

WINGS

ESSAYS ON INVERTEBRATE CONSERVATION



THE XERCES SOCIETY

FALL 2019

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“Protecting the life that sustains us” is not just a tagline for the Xerces Society; it is the principle that guides us every day. We hope that the articles in this issue of *Wings* will help to explain why this is important and illustrate some of the diverse ways in which we work to embody this principle. Thank you for your support of our work.

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Xerces' Holistic Approach to Conservation

Scott Hoffman Black

We at the Xerces Society view our work as an interconnected whole rather than as separate parts. To achieve conservation success, we must understand both science and policy. We need to inspire people and at the same time empower them with the tools they require. We also should celebrate accomplishment and ensure that those who take action receive the credit and appreciation they deserve. This holistic approach is built into our core values: Xerces is a science-based conservation organization that works with partners from diverse backgrounds. Using applied research, engaging in advocacy, providing educational resources, and addressing policy implications, we endeavor to make meaningful long-term conservation a reality.

We continue to have success with

this approach—working to understand what drives declines in key species and groups of species, and identifying how best to restore and manage habitats for these important animals. Our staff members have spent the last year testing cover-crop mixes on farms, finding the best plants to thrive under different scenarios for site management, and working with university researchers to model corridors through which pollinators can move in the face of climate change.

Xerces staff have also completed surveys for rare butterflies and caddisflies, and they've visited sites where we are seeing die-offs of freshwater mussels in order to better understand what is causing these mysterious losses. The devastating reduction in western monarch populations—down by more than



Research conducted by Xerces' conservation biologists underpins the organization's conservation work and our outreach. Photograph by the Xerces Society / Candace Fallon.

99 percent since the 1980s—has led us to survey the butterfly’s breeding habitat across the western states and to undertake a study that collects milkweed and tests it for pesticide residues.

This work is supported by networks of hundreds of community scientists. Field work by volunteers with the Thanksgiving and New Year’s counts of monarchs at California overwintering sites identified the magnitude of the butterfly’s losses so that we could sound the alarm. It also clarified both the need to focus our efforts on restoring early- and late-season nectar plants and milkweed, and the urgency of engaging additional managers to restore the forested groves where western monarchs overwinter. This combination of applied and community science pays off by allowing us to use funding efficiently, prioritizing those conservation actions that will have the greatest impact.

We are applying this same approach to bumble bees. Xerces scientists are conducting surveys and training hundreds of people to generate data on these vital animals. We’ve developed regional bumble bee atlas projects, harnessing volunteers to gather location and life-history information in Idaho, Oregon, Nebraska, and Washington, and we plan to add more states soon.

Our goal is to achieve positive transformation in policies as well as in people’s attitudes and behaviors. To do so it is vital to promote good science. Xerces conservation biologist Emma Pelton and I collaborated with Matt Forister of the University of Nevada at Reno to write a paper, “Declines in insect abundance and diversity: We know enough to act now.” The article, published this spring in the journal *Conservation Sci-*

ence and Practice, lays out the science showing insect declines and the actions needed to reverse them. Our effort was amplified by major media outlets, including *The Washington Post*, and has led to keynote talks at several conferences.

Advocacy is an important part of Xerces’ mission, an effort rendered even more important by the Trump administration’s assault on science and conservation. Whether it is ensuring that the Farm Bill includes adequate funding for pollinator conservation, that disappearing species are protected under a strong Endangered Species Act, or that local policies are enacted to protect habitat from pesticides, we continue to advocate for policies that protect insects, the environment—and, in the end, all of us.

Science also informs our education and outreach. Over the last year, we reached more than twenty-four thousand people through presentations, field days, conferences, short courses, webinars, and other events. Each of the trainings we deliver draws upon the latest science and conservation practice to meet the needs of its specific audience.

Ultimately, all of these efforts are directed toward making our landscapes more hospitable, and they have helped us to protect and restore more than two and a half million acres for invertebrates in the last decade. Whether it is working with farmers to improve farm management through Bee Better Certified, providing guidance on protecting freshwater mussels, or helping affiliates of Bee City USA and Bee Campus USA restore habitats in neighborhoods, we have found that science, education, outreach, and advocacy are all vital parts of a holistic approach to creating change that benefits all of nature.

Insect Apocalypse? What Is Really Happening; Why it Matters; and How We All Can Help

Scott Hoffman Black

This summer, I visited America's heartland, the agricultural states of Nebraska and Iowa. My trip was for both pleasure and work—seeing family in Nebraska, where I grew up, and then taking part in a farm tour in Iowa, where I was presenting an overview of the many threats to insects and the strategies for their conservation. Driving across eastern Nebraska and western Iowa with my son Theo to attend the farm tour in Grinnell one morning in July, the enormity of the impact we are having on the planet was brought home to me. Forty

years ago I remember the rolling hills along the Missouri River covered with trees and, in the flatter areas between Lincoln and Omaha, a variety of crops, including sorghum and corn, growing in relatively small fields. Back then the sea of corn and soybeans did not start until you were into Iowa and well east of the Missouri River.

All of that has changed. As we drove east from Lincoln almost every available space was corn or soybeans, giant fields stretching to the horizon. On the outskirts of Omaha, corn grew right up to



The vast corn fields of Iowa provide a graphic illustration of the changes that humans have made to our planet's environment. Photograph by Travis, Flickr.

the parking lot of a sprawling shopping mall. Even the steeper hills in the bluffs east of the river are now corn. Combine that with the urban sprawl from Omaha and Lincoln and it is easy to understand why we are seeing declining populations of insects, birds, and other animals. Wild creatures simply have fewer places to live, and all wildlife has to contend with the multiple poisons that humans use in both urban and rural areas.

When we arrived at Grinnell Heritage Farm the loss of insects was already on people's minds. Before I spoke, one farm visitor commented that "driving across Iowa you rarely see insects get smashed on the windshield anymore." This is not an isolated observation. Many scientists from the United States and Europe have noted how few insects are splattered on the fronts of cars compared with the profusion that they remember from when they were growing up. As a young man in Nebraska, my pride and joy was a 1971 Mach 1

Mustang, which I had to wash weekly to keep it clean and shiny. For many of us it seems as though there are now far fewer insects to clean off of our cars after a long trip. Indeed, the windshield of my rental car was clean following that morning's drive. But memories vary, and we really cannot rely on anecdotes of the "windshield effect" as we seek to understand long-term wildlife trends.

