climate change, and the moth has not recovered from its 2017 population crash for reasons that are as yet unknown. In 2020, we assessed the bogong moth's conservation status, which the following year resulted in the

moth being listed as endangered on the International Union for Conservation of Nature's Red List of Threatened Species. This IUCN assessment triggered a meeting initiated by the government of the Australian Capital Territory, the first National Bogong Moth Meeting, held in June 2021, with Traditional Custodians (the First Nations people with rights to the land based on traditional laws and customs) and representatives from government, business, academia, and other industries. The meeting was a success, but the takeaway message was concerning: despite the bogong moth's iconic status, critical data on its distribution and migratory flyways are unavailable. Moreover, there was no coordinated effort in place to obtain such data, leaving the way forward for the moth's conservation obscured.

To address this situation, a partnership between Western Sydney University, the Xerces Society, Invertebrates Australia (a new conservation charity), Zoos Victoria, and Professor Warrant from Lund University has been established to create the National Bogong Moth Observatory. The primary aim of the Observatory is to find answers to the two major unknowns: the distribution of the bogong moth and the paths of its migratory flyways.

The Observatory will establish and coordinate three integrated monitoring programs. Two of these will be community science projects to translate public enthusiasm into action. The first, Bogong Watch, will be an entirely new program, using tagging to track moth movements (modeled on similar projects in the United States for tracking monarch butterflies). The second, Moth Tracker, a Zoos Victoria program launched in 2019, records sightings of the bogong moth; the Observatory will leverage that existing platform to expand its geographic reach and increase the number of observations. The third component of the Observatory's work is to develop a set of national monitoring protocols for the bogong moth, which will create best practices and coordinate surveys by scientists in multiple agencies and institutions. Combined, these efforts will provide the foundation

The National Bogong Moth Observatory was established to monitor the moth's population and build a knowledge base for conservation efforts. Photograph by Ajay Narendra.

Based on a design by Ngunnawal artist Jim Williams, these bogong sculptures sit next to the National Museum of Australia. Photograph by MEGutsell / CC BY-SA 4.0.

of data and knowledge to identify critical areas for future studies to understand the causes of the observed decline, and in turn to determine priority management strategies to recover and secure the species.

This work will build strong relationships across diverse interest groups in Australia and generate the data needed to guide the efforts going forward, including informing the conservation assessment of bogong moths for the Environment Protection and Biodiversity Conservation Act 1999, which provides legal protection for the species and formally recommends conservation actions. This project promises incalculable benefits through knitting together diverse groups of people focused on the conservation of Australia's biodiversity; creating a profound positive impact on the Australian communal psyche by recovering a national icon; and healing connections with Country, perhaps even rekindling cultural activities that flourished before European invasion.

Because bogong moths require solutions that are common to the conservation of all invertebrates—such as increasing public support; requiring diverse groups to work together (some of whom may have otherwise conflicting interests); and expanding the pool of data on population distribution and different requirements across life stages—this project can provide a model transferrable to thousands of insect species and drive real progress toward their protection. It will also expand relationships between academics and Traditional Custodians, environmental charities, community scientists, government scientists, farmers, and private landholders. The strong ties between Australian conservationists and the Xerces Society have the exciting potential to elevate invertebrate conservation on the international stage.

Kate Umbers has been a lecturer in zoology at Western Sydney University since 2015. She is a founder and the managing director of the nonprofit Invertebrates Australia.

Enjoying Moths in Your Garden

Eric Lee-Mäder

Few people take notice of moths, despite their close relationship with butterflies. Even fewer people intentionally create gardens for them. The muted colors of many species, along with the reputation of a tiny fraction of them as pests in crops or wardrobes, has done little to endear moths to the average gardener. But the truth is that moths are a beautiful and interesting wildlife group that anyone can attract into a garden.

