WINGS

ESSAYS ON INVERTEBRATE CONSERVATION

THE XERCES SOCIETY SPRING 2025

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At the Xerces Society, one thing that unites all of us—staff, donors, collaborators—is a love for insects or other invertebrates. In this issue of *Wings*, the articles explore the natural history of two diverse and often misunderstood groups, wasps and grasshoppers, and one intriguing moth from New Zealand.

In the Middle of a Maelstrom

Scott Black

Recently I was lucky enough to experience a bogong moth maelstrom. I was part of a group of researchers, conservationists, national park service staff, and First Nations people gathered at the top of Mount Kosciuszko, the tallest mountain on mainland Australia, to witness this memorable phenomenon. As dusk fell, tens of thousands of moths rose out of the boulder fields all around us, and by dark there were so many in the air that I needed to keep my mouth closed so one did not fly in.

I had traveled to Australia for the 2025 Bogong Moth Summit. The bogong moth (*Agrotis infusa*) (also known as *bugung* to the aboriginal Ngarigo people and *deberra* in the language of the Taungurung) is an iconic Australian species, important to First Nations peoples and critical to ecosystems across southern Australia.

A bogong moth. As night falls, thousands of these moths rise from the ground, forming a massive flying cloud. Photograph by Andrew Allen / CC BY 4.0.

Bogong moths undertake an annual migration, traveling up to 620 miles (a thousand kilometers) from their breeding grounds across southeastern Australia to spend the summer in cool alpine caves, then returning in the fall to breed. They are food for birds, mammals, lizards, and frogs across their range, and are a vital food source for the critically endangered mountain pygmy possum (*Burramys parvus*). Unfortunately, the moths are now threatened by climate change and long-term drought, loss of breeding habitat, lights, and, likely, pesticides.

Organized by the nonprofit Invertebrates Australia, the summit had as its primary aim to explore and highlight the ecological and cultural importance of the bogong moth and to inspire involvement in its conservation. I was invited to give a talk on Xerces' approach to protecting insects and to provide input on strategies that participants could use to expand community science programs and promote conservation efforts across landscapes. Many of the participants came up and spoke to me during and after the conference about how happy they were that we were attending. One mentioned being amazed by the

Xerces' Habitat Kit program has delivered hundreds of thousands of native plants to community partners. Photograph by the Xerces Society / Angela Laws.

breadth of our programs and projects, another that they often looked at our work for ideas on how to be more successful in their own. It was an inspiring meeting, with engaging conversations and a willingness to push forward with a conservation agenda. The trip left me energized about what we can do if we work together.

Fast forward to my return to the United States—and what a contrast! We are struggling with a new conservation reality. The country is at a crossroads, and the Xerces Society is navigating uncharted waters with this new federal administration. The hollowing out of federal agencies dedicated to protecting our land and water, proposals to repeal regulations, and the likely loss of federal funding by Xerces and others has changed the conservation landscape.

I have been asked many times how, as a conservationist, I keep going in the face of what seems like endlessly bad news. My answer is that we cannot be hopeless until there is no hope left. And there is still much to hope for and there are so many people who continue to work for a better planet: this is what keeps me going. In this time of starkly differing visions of where we should be heading as a society, let us all continue to find hope and joy in things that draw us together, such as planting a pollinator garden, working to build soils through better farm management, or simply enjoying the wildlife we see around us.

Conservation happens at all levels. We need strong, intact federal agencies to protect our nation's natural wonders—and Xerces will continue to work with our federal partners wherever and whenever we can. But much conservation happens at the local level. Xerces works in all landscapes, from the wildest places to farms; from natural areas to roadsides; from city parks to backyards. The individual farmer planting habitat, a Bee City taking action to curb pesticide use, state and local agencies prioritizing conservation, or one person growing flowers for the benefit of the tiny animals all help our planet.

It is easy to get overwhelmed by national politics, but we must not despair. There is still much that all of us can do, and with your help we can step up to do what we can for the planet in whatever way works for each of us. As Xerces continues to push for conservation in all landscapes, I hope you will continue with us on this journey.

Wasp Rehabilitation Tour

Rae Powers and Jennifer Hopwood

We've all likely had encounters with wasps, or heard anxiously told tales of disrupted picnics or of black-and-yellow insects buzzing around a cup of cider in the fall. Most of these encounters involve yellowjackets, hornets, or paper wasps, social species that build complex societies housed within paper-like nests. With so many individuals to support and resources to keep safe, they have to forage actively, and, understandably, are defensive of their nests. It's these wasps that most people think of and that have inspired many a horror movie and meme—but wasps are so much more! Social wasps make up a small fraction of the approximately 123,000 known wasp species. Perhaps we should take a step back to ask: "What is a wasp?"

Wasps are one group within the Hymenoptera, an enormously diverse insect order that includes bees, ants, and sawflies. All Hymenoptera share certain traits, among them that they undergo the four life stages of complete metamorphosis (egg, larva, pupa, adult); the adults have two pairs of membranous wings, with the fore and hind wings connected by tiny hooks; and the females have an ovipositor (egg-laying structure) or a stinger. Similar to bees and ants, wasps appear to have a waist—a flexible, narrow segment of the abdomen—and long, thread-like antennae. In addition, many adults feed on nectar or other sugar-rich foods, and all of their larvae eat high-protein diets.

Although some wasp biologists would quip that bees are just vegetarian wasps and, similarly, ants are just wingless wasps, the term "wasp" is commonly accepted to mean two groups: the parasitoid wasps and the hunting wasps. These come in all sizes, shapes, and col-

While wasps have several features in common, they vary greatly in overall appearance. Ichneumon, photographed by Bryan E. Reynolds.

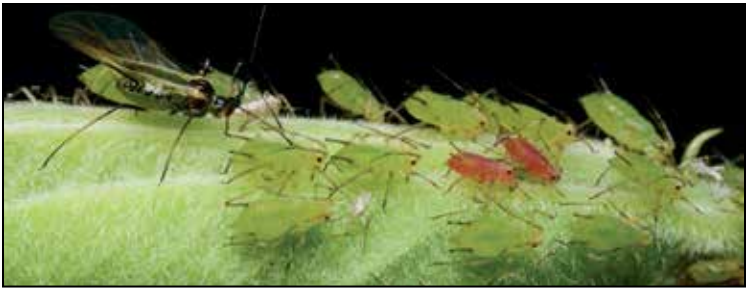
ors, and they have an astonishing array of amazing, bizarre, and slightly gruesome life histories. So, here we begin our wasp rehabilitation tour, during which we hope to endear wasps to you, or at least, to increase wasp appreciation and make you less likely to reach for the rolled-up magazine or can of spray.

