WINGS

ESSAYS ON INVERTEBRATE CONSERVATION

THE XERCES SOCIETY SPRING 2026

CONTENTS

We all have times when it is nice to turn our attention to positive stories. We hope you find the articles in this issue of *Wings* as uplifting as we do: discovering otherworldly sea slugs in tidepools; ways that you can help wildlife in your neighborhood; and eye-opening research into Monarch butterflies at overwintering sites. Enjoy.

Let's Help Nature Solve The Looming Crisis of Climate and Biodiversity

Scott Black

Natural climate solutions are something that I frequently discuss in my talks and writings. Simply put, taking care of nature helps address climate change, and helps wildlife and humans adapt to changing conditions. Natural climate solutions involve conserving, restoring, or better managing ecosystems, both natural ones as well as modified landscapes such as farms, parks, and yards. The vegetation in these systems removes carbon dioxide from the atmosphere and improves environmental resilience, helping plants, wildlife, and humans.

The amount of carbon that natural climate solutions capture can have a significant impact. A study by Bronson Griscom and collaborators, published in *Proceedings of the National Academy of Sciences*, found natural climate solutions could contribute about twenty percent of the mitigation needed by 2050 to keep global warming below 2°C (3.6°F). They are also cost-effective compared with hard infrastructure approaches for managing climate risk, such as raising flood walls or elevating roads.

Although Xerces focuses on invertebrate conservation, much of our work revolves around habitats. Together, plants and insects form the fabric of the planet. If we want to maintain biodiversity and mitigate climate change, we need to maintain and expand areas that support plant communities—our "green infrastructure." Native plants are important here but it is the combination of plants and insects that is key: plant diversity

Pollinator gardens are one of many natural climate solutions that can bring resilience and beauty to our communities. Photograph by Angela Laws.

supports a diversity of insects, which in turn supports a diversity of other wildlife. Insect diversity is needed to maintain ecosystem functions (and plant communities) over time. Retaining more insect species will buffer against losses, as some species will fare better in the changing climate. This biodiversity cushions the impacts of climate change by providing an array of microclimates that serve as important refugia for insects during heatwaves and other extreme weather events.

But how do natural climate solutions work?

Freshwater mussels can live as long as humans, bringing long-term stability to aquatic ecosystems. Clusters of mussels, known as "beds," bring structural complexity to river bottoms, providing homes for a variety of other aquatic invertebrates while filtering water as they feed. These mussel beds act as carbon sinks by removing massive amounts of algae and organic matter from the water and depositing carbon into sediments, while the mussels' shells directly lock away carbon—for decades. Our work has led to major changes in how mussels in the western United States are conserved. In just a few years, Xerces has rescued or relocated more than 77,500 freshwater mussels in collaborations with nonprofits, tribes, and federal and state agencies.

Hedgerows have long been used as a conservation practice for dust reduction and as windbreaks, but they also provide food, nesting opportunities, and shelter for pollinators, birds, small mammals, reptiles, and amphibians. With a combination of shrubs and herbaceous plants, hedgerows pack a lot of habitat value into a small space. Although most often used on farms, they also can provide habitat in the built environment, even under power lines where trees might be too tall. Hedgerows capture lots of carbon and provide resilient, long-term habitat for many animals. Working with partners, Xerces conservationists have been responsible for the creation of mile upon mile of hedgerows, and have developed planting methods now adopted by many individuals and organizations.

Sometimes, indirect approaches are the best way to support invertebrates. Beavers are renowned environmental engineers. Their dams create wetlands that store water, mitigate floods and droughts, filter pollution, capture carbon, and act as firebreaks, boosting ecosystem resilience against climate change impacts like extreme weather and wildfires—a very natural climate solution. By slowing creeks, beaver ponds recharge groundwater, leading to lush areas that support many aquatic and terrestrial invertebrates, including pollinators. Last year, Xerces was part of a coalition that successfully advocated for Oregon's Beaver and Water Quality Bill (HB 3932), which greatly increases protection for beavers on the state's public lands.