I've had many conversations about insect conservation—which stands to reason for the ED of Xerces, right?—but over the years both the frequency of those conversations and the urgency of the issue have grown. Some people question the severity of insect declines, while on the other hand news headlines have employed phrases such as "insect apocalypse," rhetoric that some scientists consider to be ahead of our understanding of the science. Moreover, industry representatives have tried to create confusion around the issue, particularly when it comes to the devastat-



The common blue (*Polyommatus icarus*) is not so common in Britain. Half of the country's butterfly species have declined in abundance, and many of them are found in fewer places. Photograph by Boehringer Friedrich.



Simple steps, such as growing wildflowers instead of a lawn, will contribute to the health of insect populations. Photograph by the Xerces Society / Sarah Foltz Jordan.

ing impacts that pesticides inflict on insect populations.

The evidence is clear that we are losing insects at an alarming rate. Among bumble bees, 28 percent of species in North America are considered threatened; 41 percent in Mesoamerica; and 23.5 percent in Europe. Among butterflies, ten-year trends in the United Kingdom show that 52 percent of species have declined in abundance at monitored sites and the geographic ranges of 47 percent of species are reduced. A monitoring program in Belgium showed that nineteen of the sixty-four butterfly species indigenous to the Flanders region have been extirpated and no longer occur there. European invertebrate species whose population trends have been evaluated show a high proportion in decline, and a far smaller fraction in-

creasing. Assessments in North America show similar trends: NatureServe assessed 636 butterfly species in the United States and Canada and found 19 percent at risk of extinction.

The situation appears no better for other groups of insects and invertebrates. Studies in the United States show that roughly a third of tiger beetle species and subspecies are sufficiently rare to be considered threatened or endangered, and 43 percent of stoneflies in the United States are at risk of extinction. Many other aquatic invertebrates are also faring poorly, with 65 percent of freshwater mussels, 64 percent of aquatic snails, and 47 percent of crayfish at risk of extinction.

Although fewer than 1 percent of described invertebrate species have been assessed for threats by the Internation-



Research shows insects declining in abundance and diversity—often at an alarming rate—on all continents except Antarctica, where no studies have been done. Robber fly (family Asilidae), photographed by Bryan E. Reynolds.

al Union for Conservation of Nature, approximately 40 percent of all those that have been assessed are considered threatened. In addition to losses in invertebrate species and distributions, reductions in total insect biomass are being reported from long-term studies done in many parts of the globe:

- ◆ Ohio, USA: A 33-percent reduction in the abundance of butterflies was observed over twenty-one years of extensive monitoring.

- ◆ California, USA: Monitoring done at sites across northern California from sea level to mountains over a forty-five-year period found that abundance is declining in all groups of butterflies.

- ◆ Costa Rica: Repeated surveys in a protected forest have found declines in entire genera of tropical moths.

- ◆ Germany: The total biomass of flying insects decreased by more than 70 percent across sixty-three study locations over twenty-seven years.

There has been some criticism of individual studies, with scientists pointing out that we still need more data to understand fully the overall scale of insect losses. I agree that additional information should be gathered. But we have enough data now to know that action is necessary, and that if we do not act the consequences will be severe. We had similar warnings about human-caused climate change as early as the 1980s, and had we acted then we might not be in the climate crisis we find ourselves in now. Some in industry and government may say, “We do not know enough,” or, “We do not fully understand the causes, so how can we take action?” These are eerily reminiscent of earlier claims that climate change is not real, and that smoking does not cause cancer.

The overall trend is clear. Assessments from all continents except Antarctica reveal declines—and in many cases the losses are severe. This is seen even in species that are widely found and well-known. Both eastern and west-

ern populations of the monarch butterfly (*Danaus plexippus*) in North America have been devastated; the monarchs that overwinter along the Pacific coast have decreased by more than 99 percent since the 1980s. Another widely distributed species, the rusty patched bumble bee (*Bombus affinis*) was once common throughout the Midwest and the northeastern United States, but its numbers have dropped by more than 90 percent; in 2017 it became the first bee in the continental United States to be protected under the Endangered Species Act.

So why are we seeing these declines? We have removed, degraded, or fragmented habitat in agricultural areas as well as in towns and cities. Less habitat means less diversity of species and less abundance of those that survive: it is as simple as that. Add in the toxic chemicals that are widely used—from the herbicides and insecticides employed in growing corn, soybeans, and many other crops, to the many pesticides applied in the quest for weed-free lawns and perfect-looking roses—and even the habitats that do remain often have

pesticide residues that can profoundly impact insects. There are additional negative consequences from invasive plants and animals, globally distributed diseases of bumble bees and other insects, poor water quality and quantity that imperil stoneflies and other aquatic invertebrates, and lights that are disruptive to such nocturnal insects as fireflies and moths. Overlay all of this with the increase in severe weather events and shifting rainfall patterns that are caused by climate change, and you can see that it is hard to be an insect in this human-dominated world.

So what do we do to encourage robust populations of diverse native insects? We need high-quality, climate-resilient habitat across the landscape. Government agencies, farmers, managers of natural areas, homeowners, and businesses all can protect and restore habitat, reduce the harm of pesticides on nontarget insects, and undertake actions to help slow climate change.

In my line of work, it is easy to become discouraged. The issues are large and sometimes the solutions seem too



Despite the growing number of studies, the status of insects such as leafhoppers is largely unknown. Red-banded leafhopper (*Graphocephala* sp.), photographed by Bryan E. Reynolds.

small. But I believe that there is hope. Although the evidence certainly shows that insects are declining in abundance, diversity, and biomass, studies also demonstrate that if we protect, restore, and enhance habitat and eliminate pesticides, then insects rebound. Research on a site in the United Kingdom showed that restoration led to a threefold increase in the numbers of a butterfly there. Similar studies in the United States show that hedgerow habitat on farms leads to greater diversity and abundance of bees and, over time, helps not just generalist bees but also those that are less common. Removal of invasive plants from streams and wetlands has been shown to improve habitat for dragonflies and damselflies. And protection and restoration of the habitat of a variety of rare insects has led to increases in their population sizes.