Our relationship with moths and moth gardening is ancient. The domestication of the mulberry silkmoth (*Bombyx mori*) likely began around 2600 BCE. According to legend, one day a wild silkworm cocoon fell from an overhead mulberry tree into the cup of tea held by the Chinese empress Leizu. Retrieving the warm, soaked cocoon, the empress realized that she could carefully unwind its wet silk around her finger. Leizu recognized that a caterpillar was the source of this amazing material and went on to establish a grove of mulberry trees (and hence the world's first moth garden) for silkworm cultivation.

Your moth-gardening aspirations might be more modest. But with more than eleven thousand moth species in

A garden designed for bees and butterflies will also support moths. A few tweaks can greatly boost their variety and number. Photograph by Justin Wheeler.

North America—placing them among the most diverse and abundant insect groups—you are assured of infinite opportunities for fascinating observation. Perhaps equally valuable to many gardeners is the fact that moths are an important source of food for countless other animals, such as bats, tree frogs, flying squirrels, songbirds, and even small owls.

In general, the life cycle of a moth is very similar to that of a butterfly. From its beginning as an egg, a moth hatches into a caterpillar, feeds for a time, pupates, undergoes metamorphosis, and emerges as an adult. Some differences exist, however, with one of the most notable being that moth caterpillars feed on a somewhat more diverse range of foods than butterfly caterpillars do. Like butterflies, the vast majority of moths feed on a host plant during their caterpillar stage, but rather than limiting themselves to leaves, some moths also eat seeds or roots, or bore into woody stems or branches and eat plants from the inside. Fewer than 1 percent of moth species (and only those in the family Tineidae) eat fabrics such as wool; tineid moths also consume other materials, though, with one species feeding on shells of dead tortoises. And at least one moth, the sooty-winged chalcoela (*Chalcoela iphitalis*), lays eggs in the nests of paper wasps, where its caterpillars munch on wasp grubs.

This wide range of larval food sources is reflected in the broad range of ways that moths lay their eggs. Those whose caterpillars have specific host requirements, such as most tiger moths (subfamily Arctiinae), seek out the required plants or locations on which to lay their eggs. In a few extreme cases, such as yucca moths (*Tegeticula*), individuals may live out their entire life cycle just on a single host plant. In other cases, such as swift moths (family Hepialidae), females may spray their eggs far and wide as they fly above grassy meadows, as though they are scattering seeds.

Another difference in the life cycles

Providing the correct host plants on which they can lay eggs and their caterpillars can feed is an important aspect of gardening for both moths and butterflies. Eggs of Oslar's oakworm, photographed by Bryan E. Reynolds.

Caterpillars of Oslar's oakworm (family Saturniidae) feeding on Gambel oak. Oaks support more species of moths than any other group of plants. Photograph by Bryan E. Reynolds.

of butterflies and moths is the pupal stage, which for butterflies consists of a chrysalis (a hardened outer casing that forms when the caterpillar sheds its skin) but for moths typically consists of a cocoon of tough silk fibers that they spin around themselves before undergoing metamorphosis. Depending on the species, the silk fibers may harden into a tough casing or remain soft and pliable, and the fibers may be either completely opaque or translucent. A number of moths add defenses to their cocoons, such as shed larval hairs that contain painful skin irritants. Other species hide their cocoons in bark crevices or leaf litter, or even spin bits of twig and plant debris into their cocoons as camouflage.

The same conservation strategies used to support butterflies also support moths in most landscapes, starting with plants. Common wisdom has it that moths visit night-blooming flowers that are typically white or pale in color such as sacred datura, morning glory, and common evening primrose. While there is certainly some truth in this, the relationship between moths and plants is infinitely more complex. For those species that do all of their feeding as caterpillars before emerging as nonfeeding adults, it is critical to recognize and protect their larval host plants. All of the moths that do feed as adults rely on sugar sources for food, primarily flower nectar, but in some cases also tree sap or rotting fruit. Those active in daylight readily visit the same wildflowers you might already be planting for a butterfly garden. Like butterflies, nectar-feeding

Common evening primrose and other flowers that open around dusk and bloom through the night are good additions to a moth-friendly garden. Photograph by Christian Ferrer / CC BY-SA 4.0.

moths usually have long tongues, allowing them to reach nectar located deep within showy tubular flowers.