To successfully address the climate and biodiversity crisis, we must protect and carefully manage our natural spaces and conserve both terrestrial and aquatic habitats. We must also move away from pesticides. Their production is a significant source of greenhouse gases, and their use impacts the effectiveness of natural climate solutions. It is important to remember that anyone can help: protect and grow native plants and don't use pesticides—and you can be part of the solution. Get started by visiting our Bring Back the Pollinators web page.

Tidepooling for Dragons

Candace Fallon

It is five o'clock in the morning when I unzip my tent and peer out into the pale July darkness. Not quite sunrise. The Pacific Ocean is out there somewhere, a distant roar. I see a light in another tent nearby, and a moment later hear its zippered door unfurling. A head pops out and turns in my direction. I grin and wave. My friend Kelly is up.

I gather my things and clamber out onto the cool sand. Kelly and I tinker for a few minutes, making coffee and tea, then take our mugs and head out toward a clump of rugged sea stacks, rock pillars detached from the shore by wave erosion. The sky brightens. Ostracods and beach fleas flip and scurry ahead of our feet. A salty mist swirls low, infused with a soft pink glow, and I realize I can't differentiate the sea from the sky—the entire landscape is a canvas of light.

To our right: the vast ocean. To our left: a thick coastal forest of spruce and hemlock interwoven with salal and salmonberry. We're on Shi Shi Beach, on the northwest edge of the Olympic Peninsula in Washington state. Ahead of us rises Point of Arches, a congregation of more than thirty sculpted rocks and sea arches tumbling into the sea from a forested headland. When we reach them, we thrill at the sight of so much exposed rock. The tide is far out—the lowest it will be all year—and we are here for one

The receding tide exposes tidepools in the shadow of sea stacks off Shi Shi Beach on Washington state's Olympic Peninsula. Photograph by Candace Fallon.

of our favorite pastimes—tidepooling.

Already we can see purple and orange Ochre Stars clinging to the rocks, brilliant against the dark background. Small pools beckon with Mossy Chitons and jewel-like Lined Chitons, Giant Green Anemones, and darting Sculpins. Kelly spots a Kelp Crab, clasping a shimmering purple slab of algae like a shield, and moments later I come across an enormous Gumboot Chiton, its body brick red and lumbering. Later I will read in one of my field guides that this creature is also known as the Wandering Meatloaf. All of these sightings produce a quiet thrill, but we're looking for one group of animals in particular: sea slugs, otherwise known as nudibranchs.

Nudibranchs are marine mollusks, related to mussels, clams, and snails. They are characterized by their soft bodies, lack of external shell (at least as adults), and external gills (the word nudibranch means "naked gills"). Almost all nudibranchs possess rasping tongues, "radulae," with which to scrape up their meals, as well as a fleshy foot that enables them to move about.

Each nudibranch carries both male and female reproductive organs. Most species have a pair of sensory organs on their heads called "rhinophores," that can be stalked or sheathed, and that help them detect chemicals in the water and may be used to find mates or prey. This is essentially how nudibranchs "smell." All nudibranchs have two eye spots on their head that are light sensitive but do not form images. Often these eyes are obscured by body pigment, so they can be difficult for us to see.

Other key features include naked gills (retractable, frilly tissues on the back end of the nudibranch), cerata and papillae (finger- or hair-like protuberances), and tubercles (short rounded bumps on the body's surface). Some species have additional tentacles (such as a pair of oral tentacles) or other appendages that can further aid in identification.

The ribbons, coils, and sacs of eggs laid by nudibranchs are unique to each

The name nudibranch means "naked gills." The gills on this Nanaimo Dorid are visible as a frilly rosette on its back. Other features include a pair of stalked sensory organs on its head. Photograph by Candace Fallon.