I also gather hope from seeing what people are doing in their daily lives. The Grinnell Heritage Farm is a shining example of what we can do on farms to help insects. Andrew and Melissa Dunham have converted their fifth-generation family farm from a business-as-usual conventional operation growing corn and soybeans to a farm that produces high-quality healthy food while providing for beneficial insects and other animals. They have moved away from pesticides and adopted organic practices. The farm features beetle banks to attract predators of crop pests, hedgerows crisscrossing the farm to offer refuge for pollinators and beneficial insects, and cover crops that provide habitat and improve soils. All of these increase biodiversity and help species adapt to climate change. And the Dunhams are by no means the only ones



Dragonflies are affected by the loss of prey species, both in the sky, and in water, where their nymphs live. Halloween pennant (*Celithemis eponina*), photographed by Bryan E. Reynolds.



Xerces Society conservationists collaborate with farm communities across the country to undertake planting projects. More than a million acres of habitat have been created or restored. Photograph by the Xerces Society / Sarah Foltz Jordan.

making an important contribution; we work with hundreds of farmers who are stepping up to increase habitat and decrease pesticide impacts. Almost a million acres have been restored through our partnerships with farmers, food companies, and state and federal agencies. Add to that all of those who are taking action in towns and cities, together with managers working in natural areas and on roadsides, and the combined effort does give me hope for the future.

The good news is that all of us can contribute. Replace part of your lawn

with native flowering plants; get rid of toxic insecticides; buy local, organic, and sustainable food when possible; and lower your climate footprint by eating more vegetables and less meat. Remember that even the tiniest backyard or balcony can be a stopover for those smallest of animals upon whom we all depend.

Scott Hoffman Black, the executive director of the Xerces Society, is an internationally recognized conservationist who has spent decades projecting at-risk insects.

Conservation at the End of a Rainbow

Michele Blackburn and Matthew Shepherd

Hawai'i is renowned for its rainbows—even the state's license plate is adorned with one—and as any child can tell you, there is treasure at the end of a rainbow. On the Hawai'ian Islands, though, the treasure isn't a pot of gold. Thanks to a combination of geological age, diversity of habitats, and extreme isolation, Hawai'i is home to a remarkable insect fauna, with many rare species that are found nowhere else in the world.

The Hawai'ian Islands are one of the most remote oceanic island groups, more than two thousand miles from other high islands or continents. The entire archipelago consists of more than 130 islands, atolls, reefs, and seamounts, stretching across fifteen hundred miles of the Pacific Ocean. The islands themselves are emergent tips of volcanoes formed over a period of thirty million years or more as the Pacific Plate passed over a volcanic hot spot in the Earth's crust. The island of Hawai'i, the youngest of the emerged islands, is still geologically active, as witnessed by the ongoing eruption of Kilauea.

The original insect colonists may have arrived floating on flotsam guided by ocean currents or borne on the trade winds as aerial plankton. The isolation of the islands limited the diversity of species that made landfall, but the species that did arrive found little competition and rapidly evolved to occupy the broad range of ecological niches from beaches to mountaintops, deserts to rainforests.

Bees are an example of fauna that,

on an island, differ from their counterparts on a large land mass. The United States has well in excess of a hundred native genera of bees, while Hawai'i has only one, *Hylaeus*, the yellow-faced bees. But that single genus has split into an outsized number of species for such a small land area. Hawai'i makes up less than two thousandths of a percent of the land area of the United States and yet it is home to more species of *Hylaeus* than the entire rest of the country.

Hawai'i's native insects face a slew of threats, including habitat loss resulting from development and agriculture; habitat degradation by nonnative animals (particularly feral sheep, goats, and pigs); competition from nonnative species; and the widespread presence of introduced predators and parasitoids. With this in mind, the Xerces Society has been working with the USDA Natural Resources Conservation Service to gather information about declining native species and to develop recommendations to inform conservation efforts for these insects. Below we describe some of the species in our initial focus.

As the only bees native to the islands, the sixty-three species of yellow-faced bees (*Hylaeus*) are important pollinators of native Hawai'ian plants. Seven of these species were federally listed as endangered in 2016. One of them, the anthracinan bee (*H. anthracinus*), has become the focus of considerable conservation attention. It is almost strictly a coastal species, found in native shrubby

beachside vegetation on the islands of Oahu, Molokai, Kahoolawe, Maui, Hawai'i, and, historically, Lanai. It has also been found at higher elevations (up to roughly two thousand feet or six hundred meters) in dry forest on the islands of Maui and Hawai'i.

The principal threat to this bee is the loss of habitat. Much of the native coastal environment that the species depends upon has been destroyed or degraded, largely due to development and the introductions of nonnative plants and animals. With native coastal habitat becoming increasingly rare, populations of the anthricinan bee are now limited to small patches. These areas have two features of importance for the

bees: food plants—they are documented foraging mainly on the native naupaka kahakai (*Scaevola taccada*)—and nesting opportunities, which are either in hollow stems or coral rubble. A further threat to yellow-faced bees are non-native ants, which prey on bee nests and compete for floral and nesting resources.

Hawai'i has just two native butterflies, the Kamehameha (*Vanessa tameamea*), which has the distinctive honor of being the state insect, and the Hawai'ian blue (*Udara blackburni*). Although the Kamehameha butterfly is large and conspicuous, adults spend most of their time flying around the canopy of riparian forests, and are thus difficult to detect or to document. Adults may also



The isolation of the Hawai'ian Islands gave rise to a unique community of bees. One of the rarest species nests in coral rubble on the beach. Photograph by Karl Magnacca.

be seen resting on the trunk or limbs of trees, as they are attracted to fermenting sap, particularly the sap of koa (*Acacia koa*). Caterpillars eat plants in the nettle family (Urticaceae), of which mamaki (*Pipturus albidus*) is the most commonly encountered. The caterpillars complete their growth on the host plants, wrapping themselves in the leaves, and they often pupate on them, too, their chrysalises resembling dried mamaki leaves.