The flower preferences of nocturnal or crepuscular (active at dawn and dusk) moths are less well understood. We know that these species are often extremely important pollinators of night-blooming plants, since other pollinators such as bees are generally inactive at night.

In creating a moth-friendly garden, your focus should be on selecting as a foundation many of the same native plants you would use to attract bees and butterflies. Building upon those, you can then add further plants that are known to be important for specific moth groups that you want to appeal to—and possibly include a great many of those plants to increase the chances of those moths visiting your garden.

Plants that do double duty as nectar sources and caterpillar hosts are especially worth growing. Sunflowers, goldenrods, bonesets, violets, and wild geraniums each support dozens of moth species—sunflowers more than a hundred of them—and deserve consideration. Shrubs and trees, though, feed the caterpillars of a far greater number of species, so no moth garden would be complete without them. Native shrubs that support diverse moths, some in excess of two hundred species, include blueberries, blackberries, meadowsweet, sumac, New Jersey tea, California lilac, buttonbush, and ninebark. And trees take the crown as moth magnets: plums, black cherries, pussy willows, aspens, and maples are among the best—with oaks in the top spot, supporting five hundred or more moth species.

It's tempting to focus on providing

plants that support the largest numbers, but we shouldn't forget that plants that host just a few species may be the only plants used by those moths, and ignoring such plants could be the death knell for those moths that rely on them. It is worth learning what you can about the moths that occur in your region, to find out whether there are less-common or specialist species that you can help.

Beyond plants, you should endeavor to eliminate insecticide use and—very significant for moths—preserve overgrown areas that have decaying stumps, snags, logs, brush piles, and leaf litter. The last can be especially important in temperate climates where many moth species use leaf litter for overwintering cover. In fact, gardeners should consider leaving piles of unraked autumn leaves where they fall rather than raking, bagging, or shredding them, and in the process sentencing possibly thousands of moths and other interesting creatures to certain death.

Another conservation consideration of special relevance to moths is protection from light pollution. Artificial lights are believed to be a factor in the decline of such nocturnal wildlife as moths and fireflies, and may disrupt the migration of birds that navigate by starlight, such as the indigo bunting. Calls to address light pollution are increasing in many parts of the United States, but, while many of the proposed solutions are a good start, the emphasis is often on strategies to improve the visibility of the night sky, such as replacing older street lights with downward-facing models—and moths need more. The best way to protect moths from light pollution is to turn off lights where possible. If you must use outdoor lighting, consider dim, low-voltage landscape lighting systems; red lights, which are typically not visible to insects and are more effective than yellow "bug lights" at reducing the impact of light pollution on moths; or lights that operate on a motion detector that turns them on when movement is detected and then shuts them off after a few minutes.

Finally—and amazingly—electronic bug zappers are still manufactured and readily available for purchase despite a

A one-banded lichen moth (subfamily Arctiinae) drinks nectar from yarrow, which is often grown in wildlife gardens. Photograph by Bryan E. Reynolds.

now overwhelming body of research demonstrating that they are useless for controlling pests such as mosquitoes. One study examining the effectiveness of bug zappers found that of the nearly fourteen thousand moths and other insects killed during a summer season by one typical residential bug zapper, only thirty-one of them were actually biting insects. The research, conducted in the 1990s, estimated that four million bug zappers were in use across the United States—and, operating for an average of forty nights per year, those bug zappers were killing roughly seventy-one billion harmless and beneficial insects. Additional research suggests that the mist of dead airborne insect parts created by bug zappers can actually harm your health. For all of these reasons, plus the fact that they cost money to purchase and operate, it's clear that bug zappers deserve scorn and ridicule rather than a place in your yard.

Once your garden is a refuge for moths, you'll want the opportunity to enjoy them. This is not as easy as it is with butterflies. While some moths commonly appear during the day, many are much more likely to be active after dark, making observation difficult. Fortunately, there are a few time-tested moth-watching methods that work well. Here are two.