A Northern Leopard Dorid is exposed by the low tide next to a coiled ribbon of eggs. Photograph by Candace Fallon.

species and can be used to help with identification. Tiny larvae, each with its own miniscule shell, hatch from the eggs and float freely through the ocean for a few weeks before dropping their shells and metamorphosing into their adult stage. Adults are short-lived, surviving just a few weeks to at most a year.

Nudibranchs are found in a vast array of habitats and oceanic zones all around the world, ranging from tropical waters to freezing seas near the poles. Just last year scientists described a new species found in the ocean's pitch-black midnight zone off the coasts of California and Oregon—the first deep-sea nudibranch! The researchers' photographs show ethereal creatures with translucent bodies and large gelatinous hoods. In one image, the nudibranch is bioluminescent, its body pricked with stars.

More than 150 species can be found off the Pacific Northwest coastline, and although it's exciting to learn about species in deeper waters, most of my nudibranch encounters have been in the intertidal zone, that liminal space between high and low tide. On a superminus tide like the one we have come to Shi Shi Beach for, a whole world that is usually underwater reveals itself.

As the tide continues to recede, Kelly and I venture further out, circling towers of barnacles and mussels—the masses of them slurping and slithering—and peering into pools. Oyster catchers scream overhead. The air is pungent with brine and drying algae.

For a moment I am distracted by an emerald mat of eelgrass—I'm hoping to find some brilliant green isopods—but then I hear Kelly call out. "Candace! Dragons!" I scurry over to see an Opalescent Nudibranch, undulating across a shallow pool. With its translucent white body studded with wavy appendages of orange and electric blue, this nudibranch looks every bit like a miniature dragon. We crouch and watch it in admiration.

Giddy with our first sightings of the day, we get more serious about our

The White-lined Dirona is fairly large for a nudibranch. Typically around two inches (five centimeters) in length, it can be more than six inches (fifteen centimeters) long. Photograph by Candace Fallon.

quest. Every nook and cranny is inspected. While Opalescent Nudibranchs can be found swimming freely, many other species tend to stick to the rocks, sand, or eelgrass found in these habitats. Soon I am rewarded with a new species—a White-lined Dirona, shimmering in a dark crevice. On another rock, a bright patch of scarlet crusting sponge catches my eye and I lean in close, intent on finding a Red Sponge Dorid. Like many species, this nudibranch is a specialist, found in close association with its prey (in this case, red sponges), even going so far as to resemble its prey in order to hide from its own predators. After several minutes I spot a couple of tiny tomato-red blobs that I'm convinced must be nudibranchs. I have to take photographs of these in order to be sure; they are barely half an inch (a centimeter and a quarter) in length, and it isn't until I zoom in on the images that I can confirm the presence of rhinophores and eye spots.

Finding and identifying nudibranchs often means gathering a number of clues, including their physical features, the habitats in which they are found, and, in cases like these, their prey. Nudibranchs are predators, feeding on a wide range of animals, including anemones, barnacles, corals, hydroids, bryozoans, sponges, sea pens, and sometimes even other nudibranchs. But they're not the only ones looking for food. Because nudibranchs are soft-bodied and shell-less, they have evolved a number of ways to evade their own predators (mainly fish, crabs, and turtles). One of these is camouflage, which can make it not only difficult for predators to find them but hard for us as well.

Some nudibranchs are also tiny, measuring one inch (two and a half centimeters) in length or less. Most are in the one- to six-inch (two-and-a-half- to fifteen-centimeter) range, but some, like the Orange-peel Nudibranch, can reach lengths up to twelve inches (thirty centimeters).

Of course, being small or blending in isn't the only way nudibranchs stay safe. Other popular strategies they use include bright warning coloration ("Hey, I'm toxic!") and distinctive odors that repel predators. Nudibranchs can even steal stinging cells or toxins from their prey and sequester them for use against their own predators.

Unfortunately, predators are not the only threats to nudibranchs. Water degradation, climate change, and overfishing can all impact their populations. In the Pacific Northwest, nudibranch pop-

ulations face marine heatwaves, increasingly unpredictable low tides, and other factors, such as ocean acidification and invasive species, that can impact the availability of prey.