The Hawai‘ian blue butterfly is widespread on the larger islands, where it can be found in shrubland and forests from the coast to an elevation of about eighty-nine hundred feet (twenty-seven hundred meters), as well as in urban and suburban areas. As with other species in the gossamer-wing family (Lycaenidae), the wings of the males shimmer in the sunshine with iridescent color. Adults have wings that are deep purplish-blue on the upper surface and turquoise-green on the undersides, hence the alter-

nate common name of “green Hawai‘ian blue.” This butterfly is mainly associated with koa, the primary host plant for its caterpillars, which feed on the tree’s flowers, buds, and young leaves. Another major native host plant is ‘a‘li‘i (*Dodonaea viscosa*), although the caterpillars also find nourishment on other native and nonnative legumes, soapberries, nettles, bittersweet, and coffee plants.

The Kamehameha butterfly was once common on six islands—Hawai‘i, Kauai, Lanai, Maui, Molokai, and Oahu—but is now considered rare throughout its range. It is known to have disappeared from some sites on Oahu, and may no longer be found on Lanai. The status of the Hawai‘ian blue is less well known; although widespread, having been recorded on those six islands plus Kahoolawe, it is generally uncommon.

Like the yellow-faced bees, these butterflies are threatened not just by habitat degradation and loss but also by



The anthricinan bee (*Hylaeus anthracinus*) is one of seven endangered Hawai‘ian yellow-faced bees. Photograph by Karl Magnacca.



Found only in Hawai'i, the Kamehameha butterfly (*Vanessa tameamea*) is the state insect. This honor has not protected it: once common, it is now rarely seen. Photograph by Forest and Kim Starr, Flickr.

the introduction of nonnative predators and parasitoids. Historically the koa on which the butterflies depend were devastated by introduced rats, cattle, goats, deer, pigs, and sheep, which modified the forest by trampling and excavating, as well as by consuming plants and seeds, thus creating grasslands where native forests once existed, interfering with the propagation of native plants, and spreading invasive ones. Even in those places where the canopy layer of koa survived, vegetation at ground level has been replaced by nonnative pasture grasses, and in more recent times the remaining koa forests have been subjected to unsustainable harvesting and converted to pasture or farms.

More than three thousand species of nonnative terrestrial arthropods,

which include insects, arachnids, and crustaceans, are thought to have successfully established populations on the Hawai'ian Islands. Introduced predatory and parasitic invertebrates—primarily insect species—may pose a significant threat to Kamehameha and Hawai'ian blue populations. Several groups of parasitic wasps (*Chalcis*, *Trichogramma*, and *Pteromalus*) and flies (*Chaetogaedia*), for example, have been documented as directly parasitizing the immature life stages of the Kamehameha butterfly.

One of Hawai'i's largest native insects is Blackburn's sphinx moth (*Manduca blackburni*), which has a wingspan of up to five inches (twelve centimeters). The complete range of host plants used by the moth's caterpillars is not entirely known, but they feed on several plants



Blackburn's sphinx moth (*Manduca blackburni*) lays eggs on native and nonnative plants. Photograph by Forest and Kim Starr, Flickr.

in the nightshade family, including the native 'aiea (*Nothocestrum* spp.) and the nonnative tree tobacco (*Nicotiana glauca*), an invasive plant.

This sphinx moth was once abundant throughout the Hawai'ian Islands, and likely inhabited much of the dry and mesic shrubland and forest that, prior to human settlement, covered more than two million acres across all the main Hawai'ian Islands, but is now known only from a few small populations on the islands of Hawai'i, Maui, and Kahoolawe. Some of the sphinx moth's known native host plants have experienced declines, among them two species of 'aiea trees that are themselves listed as endangered. The moth's decline is likely linked to its dependence on these diminishing host plants, although it is also threatened by the widespread loss and degradation of dry forests and other habitat, and, as with the butterflies, predation and parasitism by nonnative species.

Each of the four insect species featured here faces threats serious enough to put a question mark over its future.

Two of them, Blackburn's sphinx moth and the anthricinan bee, are federally listed as endangered. The moth has benefited from the designation of critical habitat—areas that are identified as essential for its survival—and the preparation of a recovery plan to aid both it and its endangered host plants. The bee has yet to have either critical habitat designated or a recovery plan developed, although its listing has resulted in studies to determine the success of translocation, captive propagation, and the potential use of artificial nests to protect bees from nonnative predators, as well as restoration projects for foraging and nesting habitat.

The two butterflies are also benefiting from conservation efforts. Programs have been initiated to map populations of the Kamehameha butterfly and to



Caterpillars of Blackburn's sphinx moth can be green or gray. Photograph by Forest and Kim Starr, Flickr.



Unlike bees, which rapidly evolved dozens of species in Hawai'i, only two species of butterflies are native to the islands, including the Hawai'ian blue (*Udara blackburni*). Photograph by Nate Yuen.

recover populations through captive rearing and reintroduction into habitats where it historically occurred. In addition, landowners in Hawai'i are encouraged to plant mamaki, the Kamehameha's native host plant. There is hope for the Hawai'ian blue in that it is found in urban areas, and one of its native host plants, 'a'li'i, establishes well in a variety of different environments, including urban landscapes, meaning that it can benefit from simple conservation measures that can be undertaken by anyone.

Prior work by the Xerces Society led to the listing of seven Hawai'ian yellow-faced bees under the Endangered Species Act. Our hope is to find ways to conserve habitat not just for these and other species that have been protected, but to focus as well on those that have not received protection. Working with federal and state agencies, and providing infor-

mation that farmers, landowners, and homeowners can use, will offer greater opportunity for the state's natural riches to flourish in this land of rainbows.

Michele Blackburn is a conservation biologist at the Xerces Society, where she works on a wide variety of conservation programs for at-risk terrestrial and aquatic species.

Matthew Shepherd has worked for the Xerces Society for twenty years in a number of different roles. He currently serves as the director of communications and outreach.

Our thanks to the following for sharing information: Jason Graham and Paul D. Krushelnycky, University of Hawai'i at Manoa; William Haines and Cynthia King, Hawai'i Department of Land and Natural Resources; and Karl Magnacca, Oahu Army Natural Resources Program.

Migrating Murals

Jane Kim (with Thayer Walker)

The stretch of California Highway 1 between Monterey and San Francisco is one of the prettier commutes I've ever had to make, 112 miles of open road passing enormous sand dunes, teeming wetlands, and booming surf. I drove that route often while studying for my master's certificate in science illustration at California State University at Monterey Bay, during the 2009–2010 academic year, taking breaks from school to visit friends and family in the San Francisco Bay Area.