Parasitoid wasps make up 73 percent of all described wasp species, around ninety thousand. These range from the world's smallest insect, the fairyfly—six-thousandths of an inch (fourteen thousandths of a centimeter) long, about the width of a human hair—to the giant ichneumon, a slender wasp with a body roughly two inches long. Astoundingly, there may be up to eight hundred thousand undiscovered or undescribed species. Scientists estimate that there is at least one species of parasitoid wasp that specializes on every insect genus.

These wasps are solitary. Females have a thread-like ovipositor that they use to lay eggs in, on, or near their host, which is typically an insect or spider. Most parasitoid wasps are host-specific, attacking a single species or a limited number of related species, and may target particular life stages in their host, from egg to adult. After hatching, a wasp larva feeds off the bodily fluids of its host; these larvae, though, are strategic, consuming non-essential fluids, tissues, or body systems first, thus keeping their hosts alive and able to protect themselves from other predators. Normally the hosts continue to function, although sometimes they are paralyzed by the egg laying. When the wasp larva completes its development, its host insect dies.

It might seem easy to be a parasitoid. Lay eggs, move on, no nest to tend; but it's not that straightforward. A single female wasp in the landscape must first find, approach, and successfully deposit an egg in, on, or near a host insect—who may be evolutionarily armed against said deposition. Host larvae may buck, roll, thrash around, or try to flee; adults may fight back. Once laid, the parasitoid egg must have the necessary tools to evade the host's immune system, not to mention any other parasitoids that may already inhabit the host. How does the female wasp overcome all these obstacles?

Let's take a look at her tool kit. First, compound eyes. No surprise: wasps use visual cues to guide them to appropriate habitat and their hosts. Next, antennae.



A parasitoid wasp (left) carefully approaches a group of feeding aphids. The wasp will lay eggs on or in the aphids, which will become food for its offspring. Photograph by John Spooner / CC BY-NC 2.0.

Wasp antennae are capable of detecting or smelling a wide range of chemical odors. The chemical cues that lead a wasp to her host are many and varied. Some come from the hosts themselves, such as those given off by their excretions. Others are from plants being attacked by insects: as the herbivores feed, a plant may emit chemicals that can alert parasitoids to the presence of potential hosts. Wasps may also use their antennae to tap or drum on a surface, seeking tactile cues to identify whether a host is inside or to assess the quality of the egg-laying site, which could be an egg mass, a mobile larva, or even an armored adult insect.

The next tool in the wasp's tool kit is the quintessential "wasp waist," the flexibility of which helps her to deposit her eggs in the correct place on a potentially writhing host. Another tool, the ovipositor, also serves as a sensory organ for many parasitoid wasps; it may be used to probe the host to ascertain its quality, to detect the presence of other parasites, or to locate the optimal location for the egg.

The final tools at the female's disposal are venoms and viruses. In addition to inserting an egg, some parasitoid wasps also inject venom. The components and effects of venom vary: they may serve to temporarily or permanently paralyze the host or to slow its development, alter its behavior or immune response, or change its nutritional quality. A symbiotic virus may also accompany the venom, which can affect the host in many of the same ways.

Although some parasitoids insert venom with their ovipositor, a true stinger—the primary purpose of which is to deliver venom—didn't evolve until

A *Trissolcus* wasp inspects stink bug eggs into which it will lay eggs of its own. Photograph by Judy Gallagher / CC BY 2.0.

a few million years after the evolution of parasitoidism in wasps. Let's move forward in evolutionary time on our wasp tour to meet the hunting wasps.

Hunting wasps have a tool kit similar to that of the parasitoids—eyes, antennae, flexible waist—but their ovipositor is modified and can only be used as a stinger to inject venom into prey to either kill or immobilize it. Like parasitoids, hunting wasps often target certain preferred species of prey, with different wasps hunting spiders or grasshoppers, for example, and others homing in on scarab beetles, stink bugs, or cicadas.

Hunting wasps include those familiar social wasps whose foraging and nesting behaviors make them more noticeable. The vast majority, though, live solitary lives that we're seldom aware of: one individual female builds a nest, lays

Hunting wasps gather prey to stock brood cells in their nests, in which they lay eggs. This thread-waisted wasp has paralyzed a caterpillar by stinging it. Photograph by Bryan E. Reynolds.

eggs, and provides food for her young, without assistance. These solitary wasps nest above ground or below. Some, such as mason wasps or mud daubers, collect or create mud to construct pots attached to plants or thin tubes plastered to the walls of homes or barns. Others, like the grass-carrying wasps, nest in hollow or pithy stems (or mason bee nest blocks), using grasses to create partitions between nest cells and to plug nest entrances. Many hunting wasps—sand wasps, golden digger wasps, cicada killer wasps, thread-waisted wasps, spider wasps, and others—dig underground nests, building separate chambers for each egg. Solitary wasps tend to be more docile than social wasps, as risking their lives in defense of nests would curb their ability to reproduce.

Cicada killer wasps (*Sphecius* spp.) are black and yellow in color and large, and can be seen flying around inspecting lawns while seeking their target prey, cicadas. With a cicada weighing nearly three times as much as she does, it is no easy matter for a female wasp to get her prey back to her nest. Often, a female will use a nearby tree as a launching pad, dragging a paralyzed cicada up the trunk in order to gain altitude and momentum to make her return flight easier. Females dig burrows ten to twenty inches (twenty-five to fifty centimeters) deep, using their mandibles to loosen soil and their spiny legs to push soil out behind them. With up to ten cells per nest, and with as many as three cicadas deposited in each cell as food for the larva, each mother works really hard for her young.

Other large, colorful wasps that we might see in our gardens are those in the Scoliidae, Tiphiidae, and Thynnidae families. These all hunt the larvae of beetles, primarily scarabs, the white grubs that often live under lawns. Scarab hunters search for their prey by flying low, landing to tap the ground with antennae to sense the grubs. Once a grub is detected, the female will dig down and immobilize it with a sting, then lay an

egg on it. A wasp larva feeds off of the paralyzed grub for several weeks, then enters its overwintering stage.

One remarkable wasp that is found throughout the tropics is the emerald cockroach wasp (*Ampulex compressa*), named for its metallic blue-green body and particular taste in prey. Upon finding a cockroach, the female delivers an initial sting that partially paralyzes her host, allowing her to insert her stinger into a specific portion of the brain of the cockroach to deliver a mind-altering venom—in effect, she zombifies it. The now-docile cockroach grooms itself for about half an hour, producing antimicrobial compounds that create a nice hygienic home for a baby wasp. Meanwhile the wasp excavates a burrow, then returns to the lethargic cockroach and, holding its antenna like a leash, leads it to the burrow. The cockroach is entombed with the egg, which when it hatches will feed off of the still-living cockroach.