Like so many other invertebrates that we study at Xerces, nudibranchs are important bioindicators of ecosystem health. Because of their sensitivity to water quality and changes in temperature, they serve as early warning systems for environmental shifts caused by climate change or pollution. They are also attractive champions for marine stewardship and conservation: their outlandish colors, mesmerizing shapes, and intriguing behaviors are sought by photographers, divers, and tidepoolers alike. In recent years, nudibranchs have enjoyed growing popularity, with entire social media accounts dedicated to their habits and ecology—and I've noticed a surge in nudibranch-focused field outings, dock fouling clubs (groups that explore what lives on docks), and bioblitzes (intense, short-term surveys in which participants collaborate to identify as many species as possible within a specific area).

Yet despite their popularity and growing threats to their homes, there's a lot we don't know about nudibranchs, including their conservation status, population trends, and risk of extinction. Although they number more than three thousand species worldwide, only a single species has been assessed for the IUCN Red List of Threatened Species—the global inventory of extinction risk for the world's plants, fungi, and animals, and a powerful tool for prioritizing and catalyzing conservation action.

Conservation efforts such as coastal monitoring and community-science tidepool surveys can help us learn more about nudibranch populations and the status of their marine habitats, and some of these programs have been in place for decades. More recently, iNaturalist has led the way in shedding light on species distributions around the globe. Even so, more research on nudibranchs and their vulnerability to such threats as ocean warming and water

Red Sponge Dorids are often hard to spot. Their color camouflages them when feeding on red sponges that may form crusts across the surface of a rock. Photograph by Candace Fallon.

This Janna's Dorid was the final discovery of a tide-pooling expedition that netted eleven species of nudibranchs. Photograph by Candace Fallon.

pollution would help us better understand what species are most at risk and how we can best protect them.

Back at Shi Shi, I notice that the water is starting to rise. I've been so engrossed in my search that I've failed to register that the tide is coming back in. I backtrack a bit, heading for higher ground, and hope for one last sighting. We're up to ten or so species for the morning, including a few I've never seen before, and I feel buzzy with excitement. I have my head craned under a rock overhang, admiring a tiny Six-rayed Star, when I hear Kelly calling for me. She has another nudibranch, a mystery. I make my way over to her, following the point of her finger, and I see it: a tiny yellow orb, no bigger than my pinkie nail, covered with nubby protrusions. I take a couple of photographs and examine the pink and cream sponge it's clinging to. A new species for us both.

Back home after the trip, I have time to go through all my photographs and post my own intertidal observations to iNaturalist. We tally eleven nudibranch species for this particular day—a personal high. Now, looking back at this list, the names have me longing for long summer days on the coast: Chocolate Aeolid, Northern Leopard Dorid, Horned Nudibranch, Modest Clown Dorid, White-and-orange-tipped Nudibranch, Red Sponge Dorid. The little yellow nudibranch we found at day's end turns out to be Janna's Dorid, found up and down the West Coast.

With only a few minus tides each year, thousands of miles of Pacific Northwest coastline, and well over a hundred species I've yet to see, I'm already plotting out my next sea slug adventures. High on the wish list this year: the Hammerhead Doto and the Shaggy Mouse Nudibranch.

Candace Fallon is a senior conservation biologist with the Xerces Society, where she works to study and protect at-risk invertebrates and their habitats. Although her main focus is currently fireflies, her interests extend much further.

Help Bring Back the Pollinators

Aaron Anderson

When I was in graduate school we lived in an apartment in a subdivided Victorian house. Our front porch was in the building's backyard, which, when my wife and I moved in, consisted of nothing but grass and tree-of-heaven saplings. We removed chunks of turf and planted small pollinator plants from the soil and water conservation district: rose checkermallow, yarrow, and Douglas aster. We threw handfuls of annual seed down, while leaving some bare soil near the house for ground-nesting bees.