It wasn't all scenic landscapes. North of Monterey, signage and billboards screamed at drivers to shop at big-box stores or to hire a personal-injury lawyer. They felt ugly and out

of place in the coastal dune landscape. As I wound along Monterey Bay and through the Santa Cruz Mountains, though, I found myself wishing for signs and billboards. Not for advertising, but for education: big beautiful signs that would explain and celebrate the wonders of the ecosystem around me.

Because signs like those did not exist, I decided to create them. In 2012, I formed Ink Dwell studio with my husband, Thayer Walker, and the Migrating Mural was born, a series of public works that celebrates wild creatures along migration corridors they share with people. As a society, we create monuments to politicians, athletes, civil rights leaders, wars; Migrating Murals are monu-



Ink Dwell launched the Migrating Mural series to celebrate animals that migrate. The first subject was the Sierra Nevada bighorn sheep, painted on buildings throughout the sheep's range. Photograph courtesy Ink Dwell.



Visually arresting and dynamic in their composition, Ink Dwell’s monarch murals adorn buildings—and stimulate conversations about conservation—from Florida to California. Photograph of “Milkweed Galaxy,” in Winter Park, Florida, courtesy Ink Dwell.

ments to the natural world, making our easy-to-overlook neighbors impossible to ignore.

The subject of our first Migrating Mural series was the endangered Sierra Nevada bighorn sheep, one of three subspecies of bighorn. They live only in a sliver of California’s Sierra Nevada mountains and, due to diseases spread by domestic sheep, by the early 1990s had been reduced to roughly a hundred animals. From 2012 to 2014 Ink Dwell worked with the Sierra Nevada Bighorn Sheep Foundation and the California Department of Fish and Wildlife to create a string of six bighorn murals along a dusty, 120-mile stretch of California Highway 395. At one point a woman in her seventies, who had lived in the Eastern Sierra her entire life, told me that she had had no idea that the sheep were her

neighbors but the murals had sparked in her a new appreciation for the animals. That alone made the work worth it. Thanks to the efforts of our conservation partners, the sheep’s population is now six hundred and growing, a major milestone in the effort to recover this endangered species.

In 2017, we turned to the sky for our second series, this time focusing on the monarch butterfly. From Vladimir Nabokov to Barbara Kingsolver, butterflies are a storyteller’s delight, and monarchs captivate North Americans like no other insect. They are stunning at every stage of life. As caterpillars they look like little tri-colored sausages, chomping on milkweed and advertising, with their yellow, black, and white banding, the plant’s toxins they carry. In chrysalis form, they hang from their



Artist Jane Kim creates building-scale butterflies in stunning detail. Photograph courtesy Ink Dwell.

host plants like dewdrops, powder green with specks of gold hinting at the magical transformation inside. As butterflies they are tiny but mighty explorers, flickering across the sky for thousands of miles like a sunbeam on the wing.

At a time when political discourse in our country revolves around issues that divide us, monarchs tell a story of unity. They belong to all of North America, with the eastern population wintering in Mexico and then spreading across the United States and Canada, providing a beautiful lesson in interdependence. Similarly, the Monarch Migrating Mural seeks to create common ground. It's a sad reality in the United States that science and conservation have become

politicized; we created the Migrating Mural to draw people together through a shared appreciation of compelling and scientifically accurate public art.

Our ultimate goal is to bring this Migrating Mural to every state and country in the monarch butterfly's North American range. Since launching the project two years ago, we've created eight monarch-focused public works across four states—Arkansas, Florida, Utah, and California—and have seen these murals bring communities together. In downtown Orlando the thirty-five-hundred-square-foot “Midnight Dream” stands across the street from City Hall and the performing arts center. While we were in production, Floridians from all backgrounds and demographics—grandmothers, teenagers, bikers—stopped to share their monarch stories and appreciation for their new monument.

In Ogden, Utah, “Monarch in Moda” anchors the city's new arts district. Residents have flocked to it as a destination for wedding, prom, and graduation photographs, incorporating monarchs into their memories of the most important events of their lives. A few miles away, at Weber State University, “Generations” fills the lobby of the Lindquist College of Arts and Humanities, a metaphor for the generations of curious students who have attended the school in pursuit of their own transformations. Weber State was so inspired by the monarch's story that it has pledged to plant two acres of milkweed on its campus.

For good reason, too, as monarchs need all the help they can get. Since the 1980s the population counts of western monarchs, which largely winter in California, have dropped from four and a half million to twenty-eight thousand.

The eastern population has seen the size of its wintering colony in Mexico shrink from forty-five acres to fifteen since 1996. Monarch numbers have fallen so precipitously that the U.S. Fish and Wildlife Service is currently considering it for listing as an endangered species, thanks in no small part to the efforts of the Xerces Society.

It was Xerces' work, in fact, that helped us choose the monarch as a subject for our Migrating Mural in the first place. As we worked through our selection process, we kept coming across Xerces' monarch-focused scientific and educational campaign. We were already smitten by the insect, but were unaware of its plight until we began following Xerces' efforts. So it is with great joy that Ink Dwell is now working with the Xerces Society as our conservation partner for the Monarch Migrating Mural.

Although the boots-on-the-ground science (and suits-in-the-capital advo-

cacy) that Xerces does for all invertebrates is crucial to maintaining a livable planet, that work is often done far from the public eye. The Monarch Migrating Mural, on the other hand, was developed specifically to draw attention and support for the protection of monarchs and other pollinators. Our hope is to channel public excitement for these projects in a manner that aids Xerces in its conservation mission—and that aids monarch butterflies in their survival.

We realize that public art won't directly solve issues such as species conservation and climate change, but we know that it can challenge and inspire us to modify the way we think and behave. Such change is the first step toward building a healthier future.

Jane Kim and Thayer Walker founded Ink Dwell Studio in 2012 to create art that explores the wonders of the natural world.



“Monarch in Moda,” in Ogden, Utah, is among the more dramatic Migrating Murals, and has become a favored backdrop for photographers. Photograph courtesy Ink Dwell.