Drape a white sheet over an overhead tree branch or something similar and use strings tied to each corner of the sheet to create a semi-taut, flat surface (similar to the sail of a ship). Then steadily shine a stationary bright light (such as a powerful flashlight) to illuminate the entire sheet. Moths as well as many other types of insects are attracted to such lights and within several minutes will begin fluttering against the sheet. After an hour or so of this type of moth watching, shut off the light and allow the moths to get on with their

Watching moths may mean setting up artificially illuminated sheets or employing other simple equipment. The reward is seeing such nighttime beauties as this parthenice tiger moth (subfamily Arctiinae). Photograph by Bryan E. Reynolds.

Making a butterfly garden better for moths may come down to choosing the right plants to feed their caterpillars. Violets are the host plants for dozens of species, and add color in spring. Photograph by Matthew Shepherd.

nighttime business. You can also gently flap the sheet or lightly brush it with your hands to encourage the moths to disperse before dawn.

Another option is to place a red lens over a flashlight (or grab a rear bicycle light) and use it to investigate insect activity on various garden plants. This is an especially good way to explore larger areas, where the red light can reveal not just moths but many other interesting nocturnal insects at all levels—from those flying across the landscape to those living out their lives along the stems and leaves of the vegetation and those moving in the leaf litter below. The best times for such moth watching in most temperate areas are the relatively warm nights between late spring and early autumn.

If you are already providing for butterflies or bees, it is a relatively small step to extend a welcome to moths in your garden. They provide a connection to a fascinating and largely unseen world and, given their importance as pollinators, as well as their value as food for birds and other wildlife, deserve their moment in the conservation spotlight.

This article is adapted from the Xerces Society's *Gardening for Butterflies: How You Can Attract and Protect Beautiful, Beneficial Insects* (Timber Press, 2016)

Eric Lee-Mäder directs the private-sector side of Xerces' Pollinator Conservation Program, supporting a team of ecologists that is focused on partnerships with the food-industry and renewable-energy sectors; collaborations with the native-plant nursery industry; and research and development of methodologies for the restoration of pollinator habitat.

STAFF PROFILE

Eric Lee-Mäder, Pollinator and Agricultural Biodiversity Co-Director

What got you interested in insects? As a kid I stumbled upon an extraordinary book, *The Amateur Naturalist*, by Gerald Durrell. The book reflected back to me the kinds of odd ditch plants and fungi and little creatures that I was familiar with, but it also pried a bit deeper into the mysterious lives of these small things. More important, it showed how they lived together in distinct communities. Reading it felt like an induction into a secret world—one in which you could decipher entire landscapes based upon observing just a few of the landscape members, often bugs.

What do you do to relax? I coach judo, both kids and adults. I've trained in the sport for more than thirty years, and it's a joy to see kids especially take up the sport, learning to use their bodies, mastering good tumbling skills, and throwing each other around the room.

What music do you enjoy? I grew up with '70s and '80s punk, and still collect records of that era. Among the contemporary threads of that tradition, a UK band called Sleaford Mods is a recent favorite.

What book are you currently reading? Mostly I read books to my kids. John Birmingham, who wrote *Chitty-Chitty-Bang-Bang*, wrote these wonderful story books in the 1970s: *Mr. Gumpy's Outing* and *Mr. Gumpy's Motorcar*. The illustrations capture a kind of magical agrarian setting of weedy fields where the patient and generous Mr. Gumpy tolerates unruly children and farm animals.

What's your favorite place to visit? I'm lucky to live in the kind of place where I'm most at home—a small seacoast town in Washington state. I'm a creature of cold and fog, abusive wind, seaweed, and pelting rain. My favorite places usually have at least one of those elements.