It was almost like magic—in just a season, what had previously been a green desert with little to support pollinators became a colorful quilt of flowers buzzing with life. Queen bumble bees visited early-season poppy blooms, and leafcutter bees snipped discs from petals of farewell to spring. Creating habitat for a diversity of native pollinators can be this easy: plant some native flowers, add shelter and nesting spots, and don't use pesticides.

If you are a regular reader of *Wings*, it likely comes as no surprise to you that many pollinators and other insect species are imperiled. Just this past year, a study in which Xerces scientists participated revealed a 22 percent decrease in butterfly abundance in the lower forty-eight states over the first two decades of this century, and we know that populations of other pollinators are at risk across the continent. It has never been more pressing to take action to protect these important creatures.

While pollinator conservation feels like a huge issue to solve overall,

Pollinator gardens provide pleasure through the beauty of both flowers and insects. Eastern Tiger Swallowtail on redbud, photographed by Bryan E. Reynolds.

it's surprisingly easy for individuals to make a real difference at home. More than thirty-six hundred different bee species are native to the United States alone, and many of them, including sensitive and rare species, will happily use yards as habitat. When you are just a fraction of an inch long, it's easy to thrive in these small spaces—if conditions are right.

Xerces' Bring Back the Pollinators campaign provides guidance on how to conserve bees, butterflies, and other pollinators in backyards, parks, community gardens, or anywhere that pollinator habitat can be created. This initiative is built around four principles: 1) grow pollinator-friendly flowers; 2) provide nesting sites and other shelter; 3) avoid pesticides; and 4) spread the word. The campaign is paired with the Pollinator Protection Pledge, through which people can make a commitment to help pollinators. So far, some twenty thousand people have signed the pledge, creating a network of small-scale habitats that helps bring color and life into neighborhoods everywhere.

This spring we have refreshed and relaunched Bring Back the Pollinators with one goal: getting everyone involved with pollinator conservation in their own neighborhood or hometown. Planted with native plants and protected from pesticides, we hope to see yards, community gardens, and parks come alive with butterflies, bees, and other pollinators—which in turn means better conditions for fireflies, frogs, birds, and other wildlife. Eighty percent of the United States' human population lives in towns and cities, and 70 percent of the country's 133 million households are single-family units. This means mil-

The graphic look of the Bring Back the Pollinators campaign was created by Maya Hutagalung and Madison Sankovitz while they were illustration interns at the Xerces Society.

Leafcutter bees require nectar and pollen, but also need hollow stems in which to nest. Photograph by Bryan E. Reynolds.

lions of backyards; if even a fraction of them can be changed, we can transform our landscapes! While BBTP is geared towards home and community gardeners, anyone who has space, from an apartment deck to rural acreage, can contribute to this change.

Flowering plants are the foundation of good habitat. Pollinators rely on pollen and nectar for food, and research has shown that gardens with a greater abundance and diversity of plants provide better conditions for native bees and butterflies. Different pollinator species are active at different times of year—some for only a few short weeks—so it's advisable to plant a variety of flowers for continual season-long bloom. You don't want a bee to emerge in your yard and find nothing to eat!

Native plants are recommended as they better support our native pollinators, which is particularly true for caterpillars needing host plants to eat. In landscaping around your home or business, though, there is room for non-native plants as long as they provide such useful resources as pollen and nectar. Xerces has materials on flower selection, including plant lists for each region with options for different site conditions and pollinator types. You'll also find our books *100 Plants to Feed the Bees*, *100 Plants to Feed the Monarch*, *Gardening for Butterflies*, and *Attracting Native Pollinators* at your local library or bookstore.

In addition to food, pollinators need places to shelter and lay eggs. For bees, a place to lay eggs means constructing a nest—and that does not mean making honeycomb. Bees do make brood cells, and bumble bees do use wax to do that, but none of the species native to the United States and Canada make honeycomb; only Honey Bees, which are not native, do that.