CONSERVATION SPOTLIGHT

Dr. Matt Forister, Reno's Butterfly Guy

Matt Forister has made his career at the nexus of science and conservation. As the Trevor J. McMinn Professor of Biology at the University of Nevada at Reno—where he is affectionately known as the Butterfly Guy—he works with students to study a range of subjects that include the evolution of diet breadth in herbivorous insects and the chemical ecology of plant-insect interactions.

For almost twenty years he has joined with his own former graduate professor, Dr. Art Shapiro from the University of California at Davis, to evaluate data on butterflies that were collected by Dr. Shapiro beginning in the 1970s and are now being collected in part by graduate students advised by Dr. Forister. This is one of the world's longest-running observational insect datasets, creating a detailed picture of long-term trends among California's butterflies.

Forister is also helping Xerces understand where and how to focus plans for habitat restoration. In partnership with Tom Dilts, a landscape ecologist also at the University of Nevada at Reno, he worked with our staff members to analyze different kinds of land use, the various crops grown within agricultural areas, and the types and amounts of pesticides employed. The resulting model of potential habitat corridors for pollinators through the northern part of California's Central Valley is helping Xerces and our partners to prioritize areas for conservation and restoration to maximize habitat connectivity.

In a further collaboration with Xerces executive director Scott Black and conservation biologist Emma Pelton, Dr. Forister coauthored “Declines in insect abundance and diversity: We know enough to act now,” which was published in the journal *Conservation Science and Practice*.

Dr. Forister is able to relay scientific principles in a way that is both easily understandable and inspiring. In this age of climate change, loss of biodiversity, and other major threats to insect populations, he is exactly the type of scientist who is needed to help lead the effort for positive change. Xerces is happy to count Matt Forister among our conservation partners and friends.



Dr. Forister conducting field work in Ecuador. Photograph courtesy Matt Forister.

INVERTEBRATE NOTES

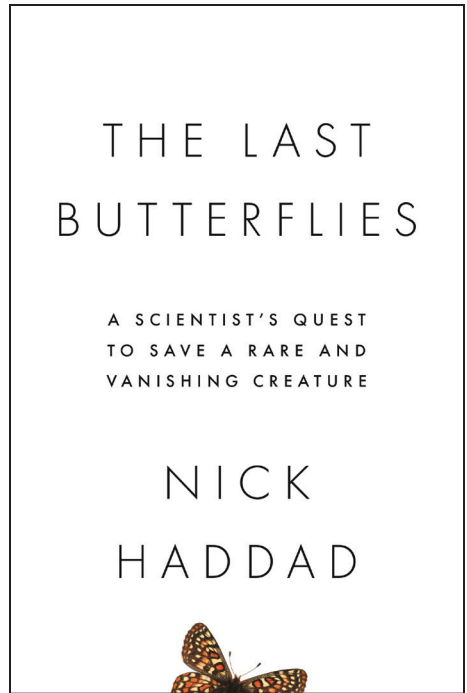
Book Review: *The Last Butterflies*

When a copy of *The Last Butterflies* landed on my desk, I imagined that it would be a quick read. But it sucked me in and I became completely engrossed in one of the best books about conservation biology that I've read in a long time. *The Last Butterflies: A Scientist's Quest to Save a Rare and Vanishing Creature* (Princeton University Press, 2019) reads with the ease of a novel. Part adventure tale and part detective story, it leads you in search of the world's rarest butterflies and the ways we might save them.

Nick Haddad didn't begin his career in pursuit of butterflies. His initial focus was the effects of habitat loss on birds and the benefits of habitat corridors. This knowledge of habitat led to an invitation to contribute to research on rare butterflies, and thus began a nearly two-decade odyssey in search of learning which butterfly is the most rare.

Blending research, historical references, and personal experience, Haddad presents profiles of half a dozen rare species, plus one that has gone extinct and one that is widespread but declining. These are dotted with fascinating nuggets: If you could gather the entire population of Schaus' swallowtail, it would weigh six ounces (half as much as your local barista's grande coffee). Live firing exercises by the Army have helped St. Francis' satyr to survive. The crystal skipper can live in gardens.

As becomes apparent, studying butterflies is not easy. Haddad doesn't sugarcoat the reality of life as a field



Lepidopterist—including encounters with snakes, thorns, and exhaustion. In the process of studying and learning about butterflies, Haddad experiences the hard work, the importance of innovation, the boredom of data collection, the excitement of realizing that a breakthrough has been made, and, of course, the satisfaction of witnessing conservation success. This should be required reading for anyone considering a career in conservation biology.

Ways in which science illuminates the natural history of the butterflies and informs conservation action are central

to each narrative—the failures, what leads to understanding what is needed, and how to create change. From there, the author goes on to highlight some considerations that are common to the species he describes: habitat management that is too passive can fail; evidence-based action is most effective; it takes time and resources to understand what butterflies require; restoration of

the rarest butterflies will not happen if the focus is on the butterfly alone; we need restoration of the whole system.

In *The Last Butterflies*, Nick Haddad takes on the role of a biographer. The half-dozen rare species that he profiles urgently need our attention. If this volume ends up as a series of obituaries, then as a society, we all will have failed.

—Matthew Shepherd

Leave the Leaves

Some people call it lazy gardening, others retaining a necessary resource for wildlife, but what to do with all those leaves every fall has become a topic of vigorous debate. Our Leave the Leaves campaign originated from a single blog post published in October 2017. It was written by Justin Wheeler, who was part of our communications team at the time. Justin also was a Master Gardener in Pennsylvania, so gardening advice

that assisted insects was the perfect combination of work and passion.

Two years on, we are seeing a growing number of articles in newspapers and gardening blogs or published by state extension services, and the topic has been picked up by other conservation organizations. More people are joining the cause and our social media hashtag (#leavetheleaves) is trending. The campaign was the subject of our first post with a reach of more than a million people on Facebook!

What does Leave the Leaves mean? Because debris and decaying organic matter are hugely important for many insects and other invertebrates, the focus of this campaign is on not being too tidy. You don't need to leave all the leaves—the point isn't to smother your lawn—but just keeping some in a pile at the back of a flower border or along the base of a hedge will provide valuable shelter for all manner of small critters. Red-banded hairstreaks lay their eggs on fallen oak leaves; luna moth caterpillars seek out leaves in which to shelter as cocoons; bumble bee queens might tuck themselves into the litter to overwinter. All in all, a garden in which you leave the leaves is a better place for insects.