What would those biologists joking about bees being vegetarian wasps have to say about actual vegetarian wasps? Gall wasps (family Cynipidae) lay their eggs in plants, using compounds to stimulate growths known as galls. Their larvae grow within these protected enclosures, feeding on plant tissues. Many gall wasps specialize on certain species, and galls can occur anywhere on a plant, including leaves, branches, buds, flowers, bark, and fruit. Oak trees host nearly 80 percent of the more than seven hundred known species of gall wasp in the United States and Canada. The galls can themselves drive community diversity: as coveted shelters for such insects as beetles or moths that move into them; for the parasitoids that use gall wasps as hosts; and for hyperparasitoid wasps, which use gall wasp parasitoid wasps as hosts. There also are vegetarian hunting wasps. Pollen wasps (vespid subfamily Masarinae) gather pollen and nectar to feed their young.

If someone said they could save us billions of dollars, we'd be all ears, and the fact is that wasps do that. They provide pest suppression both in agricul-

If grass is sticking out of a mason bee nest block, you can be sure that a grass-carrying wasp is present, using pieces of grass to separate its brood cells. Photograph by Bryan E. Reynolds.

ture and for ornamental plants that is worth at least $4.5 billion annually in cost savings and increased harvests in the United States. Wasps also help with soil health. Many species live in the soil for a portion of their life cycle—digging for prey, excavating tunnels and nest chambers, emerging from underground pupation—activities that mix nutrients and that move and aerate soil, thus increasing root growth, water permeability, and nutrient absorption, all to the benefit of both plants and soil microbes.

And wasps are also pollinators. Adults move pollen while feeding on nectar, and are known to contribute to the pollination of milkweeds and other flowers, as well as of such crops as apples, pumpkins, and mustard. Some plants have evolved to rely on wasps for pollination, in particular some figs and orchids. Those orchids, which do not produce nectar, and which, like milkweeds, have pollen packaged within pollinia, mimic the smell and appearance of female wasps, tricking male wasps into attempting to mate with their flowers. The males move from flower to flower, picking up and depositing orchid pollinia. In one instance, researchers noted that the flowers were such effective mimics that male wasps could not differentiate between them and female wasps!

Wasps are ancient creatures that provide many services to humans, and that have inspired us for centuries. Paper wasps may have sparked the creation of paper; early ink was made from wasp galls on oak trees (the Declaration of Independence was written with such ink); flexible ovipositors inspired "steerable" needles used in medical procedures; and hunting wasps hauling back much larger hosts to the nest are the models for tiny but strong micro-robots. These are just a few examples of how the ingenuity of wasps has improved our lives. Like them or not, wasps' stories are intertwined with our own.

Many hunting wasps excavate nests in the ground, or dig to find prey. Spider wasp, photographed by Bryan E. Reynolds.

The world of wasps is vast, fascinating, and, yes, sometimes a bit gruesome. We hope, though, that these stories have created a sense of wonder and curiosity that outweighs any fear of or disgust with wasps, and we encourage you to investigate these insects further. Beyond any economic or technological gains, wasps are beautiful, endlessly captivating, and a vital part of a healthy planet.

Rae Powers and Jennifer Hopwood both work for the Xerces Society as pollinator conservation specialists. Rae assists the USDA Natural Resources Conservation Service in the Great Plains, and Jennifer supports six Xerces staff from the Midwest to Rocky Mountains.

The Ghost of New Zealand

Bruce G. Marcot

On the North Island of New Zealand there resides a spectral figure with glowing red eyes: pūriri, the ghost moth. It is the country's largest moth, with the wingspan of some females exceeding five and a half inches (fourteen centimeters). Its scientific name, *Aenetus virescens*, reflects its most common color—green—but it comes in various shades of green, as well as yellow or pink. Its forewings are intricately marked with lacy patterns, sometimes darker than the wing color, sometimes paler. This striking and enigmatic creature has both ecological and cultural significance; it has several local names—including *pepetuna* and *mokoroa*—but it is best known as the pūriri moth. A nocturnal encounter with the ghost itself, combined with daytime encounters with evidence of its presence, led me on a journey of discovery regarding its unusual and most interesting life history.

This species is endemic to the central and northern sections of North Island, in areas of mature forest vegetation. Let's begin in these forests, recounting the six distinct stages of the moth's life history. Egg laying typically occurs in late September or early October, when the adult females fly around the forest, randomly dispersing large numbers of small, round, yellowish eggs. The eggs usually fall to the ground and become part of the leaf litter, where they gradually turn black. An egg hatches within twelve to fourteen days, and the moth enters the litter-phase caterpillar stage. During this two-to-three-month period it feeds on nutrients within the ground litter layer, particularly on a range of fungal fruiting bodies. After its initial molt there, the caterpillar moves into the transfer-phase stage.

In its transfer-phase stage, the caterpillar crawls up a tree, where it digs a burrow into the trunk that angles slightly upward at first and then downward into the cambium. (In cross-section, it forms a distinctive "7" shape.) The

The pūriri moth caterpillar spends its first months in leaf litter on the forest floor. Photograph by dr_robert / CC BY 4.0.

pūriri is unique, the only truly wood-boring species of Lepidoptera. Its cavity opening is sealed with a membrane, an external sign of its presence, though one not always easy to see. The membrane is composed of silk webbing, detritus, and epiphytes, which together blend its appearance into that of the tree bark, helping the caterpillar avoid predation by parrots, particularly by the kākā (*Nestor meridionalis*), another endemic New Zealand species. Further, the membrane helps increase the temperature within the cavity, promoting more rapid growth of the larva.

This cavity becomes the home of the caterpillar in its tree-phase stage. It remains in the burrow for some time, feeding on the tree's cambium. Quite how long this stage lasts is uncertain. Various resources suggest that it ranges from one to four years, while others say four to six years or even more—an amazing period of isolation.

Ensconced within the cavity, the moth passes through several instars until it eventually reaches the pupation stage, which lasts three months or so, and during which the caterpillar transforms to its adult form. This is then followed by the emergence stage, in which the pupa crawls back up the shaft it created within the tree cambium, and pushes through the membrane covering the opening. It exits the cavity in late afternoon or early evening, shedding its pupal skin at the opening and emerging as a winged adult.

Now that the long period of isolation is over, pūriri's remaining time is short. Adults have no functional mouthparts, so the free-flying adult stage during which they mate and breed lasts not much more than forty-eight hours. Little is known about how pairs find each other for mating, which apparently occurs after dark. One speculation is that males exude an attractant pheromone. Another is that emergence might be synchronized in such a way that by chance, in sheer numbers, mates find one another. If mating is successful, a

The dark pupal skin of a pūriri moth protrudes from the entrance to its tree cavity after the emergence of the flying adult. Photograph by Bruce G. Marcot.

female scatters up to two thousand eggs, thus completing the life cycle.