Who is (or was) your environmental hero? Honestly, this designation easily goes to my Xerces colleagues, who do fascinating and useful work every single day. The small team of only six or seven people who were working at Xerces when I started are particularly heroic to me, having invented insect conservation at a time when there was no mainstream roadmap for what that could look like. Everything that Xerces is today, and so much of the broader public dialog about pollinators and biodiversity, is an outgrowth of those people's efforts.

Invertebrates Australia

The wildfires that ravaged southeast Australia between September 2019 and March 2020 were catastrophic for the region's wildlife, but one good thing did arise from the ashes: a new conservation organization, Invertebrates Australia. Driven by the realization of how little was known about the impacts of the fires on invertebrates, a group of scientists established the nonprofit to provide an integrated scientific approach to the conservation and promotion of all Australian invertebrates. Scott Black, Xerces' executive director, has been an advisor as the organization has taken shape.

The work of Invertebrates Australia is organized into three programs:

Inspire uses education and community science to increase public engagement in invertebrate conservation. Its flagship projects capitalize on highly visible charismatic species to make science accessible. The Christmas Beetle Count is asking people to report sightings of adults of these eye-catching beetles via iNaturalist. The new Bogong Watch project aims to chart the migratory flyways of bogong moths as they complete their summer migration to the Australian Alps and back.

Inform both builds awareness of invertebrates and undertakes advocacy to gain protection for them. One of the main initiatives for this program connects directly to the organization's origins. Conservation Assessments for Fire-Affected Invertebrates is preparing status reports for dozens of species impacted by the 2019–2020 bushfires. These assessments will lead to government protection and conservation benefits for many species that the fires have pushed toward extinction.

Investigate is expanding knowledge about and access to information on invertebrates, including many little-known species. Some projects are gathering data on specific species, such as a terrestrial snail endemic to Lord Howe Island, or the ecology of a narrow group, such as pollinators of three critically endangered orchids. The program's major task is the creation of InverTraits, a database of ecological and life-history traits for all Australian invertebrates. This huge undertaking will be open access, providing an enduring tool to inform conservation and land management.

Visit invertebratesaustralia.org to learn more.

Common Christmas beetle (*Anoplognathus porosus*). Photograph by eyeweed / CC BY-NC-ND 2.0.

Bee City and Bee Campus Affiliates are Changing the World

Bee City and Bee Campus communities transformed thousands of acres for pollinators last year. Photograph courtesy University of Illinois Chicago.

The Bee City and Bee Campus program offers towns, cities, and colleges the opportunity to unite around a shared purpose: protecting pollinators. Affiliates are asked to create habitat, reduce pesticides, and undertake community outreach, and then to report on their activities and achievements each year. And their reports show that they truly are having an impact.

In 2022, the network comprised 327 communities in forty-six states, plus Puerto Rico and Washington, D.C. Collectively, the affiliates organized 1,735 pollinator-related community events, which were attended by in excess of a quarter of a million people. More than nineteen thousand volunteers implemented 1,625 habitat projects that transformed 12,900 acres. Campuses also engaged nearly forty thousand students and community members in courses, service learning projects, and continuing education classes.

Statistics can be impressive, but they mask the strength of this movement—the enthusiasm, creativity, and talents of each of our affiliates. These are people pulling together to incrementally change the world. In Moorestown, New Jersey, a thirty-foot-wide pollinator habitat was planted along one side of Swede Run Fields park. Talent, Oregon, unveiled what is claimed to be the world's smallest park, a 374-square-inch hexagon containing five pollinator-friendly native plants. In Lexington, Massachusetts, high-school students made and distributed hundreds of packages of native plant seeds. In Nevada, Carson City held its Second Annual Pollinator Parade. In Westminster, Colorado, goats are used instead of pesticides to get rid of noxious weeds and help prepare the ground for seeding of new habitat. In Greenwood, South Carolina, staff use a weed flamer instead of pesticides.

Major funding for Bee City and Bee Campus comes from the Carroll Petrie Foundation.