STAFF PROFILE

Emily Krafft, Grants Associate

What got you interested in insects? Honestly, I didn't think much about insects between leaving elementary school and arriving at the Xerces Society. Since I began working here, I have learned about so many fascinating creatures that I wasn't even aware of.

What made you want to work here? I had worked for several years at environmental organizations promoting solar energy and the reuse of building materials, and was looking for a new opportunity. I knew that I wanted to keep working for the environment, and that I wanted to be at an organization with a mission that resonated with me. When I saw a job ad for the Xerces Society and learned that there was an organization dedicated to invertebrate conservation based right here in Portland, I was intrigued.

What's the best thing about your job? As a grant writer, I get to tell the story of how the work of our staff and volunteers relates to critical issues such as sustainable agriculture, clean water, climate resilience, and the protection of endangered species. I am constantly learning from my coworkers about what they are finding in the field and what strategies they believe will make the greatest difference. Doing this work gives me a great bird's-eye view of the organization, which I find extremely valuable from both a fundraising and nonprofit-management perspective, and as an environmentalist seeking effective ways to make change.



Who's in your family? My partner, Randy, who is an incredible carpenter and craftsman.

Who is (or was) your environmental hero? At this critical time, when we are staring into the face of the climate crisis, I see heroes emerging everywhere. The youth on the front lines, in the streets, and in government offices showing us what is possible, are my heroes. I am indebted to the water protectors and indigenous leaders who continue to defend the land, the water, and our future.

What book are you currently reading? Naomi Klein's new book, *On Fire: The Burning Case for the Green New Deal*. I am a big fan of her work and the way in which she connects the dots between climate change and economic, racial, and social justice.

Conserving the Jewels of the Night

If you were in the midwestern or eastern United States or Canada this summer, you may have noticed that it was a particularly good year for fireflies. Likely spurred by mild and wet conditions—both of which can favor firefly development and increase the abundance of such prey as snails and earthworms—this population boom masks the insect's apparent downward trend. While long-term monitoring studies in North America are sparse, a growing number of anecdotal reports, backed by expert opinion, indicate that many fireflies are indeed declining.

This is why we have launched a new campaign, Conserving the Jewels of the Night, to advance our understanding of firefly distributions, life histories, and extinction risks; identify and address threats to their populations; and recover those that have declined. Key components of this effort are compiling a species-occurrence database for the United States and Canada; assessing the conservation status of fireflies; protecting and restoring known firefly habitats; and conducting research to fill the gaps in our knowledge of their diverse life histories, population trends, and responses to threats.

We are also stepping up our outreach effort to engage land managers, farmers, staff at city and county parks, and the public at large to educate them on the importance of conserving fireflies and their habitats and to engage them in conservation action. To help

people incorporate firefly-friendly practices into gardens, parks, and other places, we published *Conserving the Jewels of the Night: Guidelines for Protecting Fireflies in the United States and Canada*.

One of our key partners in developing the guidelines and launching this campaign has been Dr. Sara Lewis, a firefly researcher based at Tufts University, and co-chair of the International Union for Conservation of Nature Firefly Specialist Group and its North American subgroup. We also thank other members of the North American subgroup who have shared knowledge, resources, and feedback with us, as well as participants in the Fireflyers International Network.



The magical light of fireflies is at risk of disappearing from the modern world. Photograph by Radim Schreiber.

Protecting Monarchs and Pollinators in the Face of Climate Change

The western monarch population has plummeted from more than four million in the 1980s to fewer than thirty thousand last winter. A critical step in recovering monarchs in western North America is restoring quality habitat, particularly where western monarchs breed and overwinter in California.

Monarch and Pollinator Habitat Kits are a new Xerces' approach to restoring climate-smart habitat in California. Each kit contains sixteen hundred drought-tolerant native plants valuable for monarchs and other pollinators. Developed with longtime partner Hedgerow Farms, the kits will help to increase pollinator habitat and connectivity, an important part of our strategy for increasing pollinators' climate resilience.

Thanks to grant funds from the Wildlife Conservation Society, Xerces provided thirty kits to restoration partners, primarily in agricultural lands and natural areas across California. Agencies and community organizations were invited to apply to receive one of the kits.

We had more than thirty applications, necessitating some difficult decisions. Reading the applications was fun, and it was inspiring to see the great work being done. The Napa County Resource Conservation District, for example, will join with local high-school students to plant their kit at a demonstration vineyard, where the students will also host a bilingual community event about monarch conservation. The thirty projects will combine to create more than a hundred acres of climate-smart pollinator habitat.

The kits were delivered in October, and next spring the recipients will submit reports detailing what they did and how well it worked. Tapping into the amazing expertise and enthusiasm that already exists in conservation districts, state and federal agencies, and community conservation groups, these kits are a great way to multiply restoration efforts. We hope to repeat this project in California next year, and to extend it to other parts of the United States.

Highlights from our Pollinator Conservation Work

The Xerces Society has the largest pollinator conservation program in the world. We work with farmers, gardeners, land managers, agency staff, and others to create habitat for bees, butterflies, and beneficial insects. With staff based in more than a dozen states and offering a diverse array of expertise, we are able to provide support and expert guidance to scores of habitat projects and participate in many events. Here are some examples of our work from recent months.

RaeAnn Powers, Farm Bill pollina-

tor conservation planner in Nebraska, partnered with the state's Game and Parks Commission and others to host a pollinator habitat establishment and management workshop at Ponca State Park in northeast Nebraska. Approximately ninety conservation professionals gathered to learn from each other's experiences with establishing and maintaining pollinator habitat. Although most attendees were from within the state, people came from as far away as South Dakota and Iowa.



Southern dogface (*Zerene cesonia*), photographed by Bryan E. Reynolds.

Tax-Wise Giving

At the end of each year, we look to you, our loyal and generous donors, to provide us the foundation to continue this essential work forward into next year. For those of you looking to make a tax-wise gift with a significant impact, we want to share with you a few giving tips:

- ◆ Gifts of appreciated securities or publicly traded stock that have increased in value and that you have owned for more than one year may provide greater tax benefits than giving cash.
- ◆ If you are seventy and a half years of age or older, you may give through your individual retirement account (IRA) to take advantage of tax savings. The maximum total amount of qualified charitable distributions is \$100,000 per person each year without incurring income tax on your withdrawal.