What, then, are the signs of pūriri in the forest? The adults are nocturnal, live for only a short span to mate and die, and occur in forest understory vegetation that is often dense, so encountering them is a rare event. The main signs are those tree cavities created during the tree-phase caterpillar stage, and it was cavities that I mostly found. But locating one with a fresh membrane cover signaling the presence of a dormant pupa is not a frequent occurrence. Typically one finds vacant cavities, many of which may have been at least partially healed over by subsequent tree growth.

In the tree-phase stage, the moths primarily inhabit understory native hardwood trees. These include the putaputawētā or marbleleaf (*Carpodetus serratus*), lacewood or ribbonwood (*Hoheria* spp.), mānuka (*Leptospermum scoparium*), and māhoe or whiteywood (*Melicytus ramiflorus*)—and in particular the moth's namesake, the pūriri tree (*Vitex lucens*), also called New Zealand mahogany, teak, oak, or walnut (strictly all of these being misnomers). In general, the native forests used by the pūriri moth are diverse. For example, along the Waipapa Loop hiking trail—less than two miles long—in Pureora Forest, I cataloged at least six species of large overstory native trees (rimu, tōtara, miro, mataī, white pine, and celery pine) and several species of understory native hardwoods (dracophyllum, coprosmas, lancewood, and mountain tōtara), collectively forming a verdant, partially closed-canopy woodland.

The vacated tree cavities created by pūriri moths are occupied by some spiders and insects, particularly the tree wētā, a cricket-like New Zealand endemic, from which the tree name putaputawētā is derived. The cavities also may become prime real estate for other forest dwellers, in an interesting ecological parallel to other forests of the world where cavities that are created and abandoned by woodpeckers can then be used by invertebrates, small owls, squirrels, bluebirds, and many other species. As New Zealand has no native woodpeckers, the pūriri serves as an "ecological engineer," a primary cavity excavator providing an element of habitat for other animals of the forest.

Old burrows are the most frequently encountered evidence of pūriri moths. Photograph by Gillian Candler / CC BY-NC 4.0.

There is concern about the impacts of the moths on some tree plantations, because the cavities their caterpillars create reduce the soundness and value of the wood. Pūriri have been recorded causing damage to Australian blackwood (*Acacia melanoxylon*), which was introduced to New Zealand for its decorative lumber. Timber taken from infested trees often has defects caused by

the cavities or by the effects of secondary rot. Such damage has stifled the use of another tree, southern beech (*Nothofagus*), for plantation forestry on North Island. Pūriri have also used some fruit trees and poplars, but to a lesser extent. In general, though, the concern is minor for the moths in their tree-phase stage inhabiting commercially planted trees, and one study found no significant impact of the moth on its native namesake host, the pūriri tree.

Even if control of pūriri damage were needed, there would be no feasible way to achieve it. Their sealed cavities thwart the use of sprays, so they would have to be individually located and injected with insecticide, making widespread control unworkable. Other exotic and invasive forest insect pests pose a greater hazard to plantation forestry in New Zealand, and are the more appropriate focus of regional and national biocontrol programs.

Moths are often pollinators, but given that adult pūriri are short-lived and have no mouthparts by which to feed, any incidental pollination func-

The pūriri moths burrow mainly into trees in the understory of mixed forests. The pūriri tree is a preferred home; this specimen has multiple cavities. Photograph by Jacqui Geux / CC BY 4.0.

tion seems highly unlikely. (Overall, the role and importance of moth pollinators in New Zealand is not well studied. Maybe we'll be surprised one day.)

Pepetuna, the most widely used alternate common name of pūriri, derives from the Māori phrase *pepe tuna* ("eel moth"). In a traditional practice, some Māori would extract caterpillars (which they refer to as *mokoroa*) by flooding their tree cavities with water, and then use them for eel bait or for food. Eels themselves sometimes feed on pūriri during the eels' migration to the sea between September and January, as they encounter the caterpillars on the flooded forest floor on rainy nights.

The pūriri moth plays an important role in traditional stories of the Māori people, who view it as a descendant of the god of the forest. Flying at dusk and at night, pūriri is considered to be a denizen of and a messenger from the world of spirits, or the spirit of an ancestor returning to visit its descendants. Interestingly, this parallels how nocturnal owls are viewed in some other cultures of the world as spiritual beings, messengers, and visitors. The Māori stories remind us to view ecosystems in a way that is far broader than can be captured in strict scientific description. They provide a basis for seeing the world through a socio-natural history perspective that values and honors even seldom-seen nocturnal life.

And my encounter with the ghost itself? On a late November evening, after discovering a number of tree cavities during the day, I made my way back to a field cabin at Pureora Forest Reserve in the company of a wonderful local biologist, Dr. Steven Pawson, associate professor at University of Canterbury. There,

With eyes that shine red in the darkness, the pūriri moth is a ghostly presence in a nighttime forest. Photograph by Emma & Tom / CC BY-NC 4.0.

in the deep dark of night, we called in a morepork owl (*Ninox novaeseelandiae*), another endemic New Zealand species and a known predator of the moth. And, as my host donned a headlamp, he was suddenly tagged on the head by a flying female pūriri, attracted to the light. This provided a most auspicious and fine ending to the day.

So it was that with my excursions into the forest world of the pūriri I came to appreciate its remarkable life history and its ecological and cultural roles, bringing home to me the wonderful spirit of the ghost moth of New Zealand.

Bruce G. Marcot is a research wildlife biologist with the USDA Forest Service Pacific Northwest Research Station.

The Joy of Grasshoppers

Angela Laws

Grasshoppers hold a special place in my heart. Before starting my job at the Xerces Society, I was fortunate to spend more than twenty-five years doing field research on grasshoppers—in mountain prairie in western Montana, in old fields in Michigan's Upper Peninsula, in coastal prairie south of Houston, and in tallgrass prairie in eastern Kansas. Each of these study sites had its own unique assemblage of grasshoppers, and I enjoyed getting to know all of them. I have vivid memories of walking out on the prairie in spring, flushing up newly hatched grasshopper nymphs and watching them pinging around from plant to plant like tiny popcorn. Or monitoring grasshopper density while being serenaded by meadowlarks and small grasshoppers. These insects are integral to grassland ecosystems, and my time doing this research inspired my love of both grasslands and grasshoppers.