Bumble Bee Atlases Create a Conservation Community

Historically, the vast majority of data gathered about bumble bees in North America has not been collected for the purpose of making conservation decisions. What exists is largely a catalog of museum specimens, with limited information about what effort went into collecting an animal, what habitats it was found in or near, and what plant it might have been visiting. This lack of knowledge hinders conservation efforts such as habitat creation and restoration, and impedes the prospects of helping these important animals recover.

In 2018, the Xerces Society, along with state partners in Washington and Idaho, sought to change that by launching our first Bumble Bee Atlas project. The idea was to harness the power of community science to learn more about where bumble bees are thriving, the flowers they visit, the habitats they occupy, and where they might need our help. We developed a protocol that allows volunteers to go out and do non-lethal sampling of bumble bees, and still provide the high-quality data we need to inform conservation decisions. From that beginning, atlas programs are now blossoming across the country thanks to the support of our partners and funders.

Bumble Bee Atlas programs were active in fifteen states this year, and we will be adding at least four more states in 2024. These programs have engaged thousands of volunteers and gathered more than fifty thousand records that will shape bumble bee conservation now and well into the future. Volunteers are central to this success, and we owe them a heartfelt thanks for what has been achieved due to their efforts.

To learn more, and to find how to participate in the atlas closest to you, visit bumblebeeatlas.org.

Starting in the Northwest, the Bumble Bee Atlas programs have grown to encompass fifteen states, connecting people with a shared interest in conserving these insects. Photograph by the Xerces Society / Rich Hatfield.

Spraying Halted on Twenty-Five Thousand Acres in New Mexico

This summer, Xerces and our allies succeeded in halting aerial spraying across twenty-five thousand acres of New Mexico's Rio Chama watershed. That victory is part of a long-term campaign to end excessive insecticide use to kill native grasshoppers in western rangelands.

The Rio Chama is a designated State Scenic and Pastoral River, with one section also protected federally as a Wild and Scenic River. The watershed is a mix of lush green and sparse sagebrush, and much of it is public land. The target of the spraying was native grasshoppers, an important part of rangeland ecosystems and food webs, which sometimes compete with cattle for limited forage.

On June 13, the Animal and Plant Health Inspection Service (part of the USDA) posted online a contract to spray public lands in the Rio Chama watershed with carbaryl—a broad-spectrum insecticide that is toxic to a wide variety of insects, birds, fish, and mammals, and is also considered a likely human carcinogen—starting as early as June 26.

There was no public announcement of the planned spraying. We learned of it thanks to our staff regularly checking government websites for new contract listings. Xerces immediately contacted collaborators in New Mexico and also reached out to local media. Within a week, residents were organized and asking questions. Tribal members who live downstream of the proposed spraying, wildlife conservationists, organic farmers, and many others who care about the area demanded that the proposal be canceled and that a transparent and collaborative plan be established for the area. The Bureau of Land Management,

Thanks to Xerces and our local partners, aerial spraying of wildlands in the Rio Chama watershed was stopped. Photograph by Robert N. Clinton / CC BY-NC-ND 2.0.

Juniper hairstreak (*Callophrys gryneus*). Photograph by Bryan E. Reynolds.

Tax-Wise Giving

At the end of each year, we look to you, our loyal donors, to provide the foundation for us to continue our essential work into the new year. For those of you looking to make a tax-wise gift with a significant impact, we recommend talking to your professional advisor about the following options:

- Gifts of appreciated securities or publicly traded stock. Account transfer information can be found at xerces.org/donate/stock.
- If you are 70½ years of age or older, you may be able to give directly from your individual retirement account (IRA). The maximum total amount of qualified charitable distributions (QCDs) is $100,000 per person each year without incurring income tax on your withdrawal. Also, QCDs don't require that you itemize, which due to the recent tax law changes, means you may decide to take advantage of the higher standard deduction, but still use a QCD for charitable giving.