The huge majority of bees are solitary, with a single female making her own nest. Roughly 70 percent of species nest in the ground, digging narrow tunnels in the soil, with brood cells constructed in a cluster at the end of the

Butterflies need secure places for their chrysalises as well as nectar flowers and caterpillar host plants. Photograph by Bryan E. Reynolds.

tunnel or off to its sides. It's into these brood cells that the bees deposit the nectar and pollen they collect from flowers to feed their offspring. Research has found that the proportion of ground-nesting bees is often lower in towns and cities, likely because they lack places to nest. All those roads, parking lots, driveways, and sidewalks, and even areas of turfgrass, reduce the amount of exposed soil. You can support ground-nesting bees by leaving patches of bare soil in your garden.

The other 30 percent of bees create nests in cavities above ground. Where they nest varies among species, but typically they occupy pre-existing holes such as hollow plant stems or borer beetle tunnels in dead trees and snags, in which they make a series of brood cells along the tunnel. With so many species, there are a few that buck the trend. Carpenter bees will make their own holes by chewing into an agave stem or other soft wood. Other species prefer to nest in such seemingly odd places as empty snail shells, and will happily occupy human-created spaces including uncovered faucets, little-used hosepipes, and holes in patio furniture.

And then there are bumble bees, which are unusual in many ways. They are social and live in an annual colony; only new queens hibernate, emerging early the following year to seek out a small cavity in which to start their own colony. Most species—there are around fifty in North America—occupy spaces such as abandoned chipmunk nests or other underground holes, but some will nest above ground beneath grasses or between rocks, or move into less-natural locations such as birdhouses or wall cavities. They are opportunists!

For butterflies and moths, laying eggs requires first finding appropriate host plants that their caterpillars can eat, and the plants they need vary from species to species. Some butterflies may be able to utilize a wide range of host plants; the Gray Hairstreak and Anise Swallowtail are two that may feed on dozens of plant species. The majority of butterflies, though, are more particular (like people, their kids are picky eaters). The best-known example is probably the Monarch and its reliance on milkweed.

Beyond nesting sites and host plants, shelter for times when the weather is bad or food resources are limited—which could be single rainstorms or lengthy periods such as winter, or, particularly in desert regions, the height of summer with excessive temperatures—is another important factor determining insect populations in a habitat. Our

ground- and tunnel-nesting bees will remain in the brood cell for a year, hence the importance of retaining plant stems and undisturbed areas of soil. Other pollinators rely on a range of places to hide—all those little nooks and crannies that can be found in between twigs and branches, under fallen leaves, in a gap between rocks, or sheltered by a structure. A pollinator garden should include as many such places as possible.

We encourage gardeners to "leave the leaves" in their habitat, which provides a protective and insulating layer for an incredible diversity of invertebrates, from overwintering bumble bee queens to butterflies and moths—and a diversity of other wildlife such as fireflies. A bonus? It's easy to do this "lazy gardening." You can simply leave leaves where they fall, or rake them into designated areas such as garden beds or around trees.

The third BBTP principle is to avoid pesticide use. Pesticides are a leading cause of insect declines, and one that is often overlooked. Our residential landscapes can have pesticide contamination at levels that are risky to pollinators. Research led by Xerces scientists has found multiple pesticides contaminating milkweed and other butterfly host plants growing in parks, gardens, roadsides, and elsewhere. In many cases, these host plants would be lethal to a caterpillar that eats them. The good news is that we can all help reverse this ubiquitous background pesticide contamination, and part of doing so involves no significant action on your part. Just by accepting some level of cosmetic damage to plants in your garden, you immediately reduce the reason why pesticides are often applied.

And for a pollinator gardener, such damage is a good sign because this

Installing a sign—homemade or purchased—is an effective way to let neighbors know that there is a reason why your garden looks different. Photograph by Matthew Shepherd.

means your yard is being used by pollinators, as well as a broad community of insects, birds, and other animals. Butterfly caterpillars need to munch on host plants, and leafcutter bees will cut discs out of petals and leaves for nesting material. Even the presence of plant eaters like aphids isn't bad—low levels support lady beetles, syrphid flies, or lacewings, "natural enemies" that do an incredible job of suppressing pest populations. The more diverse your habitat plantings are, the more diverse the community of these creatures will be. Most of the same plants that support pollinators also support natural enemies, so creating multifunctional habitat can be easy.