From the delicate toothpick grasshoppers (*Achurum* spp.), to the great crested grasshopper (*Tropidolophus formosus*) with its attractively patterned wings and the striking rounded crest-like structure behind its head, grasshoppers can come in a variety of shapes and sizes, and many are quite lovely. One of the most colorful species in the United States is the pictured grasshopper (*Dactylotum bicolor*), also known as the rainbow or barber pole grasshopper. These flightless insects have a variety of color variations, but are usually black and yellow, with orange and blue markings. One of my favorites is the striped slant-faced grasshopper (*Amphitornus coloradus*), a handsome species with stripes down its backs and sides, sword-shaped

The aptly named great crested grasshopper has a distinctive ridge behind its head. Photograph by Jon McIntyre / CC BY-NC 4.0.

antennae, and bright-blue hind legs.

I'm sorry to say that grasshoppers are not beloved by the public. People would ask me what I did for a living, and upon their learning that I studied grasshoppers, I would watch their facial expressions settle somewhere between bewilderment and horror. Usually they would follow this up by asking if I was trying to figure out how to kill them. "No," I would respond. "I actually really like grasshoppers." (How that plays out now is such a contrast. When I tell people that I work with pollinators, they smile warmly and say something along the lines of "Oh, how wonderful!" The 180-degree turnaround really threw me for a long time.)

It is true that some grasshopper species are pests on an economic scale, and that no doubt contributes to their bad reputation. Periodic outbreaks occur among about two dozen species in the United States, during which they might reach pest status, and in some years cause extensive damage to rangeland and grassland ecosystems. The Xerces Society is working with agencies, land managers, and local communities to improve the way we manage grasslands, so that we can minimize the spraying of toxic pesticides—particularly on our public lands, where this effort has protected millions of acres. Also, along with such key partners as the USDA Natural Resources Conservation Service, we're collaborating with ranchers to improve rangeland health, biodiversity, and resilience in ecosystems where grasshopper outbreaks can be a problem. The fact is that, although some species are pests on occasion, the majority of these native insects are not a nuisance; indeed, grasshoppers are an integral part of the grassland and rangeland ecosystems they inhabit.

One of the most colorful grasshopper species in the United States is the pictured (or rainbow or barber pole) grasshopper. Photograph by Bryan E. Reynolds.

Grasshoppers are members of the order Orthoptera, which also contains crickets and katydids. There are more than twenty thousand known species of Orthoptera globally, and around twelve hundred in the United States and Canada. These insects have powerful hind legs that make them strong jumpers, and hind wings that fold when closed, like an accordion or a fan. They are divided into two groups: the long-horned orthopterans (suborder Ensifera) and the short-horned orthopterans (suborder Caelifera). As the name suggests, long-horned orthopterans—the crickets and katydids—have long antennae, longer than their bodies. The short-horned orthopterans are the grasshoppers, which have antennae that are much shorter than their bodies.

Grasshoppers undergo simple metamorphosis, meaning that the juvenile stages (nymphs) look very similar to the

Grasshoppers typically lay eggs in the ground. A frothy secretion hardens into a protective egg pod. Band-winged grasshopper, photographed by Bryan E. Reynolds.

adult stage. There is no dramatic transformation, nor is there a pupal (chrysalis) stage, rather just gradual change during several molts as a nymph, followed by a final molt to become an adult. Adult females lay egg pods—containing several eggs—in the soil. The nymphs emerge and go through several stages called instars, before molting into adults. Grasshoppers live for less than a year, and are herbivores during all life stages. Most species overwinter in the egg stage, but a few do so as late-stage nymphs, emerging as adults in early spring. As adults, most grasshoppers, but not all, can fly.

In the United States, there are five families of grasshoppers. Three of those families—monkey grasshoppers (Eumastacidae), desert long-horned grasshoppers (Tanaoceridae), and pygmy mole crickets (Tridactylidae)—are, all together, represented by fewer than twenty species.

The delightful pygmy grasshoppers (family Tetrigidae, around thirty species) are semi-aquatic. These small creatures—less than three-quarters of an inch (two centimeters) long as adults—are often found along the edges of ponds and streams, where they feed on algae. They jump into water and can swim to avoid predators. Their pronotum (the structure behind the head that looks a bit like a small cape thrown over the grasshopper's "shoulders") extends over their abdomen and wings, and can have nice geometric patterns. The coastal prairie where I worked outside of Houston flooded regularly, and pygmy grasshoppers were common there.

The majority of the insects that we picture when we think of grasshoppers belong to the family Acrididae, which has approximately 630 species in the United States and Canada. Most of these belong to one of three sub-families: Melanoplinae, Gomphocerinae, and Oedipodinae. The Melanoplinae are called spur-throated grasshoppers, after the small spine found at the base of their throats. I usually think of these as "generic" grasshoppers; if you see one, you know instantly that it's a grasshopper. The Gomphocerinae are the slant-faced

grasshoppers. Most species have acutely angled heads, and are often very slender and good at blending in with blades of grass. When disturbed, these grasshoppers tend to flush and then land deep in a patch of grass and remain still, hoping to be overlooked by predators (or by researchers with sweep nets). Finally, the Oedipodinae are known as band-winged grasshoppers. They are strong fliers and often have brightly colored wings of red, yellow, or blue, sometimes with black bands. Some Oedipodinae make clicking noises when they fly, but their flashy flight is offset by their effective camouflage. Many are mottled brown or gray, allowing them to blend into the ground when they land.

Orthopterans are known for their noise. While grasshoppers do not sing as much as katydids or crickets, males of some species do have courtship songs produced through stridulation, the rubbing together of body parts. In the case of grasshoppers, the noise is usually produced by the hind femur rubbing on the forewings, with individual species having different songs with which to attract mates. The clicking of band-winged grasshoppers in flight is called crepitation, or wing snapping, likely produced by the wing membrane being abruptly pulled taut.

I was lucky enough to do research at two grassland sites with American bison (*Bison bison*)—the National Bison Range in Montana (now the CSKT Bison Range on land belonging to the Confederated Salish and Kootenai Tribes at the center of the Flathead Indian Reservation), and the Konza Prairie in Kansas. The Konza Prairie is part of the network of Long-Term Ecological Research sites where biologists study the ecology of different landscapes across decades, and is one of my favorite places in the whole world. Nestled in Kansas' Flint Hills, Konza is a beautiful rolling prairie—emerald green in the spring and teaming with life. I loved seeing bison every day on my way to work, and hearing their gentle grunting and growling as they grazed. Understandably, bison naturally get a lot of attention. They are impressive animals and important to the health of prairies. Our nation's grasslands were shaped by evolutionary forces of climate, fire, and grazing, and bison grazing cer-

Slant-faced grasshoppers are easily recognized by the shape of their heads. Photograph by Bryan E. Reynolds.

tainly makes a big impact. Researchers at Konza Prairie have documented how bison grazing (especially when combined with periodic fire) leads to higher biodiversity of a variety of taxa, including plants, small mammals, spiders, and grasshoppers.