Before making a charitable donation, please reach out to your personal tax or legal advisor for advice about your situation, and on how to properly execute a gift. Gifts should be initiated well in advance of the end of the year to ensure that they fall within the intended tax year.

The Xerces Society does not render tax or legal advice. If you would like to notify us of a gift you have planned or need our brokerage account information to complete a stock transfer, please email us at membership@xerces.org.

Thank you for your support!

Also based in Nebraska, senior pollinator conservation specialist Jennifer Hopwood does work that takes her far afield, especially when collaborating with agencies that manage roadsides. In early summer Jennifer traveled to

Colorado to deliver day-long pollinator conservation short courses to staff at the state's Department of Transportation. These workshops covered pollinator ecology; the importance of roadside habitat for pollinators; management, de-

sign, and planning of pollinator-friendly roadsides; vegetation establishment; and public outreach. They represented a personal milestone for Jennifer: She has presented fifty short courses in her decade at Xerces. From Vermont to Nevada, she has addressed farmers, ranchers, staff at the USDA Natural Resources Conservation Service, extension agents, land managers, gardeners, restoration practitioners, and department of transportation personnel, among others.

Sarah Foltz Jordan, senior pollinator conservation specialist and habitat restoration specialist, spent much of her summer focused on “beetle banks”—long linear strips of native plants integrated into crop fields to provide shelter for predatory ground beetles and other insects that support natural pest control on farms. Historically more com-

mon in Great Britain, this practice has been gaining momentum in the United States’ upper Midwest region. Beetle banks were installed on five Iowa farms, supported by a Conservation Innovation Grant from the Iowa Natural Resources Conservation Service.

Nancy Lee Adamson, our senior pollinator conservation specialist based in North Carolina, led a workshop for Tricycle Urban Agriculture in Richmond, Virginia. Partnering with the NRCS, this is the third year Nancy has presented workshops as part of Tricycle’s yearlong fellowship program providing in-depth training and hands-on experience at two urban farms. The workshops also highlight the value of providing habitat for other agriculturally beneficial insects—predatory and parasitoid species that are natural enemies of crop pests.



A “beetle bank” that will provide shelter for ground beetles and other predators of pests in the adjacent crops is created by planting bunch grasses and wildflowers along a low mound. Photograph courtesy Iowa Valley RC&D.



Crotch's bumble bee (*Bombus crotchii*) is one of four species that in California recently moved one step closer to protection. Photograph by the Xerces Society / Stephanie McKnight.

Protecting Bumble Bees in California

In June, the California Fish and Game Commission voted to grant four bumble bees “candidate species” status under the California Endangered Species Act (CESA). The four species—the Western bumble bee, Suckley’s cuckoo bumble bee, Franklin’s bumble bee, and Crotch’s bumble bee—are highly imperiled, having experienced significant population and range declines in the state. The Commission’s decision was in response to a petition by the Xerces Society and our conservation partners Defenders of Wildlife and Center for Food Safety.

There will now be a twelve-month period during which staff of the California Department of Fish and Wildlife will conduct a status review, gathering data and public comment that will lead to a final recommendation. Candidate status under CESA brings immediate protections from activities that could cause the species to go extinct during the re-

view period. Protection by the state of California will give these pollinators a chance.

Efforts are underway to restore habitat for bees on farms and in cities throughout California. Many farmers are already playing a leading role in restoring habitat for pollinators; the Xerces Society is working collaboratively with agricultural operations across the state to successfully produce food and protect vital pollinator resources, and there is further opportunity to expand these partnerships.

Xerces has a long history of conservation in California. We aim to conserve diverse pollinator communities, which are necessary for the long-term sustainability of California’s agriculture. It is vital that we take action now to address declines in insect abundance and diversity—including saving these four species from going extinct.

Bee City USA Begins a New Chapter

Bee City USA was the brainchild of Phyllis Stiles, who in 2011 came up with a great concept for how cities could contribute to reversing pollinator declines. Her dream began to be realized when Asheville, North Carolina, was certified as the first Bee City in 2012. Augmented by the addition of Bee Campus USA in 2015, Bee City has grown into a nationwide network of nearly two hundred affiliates and is the gold standard for pollinator conservation in cities, towns, and colleges across the United States.

Bee City USA was a labor of love for Phyllis, who built the organization with a few volunteers and no funding. In 2017, she approached Xerces to talk about joining forces, an obvious step since our staff had been providing guidance since the early days. In June 2018, Xerces officially adopted Bee City USA

and Bee Campus USA, and Phyllis joined our staff to ensure a smooth transition.

Phyllis is now moving on to a well-deserved retirement. As she steps away from Bee City, she notes that “pollinator champions who volunteer their time and amazing talents to recruit their friends and neighbors into the pollinator conservation cause have always been my inspiration.”

Although Phyllis will be sorely missed, we are pleased to announce that we have hired Molly Martin to continue the work of growing and supporting the network of Bee City affiliates. Molly has a background in studying native bees and teaching science, and, like Phyllis, a passion for engaging people in conserving pollinators. Our goal is for Phyllis’s vision to live on as we take the next steps with this incredible program.

WINGS, Fall 2019

Volume 42, Number 2

Wings is published twice a year by the Xerces Society, an international, non-profit organization dedicated to protecting the diversity of life through the conservation of invertebrates and their habitat. A Xerces Society membership costs \$35 per year (tax-deductible) and includes a subscription to *Wings*; the magazine can also be downloaded from our website as a PDF.

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For information about membership and to learn about our conservation programs for native pollinators, endangered species, and aquatic invertebrates, as well as our efforts to reduce the impacts of pesticides, contact us:

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Flies in the family Tabanidae—known as horse flies or deer flies—frequently have distinctively colored or patterned eyes. Photograph by Bryan E. Reynolds.

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On the cover: The health of our environment and the security of our food supply are reliant on there being a diversity of insects to pollinate flowers, control pest species, dispose of decaying material, and provide numerous other ecosystem services. Research from around the world shows that these essential animals are declining, sometimes at an alarming rate. Photographs by Bryan E. Reynolds.