Research shows that individual sites such as yards and parks can truly make a difference, serving as oases for pollinators in urban and suburban landscapes. More than seventy species of bees were identified in gardens in urban areas of California's East Bay. In New York City, fifty-four species of bees and twenty-four species of butterflies were discovered in community gardens in East Harlem and the Bronx. A study of suburban yards in nearby Westchester County showed that the garden bee community strongly resembled that of a local nature preserve. Another study, across the Atlantic, found 58 percent of the United Kingdom's solitary bee genera in the yards of one town alone! If one site is good, many are better: the conservation value of individual sites is amplified if more people on a block, in a neighborhood, or across an entire community act to help wildlife. Our efforts scale up as more habitat is created and connected across the landscape.

This is why the fourth BBTP principle, spreading the word, is so important. Doing this can be as simple as chatting with friends and neighbors, or engaging with such local groups as neighborhood organizations or homeowners' associations. Consider putting a Xerces "pollinator habitat" or "pesticide-free" sign in your yard to spread the word to passers-by. You can find community through in-person gatherings or groups on social media, and you can contribute observations from your garden habitat to Bumble Bee Watch or iNaturalist.

Join with others on this journey by signing our Pollinator Protection Pledge and committing to these four principles. As part of the BBTP relaunch, pledge signers will receive a quarterly e-newsletter with tips and inspirational stories. We're also hosting quarterly Q&A sessions with Xerces staff, held online so that anyone can attend, ask questions, and learn. Our 2026 Xerces Webinar Series will be BBTP-themed, and every month we'll host a talk diving into the details of a different aspect of providing habitat for pollinators, from alternative pest management to gardening in small spaces. And you'll find this and more in episodes from our podcast, *Bug Banter.*

While reversing declines in pollinator populations is a big task, we can all play a role in helping these species, one space at a time. It is people who create change in their yards and in their communities that make a real difference. We'd be honored to have you join us!

Aaron Anderson is a pesticide program specialist on Xerces pesticide reduction team. He works to reduce pesticide use in residential landscapes, including promoting alternative pest-control measures and pollinator-friendly gardening practices.

Solar Panels and Eyelash Glue: Monarch Tagging Gets an Upgrade

Ashley Fisher and Emma Pelton

In the 1980s, millions of Monarch butterflies gathered each fall in forested groves along the California coast to shelter through the winter. This year, just over twelve thousand Monarchs were recorded, a more than 99 percent decline in the western population of these iconic butterflies.

A crucial part of recovering western Monarchs is to protect and restore the hundreds of overwintering sites, which, although small in comparison with the multi-state region across which Monarchs spread for breeding, are an essential element in their life cycle. If we do not protect overwintering sites there is little benefit from conserving breeding habitat, as the migration will be gone. Management and policy decisions for these sites would greatly benefit from a better understanding of how often, how far, and when Monarchs move. But trying to follow a butterfly, especially one that moves as fast as a Monarch, is very hard. If you've ever chased a butterfly, you likely have memories of watching it float effortlessly over bushes, trees, and buildings as you rushed inelegantly behind. Figuring out how to best track butterflies' movements has been a long-standing goal not only for overzealous kids, but also for professional biologists

New research offers insight into how western Monarchs move around overwintering groves on the California coast. Photograph by Michael Ready.

studying western migratory Monarchs, including our team here at Xerces.