While grasshoppers may not get as much love as bison, they also evolved along with the grasslands, and are essential to the workings of these ecosystems. Grasshoppers live alongside those iconic mammals, feeding on plants and, in turn, providing sustenance for many other animals. Because grasshoppers are usually so common and abundant in grassland and rangeland ecosystems, they are an important and reliable food source. Grassland birds, which are declining at a faster rate than are birds in other types of habitats, rely on insects—grasshoppers in particular—for food. Other vertebrates, among them small mammals, lizards, snakes, frogs, and even fish, regularly consume grasshoppers. A variety of invertebrate predators also feed on them, including robber flies, mantids, and spiders, the last of which are particularly effective predators of grasshoppers. I often saw small lynx spiders and jumping spiders catch and consume grasshoppers substantially bigger than themselves.

Much of my research was focused on understanding predator–prey interactions between wolf spiders and grasshoppers. Wolf spiders, quite common in the grasslands where I worked, regularly feed on grasshoppers. Research on spider-grasshopper interactions in a variety of systems often shows that, when spiders are present, grasshoppers reduce plant biomass less than they do when spiders are absent, a phenomenon known as a trophic cascade. Interactions such as these help shape the way that

The Konza Prairie, in Kansas' Flint Hills, retains good grasshopper diversity thanks to bison and fire. Photograph by Vincent Parsons / CC BY-NC 2.0.

Young grasshoppers (nymphs) look a lot like adults, but do not have developed wings. Photograph by Bryan E. Reynolds.

grassland ecosystems function.

Grasshoppers have additional important roles in grasslands, apart from serving as food for other species. They have been shown to help determine the composition of vegetation, and, by converting plant tissue into easily decomposed frass (insect poop), they facilitate, and sometimes accelerate, nutrient cycling. This means that there is higher plant production in a grassland with grasshoppers than one without. Different species have different feeding preferences. For example, some feed only on grasses, while some prefer forbs (flowers and shrubs), and others prefer a mix of grasses and forbs. Depending on the assemblage of grasshopper species present, and on the relative abundance of those species, they can influence the composition of vegetation in a grassland. Experiments that manipulate grasshopper assemblages show that their effects on the composition of vegetation can, in turn, affect the soil microbial community, further influencing nutrient cycling.

Grasshoppers also serve as hosts for many different parasites and parasitoids. Among these are horsehair worms, a particularly fascinating parasitoid. The adult worms breed in aquatic habitats, where they lay sticky strings of eggs in the water or on adjacent vegetation. Once the eggs hatch, the tiny larvae remain on the vegetation, where they get ingested by feeding grasshoppers). When horsehair worms reach maturity, they reprogram grasshopper behavior, causing them to commit watery suicide so that the worms can emerge from the grasshoppers in streams or ponds and reproduce.

All in all, grasshoppers are a fun group of invertebrates to get to know, with surprising variability in size and appearance. Next time you are in a grassland, take a closer look at these important insects.

A conservation biologist with Xerces' endangered species team, Angela Laws works on habitat restoration for pollinators and monarch butterflies in California. Her role also involves incorporating climate resilience into restoration projects.

Partnering to Protect Freshwater Mussels

Freshwater mussels perform many important functions in aquatic ecosystems, such as providing structural habitat (nooks and crannies to hide in) for other aquatic species, and water purification (biofiltration). Studies have found that when you have intact beds of freshwater mussels you have healthier salmon populations, because there are more macroinvertebrates for juvenile fish to eat. Mussels also filter a lot of water. One study found that mussels in a stretch of the Mississippi River near Minneapolis filter some seventy-five times as much water per day as a nearby wastewater treatment plant. As Emilie Blevins, mussel conservation lead at Xerces, likes to say, mussels are the "Brita filters" of our waterways.

For years, though, mussels tended to be overlooked, even by professionals whose river-restoration work involves correcting past human-caused damage to riverscapes—clearing and straightening of channels, hardening of river banks—efforts that cover hundreds of miles annually. One place where we are starting to see change is with the removal of defunct or failing dams, where mussels now get a helping hand—or in most cases, lots of helping hands.

Removal of dams that are dilapidated or that no longer serve a purpose is vital for the conservation of our rivers, restoring natural flow conditions and reestablishing connectivity for salmon and other fish. Although highly beneficial in the long term, dam removal can have significant short-term impacts on organisms that live downstream, either by smothering them with the accumulated sediment released when dams are demolished, or by scouring habitat as rivers begin to flow freely. Although this can harm a variety of creatures, freshwater mussels are particularly at risk because they are largely immobile and cannot escape being suffocated under the sediment. One solution is to move mussels out of harm's way by relocating them before a dam is removed. This has become an important strategy that Xerces staff use to ensure that declining mussel populations are protected during river-restoration work.

For example, in 2023, Xerces staff worked in collaboration with the Klamath Tribes, the Karuk Tribe, the Yurok Tribe, the U.S. Fish and Wildlife Service, the California Department of Fish and Wildlife, the Oregon Department of Fish and Wildlife, Trout Unlimited, River Design Group, and the Chicago Botanical Gardens Internship Program to relocate more than four thousand western ridged mussels—western North America's most imperiled mussel species—from sites affected by dam removal on the Klamath River in northern California. We also marked many others that could not be moved, as part of a study to understand whether any of them survive downstream after the sediment is released, a key unknown when it comes to mussel-conservation efforts.

In 2024, working with Columbia

Land Trust and the Cowlitz Tribe, Xerces staff relocated about thirty-seven hundred mussels as part of the removal of the Kwoneesum Dam from Wildboy Creek, a tributary of the Washougal River in Washington state. Our team carefully collected each mussel by hand, and placed them in a protected location downstream before dam removal began.

Xerces staff also worked closely with the U.S. Fish and Wildlife Service, the Burns Paiute Tribe, and volunteers from High Desert Partnership, Ducks Unlimited, and Friends of Malheur National Wildlife Refuge in August 2024 to protect an important population of the western ridged mussel. Togethe we relocated more than eight thousand mussels at Oregon's Malheur National Wildlife Refuge during dewatering associated with the removal of the Dunn Dam from the Donner und Blitzen River.

As infrastructure ages, and as we re-evaluate the importance of healthy, free-flowing rivers, dam removals are becoming more frequent. Over the last two decades more than sixty dams have been removed each year in the United States. Thanks to Xerces' efforts, federal and state agencies, Native tribes, other nonprofits, and restoration practitioners are now starting to routinely work with us to move mussels to safety, or to revise projects so that freshwater mussels are not impacted. Looking ahead, Xerces staff are collaborating with others to expand our impact, including surveys during the planning for removal of two dams. This important work and the associated conservation wins can only happen with many hands, which is why we will continue to partner for mussel conservation. We are grateful to our collaborators and supporters. Thank you!