The Xerces Society does not render tax or legal advice. Please reach out to your professional advisor for advice about your situation. As always, a non-cash gift should be initiated well in advance of the end of the calendar year to ensure the gift falls into the tax year that you intend. If you'd like to notify us of a gift you have planned, please email us at membership@xerces.org. Thank you for your support!

which manages the bulk of the lands to be sprayed, first put the proposal on hold and then on June 29 canceled it—just two weeks after it was posted.

While cancellation of the spraying operation was great news, it is not the end of the task. A great deal of hard work is still necessary: such spraying could occur in seventeen states in the West. We believe that toxic insecticides should

seldom be used, and then only after analysis of the impacts to wildlife and humans using current science. Years of heavy use, drought, and a changing climate are stressful to public lands. By rethinking how we use and manage these places, we can support healthy and diverse wildlife and ensure that the lands also support the interests and livelihoods of people.

Partnering with the Natural Resources Conservation Service

Over the past nineteen years, Xerces and the USDA's Natural Resources Conservation Service have built a strong and impactful partnership. The NRCS is responsible for implementing taxpayer-funded conservation work on farms, ranches, pastures, and privately managed forests across the United States, including efforts to protect soil and water and to conserve biodiversity.

To do this work effectively, the NRCS works closely with partners, such as the Xerces Society, who can provide unique and specialized expertise to help their staff, as well as to assist farmers, ranchers, and foresters.

Xerces now has fifteen staff members, from California to Maine, who serve in formal partner positions with the NRCS. This team provides a wide range of services that help the NRCS provide technical or financial assistance for creating or managing beneficial insect habitat across the country.

We have trained tens of thousands of farmers, ranchers, NRCS staff, and other conservationists about how to conserve invertebrates. We've developed documents for NRCS staff at all levels, including specifications for conservation practices, plant lists, seed mixes, and guides to creating and managing habitat. Our team has also worked directly with growers and NRCS field staff to create hundreds of farm-specific conservation plans for locations as varied as

Cover crops with native and non-native flowers support insects and build soil health. Photograph by the Xerces Society / Mace Vaughan.

blueberry farms in Oregon, rangeland in Oklahoma, and urban farms in the center of Detroit.

The results include cropland converted to permanent meadows, prairies, and field borders; in-field flower strips to feed beneficial insects that attack crop pests; cover crops designed to provide bursts of bloom; wetlands planted to support monarch butterflies; riparian areas restored to create habitat corridors across farmland; and much more—in excess of one and a half million acres of insect habitat across the United States!

Remembering Gary Casabona (1959–2023)

Pollinators lost a passionate advocate—and the Xerces Society lost a true friend—with the passing of Gary Casabona on June 18 of this year. Gary served as the Rhode Island NRCS state biologist for many years, during which time he was a close collaborator and mentor to Xerces staff in the Northeast. His contributions to the conservation of wildlife and at-risk species was vast. He supported habitat-management projects for salt-marsh sparrows, shrubland birds, New England cottontails, wetlands, oyster restoration, improved fish passages, and, of course, pollinators.

After Gary retired from the NRCS in 2021 he worked for Xerces part-time, training and mentoring new Xerces staff members and providing technical assistance on pollinator-habitat projects. He also helped University of Rhode Island scientists to study declining pollinator species, and spent his free time birding and playing guitar.

***WINGS*, Fall 2023** **Volume 46, Number 2**

 Xerces Society Executive Director: Scott Black. *Editors*: Scott Black, John Laursen, and Matthew Shepherd. *Design and Production*: John Laursen. Printed on recycled paper.

Visit us at xerces.org or contact us at 855-232-6639.

Moths are so different as adults and larvae that they may have two names. Larvae of smeared dagger moths (*Acronicta oblinita*) are known as smartweed caterpillars. Photograph by Bryan E. Reynolds.

A $35 per year Xerces Society membership includes a subscription to *Wings*.

On the cover: With about a hundred and sixty thousand species worldwide, moths are a remarkably diverse group of insects, some of which don't look like what we usually expect them to. Texas wasp moth (*Horama panthalon*), photographed by Bryan E. Reynolds.

XERCES SOCIETY
for Invertebrate Conservation