Volunteers from the U.S. Fish and Wildlife Service, the Paiute Burns Tribe, and several nonprofit organizations worked alongside Xerces staff, searching carefully for freshwater mussels before the Dunn Dam was removed from Oregon's Donner und Blitzen River. Photograph by Alexa Martinez / FWS.

STAFF PROFILE

Melissa Manuel, Donor Engagement Specialist

What got you interested in invertebrates? I grew up in Illinois and Michigan, where I remember catching lightning bugs in the evening and playing with "roly polies" in my grandma's garden. My parents tell a story where, when I was four, I insisted on carrying a boxelder bug in a cup with me on a long road trip because I had formed an emotional attachment.

How did you hear of the Xerces Society? I heard about Xerces in an earlier part of my career, when I was an urban farmer and agroforester. I worked with my local Natural Resources Conservation Service and Farm Service Agency staff on a grant that required installing pollinator habitat, and I remember the farm service agent describing Xerces' work in helping with establishing the guidelines.

What is most satisfying about your work here? What I find so rewarding about my role at Xerces is that I have the privilege of getting to interact daily with our donors and members. As a big gardening fan, I love getting to chat with the Xerces community about the ways they are looking out for invertebrates in their yards, farms, and communities.

What do you do to relax? I love a long walk through the woods with friends. I enjoy film photography and I like to shoot 35mm film on my Pentax K1000. My favorite subject matter is portraits of plants and people. I just got a macro lens, so I am eager to capture some invertebrates in future creative projects.

What's your favorite place to visit? My great-grandma's farm in Leaf River, Illinois. My aunt and uncle still manage the land, and they have planted about seven acres of wildflower and native prairie near an old oak grove on the farm. It's such a special place to be.

Who is (or was) your environmental hero? My personal and professional experiences have shown me that Indigenous peoples are environmental heroes across the globe. I believe we should always honor and defer to their expertise in land stewardship. As a member of the Coharie Tribe of North Carolina, I am grateful to have witnessed the Xerces Society's commitment to respecting and collaborating with Indigenous communities as we work together toward our shared conservation goals.

Mixed News on Overwintering Monarchs

In January, Xerces released results of the twenty-eighth annual Western Monarch Count of overwintering monarch butterfly populations in California. Just 9,119 butterflies were seen during the peak mid-season period, the second lowest number ever recorded. (The all-time low, in 2020, was fewer than two thousand monarchs.) This was a sharp decline from the past three years, when more than two hundred thousand monarchs were observed each winter. Back in the 1980s, millions of butterflies were observed, a number that scientists consider to represent a stable population.

In March, World Wildlife Fund–Mexico and partners reported on the number of monarchs overwintering in central Mexico. The butterflies were found covering an area of 4.42 acres (1.79 hectares), almost double the 2.22 acres (0.9 hectares) measured last year. Sadly, the numbers are still well below historic norms: last year was one of the worst ever recorded.

These numbers underscore the importance of December's announcement from the U.S. Fish and Wildlife Service, proposing to list the monarch butterfly as a threatened species under the Endangered Species Act. The proposed listing follows a petition submitted in 2014 by Xerces, with Dr. Lincoln Brower and other organizations.

Once the monarch is listed, that should lead to vital support, including improved protection for overwintering habitat in California, greater focus by agencies on species conservation, and more incentives for restoration of

The number of monarch butterflies overwintering in Mexico was higher than last year, but still at a historic low. Photograph by the Xerces Society / Candace Fallon.

breeding habitat. But, unfortunately, this announcement is just one more step toward that. A public comment period on the listing was open until March 12—but the FWS immediately reopened the comment period for a further sixty days.

The Xerces Society is part of a trinational delegation working to protect monarch butterflies across their migratory range through Mexico, the United States, and Canada. Xerces Society staff collaborate with farmers, ranchers, land managers, park managers, gardeners, corporations, and others to plant milkweeds and nectar plants that can support breeding and migrating monarchs. The butterflies also need greater protection from pesticides, which are used widely in businesses and homes, and in agricultural landscapes.

Success in Xerces' Insect Authority Campaign

As described in Xerces News in the fall 2024 issue of *Wings*, we are working to ensure that all U.S. states are able to include insects in their wildlife management and conservation work. This effort reached another milestone in March when Governor Michelle Lujan Grisham of New Mexico signed Senate Bill 5 into law. This wide-ranging bill reformed the state game commission, including expanding the definition of "wildlife" to include invertebrates.

A newly passed bill in New Mexico will benefit the Morrison bumble bee and other insects across the state. Photograph by Mike Andersen / CC BY-NC-ND 4.0.

The bill passed quickly through the New Mexico legislature thanks to bipartisan support in the legislature and strong backing by the public. Xerces was part of a broad coalition of organizations who supported this bill. Participating groups included hunters and anglers, outfitters and guides, conservationists, farmers and ranchers, and animal rights groups. Xerces' New Mexico-based pollinator conservation specialist, Kaitlin Haase, contributed to the effort by providing testimony and mobilizing the public to get involved.

New Mexico is a biodiversity hot spot, with thousands of species of bees, butterflies, and other pollinators, not to mention myriad additional insects and other invertebrates. Now these important animals can be conserved and managed alongside other wildlife.

Following our recent success in helping to secure insect management authority for Colorado, nine states remain that either have limited legal authority to conserve insects or lack it altogether. We are working with partners in Nevada and Pennsylvania to pass bills, and building networks elsewhere to draft legislation.

Study Finds U.S. Butterfly Populations Severely Declining

Xerces staff contributed to a new study that found populations of butterflies across the United States are falling. Published in the journal *Science* in March, the study concluded that the total abundance of butterflies declined by 1.3 percent a year from 2000 to 2020—a 22 percent loss. This means that for every five butterflies seen twenty years earlier, there were now only four.

This was the most comprehensive study of U.S. butterfly population trends ever undertaken. It was initiated by Cheryl Schultz, professor at Washington State University, after talking with Xerces executive director Scott Black several years ago about the need for an overall assessment of butterflies. It was completed by the Status of Butterflies in the U.S. Working Group, which formed to bring together all available butterfly monitoring datasets to develop a picture of the health of butterfly populations across the contiguous United States. Several Xerces staff members joined university and agency researchers in the working group, which was hosted by the U.S. Fish and Wildlife Service Center for Pollinator Conservation and the U.S. Geological Survey's John Wesley Powell Center for Analysis and Synthesis.

While a number of studies have previously shown regional butterfly declines, this is the most complete picture of the status of U.S. butterflies. In addition to the concerning overall loss, there were dramatic declines for individual species: a hundred and seven fell by more than 50 percent, and twenty-two by more than 90 percent.

Butterflies in the United States have declined by more than one-fifth this century. Pallid skipper, photographed by Ken Kertell / CC BY-NC 4.0.

Although the news is alarming, some butterfly species had increasing populations in at least one part of their range, with nine species increasing across their entire range. For example, the gulf fritillary is expanding its presence in central California.

Study co-author Scott Black noted that "there is hope for these animals if we focus on providing habitat for butterflies across all landscapes, from cities and towns to agricultural lands to natural areas."

Bumble Bee, Butterfly to be Considered for Protection

In January, the Morrison bumble bee (*Bombus morrisoni*) and the large marble butterfly (*Euchloe ausonides*) moved one step closer to protection when the U.S. Fish and Wildlife Service announced that it would conduct a species status

Your Legacy for Invertebrates

When I walk outside, I see more than houses, sky, and ground. I see native bees—and I get a thrill. I see woolly bear caterpillars. If I'm lucky, I see a sideband snail. I see birds and know that many of them are catching insects. Every little critter makes my walk outside a little more special. I used to walk outside and just see bugs, but over the years the Xerces Society has given me an education and an appreciation for the identities, the roles, and the lives of our myriad invertebrates. Xerces not only helps me to appreciate our native world, but they work to support and maintain "the little things that run the world."

I LOVE the opportunity to financially support this important work with monthly giving and planned giving. That financial support makes both the world better and my world richer.

—Steven Clark, Washougal, Washington; loyal Xerces member since 2004, whose favorite invertebrate is the Malone jumping slug (*Hemphillia malonei*).

Connect with Melissa at engagement@xerces.org or visit xerces.org/donate/planned-giving.

assessment for each of them. In doing so, the FWS agreed that the petitions submitted by Xerces in 2023 provided sufficient evidence that these species are declining. The species status assessment is a formal evaluation of the population size, trends, and threats. Once it is completed, FWS will decide whether or not protection is warranted.

The Morrison bumble bee is considered a "super-pollinator," contributing to the stability of both wildlands and agricultural systems. Historically, the bee could be found in grasslands, sagebrush steppes, and woodland edges across the western United States. Now, however, the species has disappeared from large portions of its range, and may have declined in abundance by 74 percent.

Volunteers with the Bumble Bee Atlas program are playing an important role in this story, as data they gathered will be used by the FWS assessment of the Morrison bumble bee.

The large marble butterfly also was previously common across western and midwestern states. The caterpillars feed on various plants in the mustard family, and although the butterfly can be found in many different areas, its preferred habitats include grasslands, sagebrush, and canyons.

Despite its wide distribution, recent studies have ranked the large marble as one of the western butterfly species most at risk of extinction in the next fifty years. Our petition therefore asked that the species be listed as threatened, with the exception of the subspecies *Euchloe ausonides ausonides*, which is already absent throughout much of its former range in California and for which we requested listing as endangered.

Federal protection is especially important for both the bumble bee and the butterfly, because they occur in several states where state wildlife agencies lack the legal authority to protect or manage for insects and thus are unable to address their conservation needs.

Although widespread, the large marble is declining and is now absent from some areas. Photograph by Robin Gwen Agarwal / CC BY-NC 4.0.

Current EPA assessments based on honey bees fail to protect native species. Photograph by Sara Morris.

Xerces and Earthjustice Urge Improved Oversight of Pesticides

It has long been recognized that lax regulation is putting pollinators at risk by allowing harmful pesticide uses. Under federal law, the Environmental Protection Agency is charged with ensuring that pesticides, before they become commercially available, don't have unreasonable adverse impacts on the environment. The EPA's existing assessment framework is inadequate for determining the risk to wild bees, moths, and butterflies, leaving them vulnerable.

Currently, the EPA requires pesticide manufacturers to submit a narrow set of data on honey bees to assess harm to all invertebrate pollinators. The reliance on the honey bee for testing has negative implications for the safety of our native bees and other pollinators, given their vastly different life histories. This process hugely underestimates the toll of pesticides on pollinators, allowing harmful chemicals into the market.

To change this, the Xerces Society combined its scientific expertise with the legal knowledge of Earthjustice to submit a regulatory petition that asks the EPA to correct flaws in the way it assesses pesticide risks to pollinators. In the petition we ask the EPA to expand the diversity of insects on which it gathers data in order to make informed decisions. Rulemaking for a federal agency is a lengthy administrative process, and the petition is just the first step. Hopefully the process will end with new EPA regulations that require pesticide manufacturers to submit data on impacts to solitary bees, bumble bees, butterflies, and moths when determining whether and how a pesticide can be used.

Not all actions need to be taken at the system level. We can all help protect wildlife: when you see a blemished leaf, is it necessary to apply something to "protect" the plant? In general, no. Most plants can handle a little nibbling and very few insects cause serious harm.

Short Bites

New publications: Our publications library, xerces.org/publications, offers many materials for free download. Recent additions include updated regional lists of nectar plants for monarchs, with the best plants to fuel migrating monarchs. Another new resource is the fact sheet *Protecting Fireflies from Pesticides*, which provides information on firefly life cycles, their habitat needs, and the threats they face from pesticides, so that you can take action at home to help conserve these charming insects.

X Kids: With spring here and summer not far away, it's the perfect time for the *X Kids* activity book. Available for download in either English or Spanish at xerces.org/xkids, *X Kids* was designed for children in grades four to five, and the activities can be done individually or in a classroom or other group. They do not require any materials beyond what can be found at home.

Bug Banter: Xerces' podcast releases two episodes each month, on the first and third Tuesdays. Recent episodes have covered topics as varied as earthworms, science communication, changing the way that the Environmental Protection Agency assesses pesticides, and using technology to track monarchs. To listen, visit xerces.org/bug-banter, or search for Bug Banter wherever you get your podcasts.

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Wings is published twice a year by the Xerces Society, an international, donor-supported nonprofit organization dedicated to protecting the natural world by conserving invertebrates and their habitat. A Xerces Society membership starts with a suggested tax-deductible donation of just $45 per year and includes a subscription to *Wings*. To become a member or to make a gift to support your favorite invertebrates, please visit xerces.org/donate.

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

This tiny wasp emerging from a squash bug egg is *Gryon pennsylvanicum*, a parasitoid. The female wasps lay eggs in the eggs of squash bugs, within which their larvae feed, grow, and pupate. Photograph by Elijah Talamas, USDA-ARS.

A $45 per year Xerces Society membership includes a subscription to *Wings*.

On the cover: Paper wasps live in small annual colonies. Their nests, found hanging from trees, fences, or other structures, are made from pulped plant fibers. Photograph by Bryan E. Reynolds.

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