For decades, tracking Monarch movement has been done using small stickers, known as tags, attached to the butterflies' wings. Each tag has a unique number. We would record the location where the sticker was applied, and if it was spotted again, we'd learn where the Monarch had traveled. This is a simple system, and one that has provided many years of migration data. Tag recoveries, though, rely on some other person somewhere along the butterfly's route spotting the tag, being able to read the number, and knowing how to report that discovery to the right researcher. Not surprisingly, only a small percentage of tagged Monarchs are ever reported, and, even when they are, the observations usually give you only starting and ending points. What they do not tell you is how the Monarch got between those two points—their route across the landscape, where they rested, the speed at which they flew. Recent advance-

The first step in tagging Monarchs is gathering them. A telescoping handle allows scientists to reach clusters on branches. Photograph by the Xerces Society / Emma Pelton.

Researchers set up a mobile lab, which allows them to affix the tags without harming the butterflies. Photograph by the Xerces Society / Ashley Fisher.

ments in radio telemetry technology, however, have made precise tracking of butterflies a reality. It's already changing what we know about Monarch butterflies' movement and migration.

Radio telemetry has been used since the 1960s to track wildlife. A radio transmitter—another kind of tag—was attached to the animal, and a handheld or stationary receiver (sometimes a large tower) was used to pick up emitted signals. Originally, this could be used only with large animals because of the size of the transmitters. Over time, those transmitting tags became smaller and lighter, which allowed biologists to track smaller animals. The largest established network of tracking towers is the Motus system, coordinated by the nonprofit Birds Canada, with hundreds of permanent antennae that map bird and bat migrations across the Americas. Even though golden-winged warblers weighing a third of an ounce (ten grams) have been tracked by this system, the tags were too large for an insect—until now.

Ultralight radio tags called Blū Morpho (with Blū+ capabilities) have revolutionized how scientists can track Monarchs (and may soon be used on other species). Developed by Cellular Tracking Technologies, the Blū+ transmitter uses a tiny solar panel instead of the battery that powered prior models. As a result, the tag weighs just seventy milligrams (less than three-thousandths of an ounce), equivalent to about two grains of rice, and has a lifespan longer than that of a Monarch.

A second advance is that the new tags transmit information on the Bluetooth frequency (2.4 GHz band) and consequently can be detected far more frequently, because they don't rely solely on receiver towers. The new frequency is the same as any Bluetooth-enabled smartphone, something that millions of us carry. In other words, if you're riding the bus or walking your dog and a tagged Monarch passes close by or is roosting in a tree overhead, you could contribute location data. Now there is potential to get hundreds or even thousands of detections per butterfly, giving

A Monarch warms itself in the morning sun after a tag has been attached to its back. Photograph by the Xerces Society / Ashley Fisher.

us a significantly more detailed picture of Monarch movement.

Xerces scientists recently used these new radio tags on a small number of Monarchs in California in order to better understand how they make use of overwintering habitat. For this, we partnered with Point Blue Conservation Science, California State Parks, County of Santa Cruz, and other local public-land managers to study Monarch butterfly movement during the 2025–26 overwintering season. We tagged Monarchs at three sites—Natural Bridges State Park, Lighthouse Field State Beach, and Moran Lake—in Santa Cruz, seventy miles down the Pacific Coast from San Francisco.

While these tiny tags are a feat of engineering, it feels like a little triumph to successfully attach one to a Monarch. A tag is placed on the butterfly's back between the base of its wings, allowing the small solar panel to be exposed to light when resting and flying. This placement also allows a Monarch to fly to visit flowers and migrate as well as to mate and lay eggs unimpeded. The secret ingredient to get a tag to stay is, believe it or not, eyelash glue! This turns out to be very effective at affixing the tag to the butterfly, and is one of the safest adhesives to use. The Monarch's wings are opened and covered with glassine envelopes to protect them as glue is gently applied to the butterfly's back; the tag is then placed and the glue allowed to dry.

To track the tagged butterflies, we installed a handful of receivers that listen 24/7 for tag "pings" at nearby overwintering sites to increase our chances of detecting when they arrive at and leave these known Monarch hotspots. We also used handheld tracking devices to expand the study area by surveying overwintering sites where we could not place permanent receivers. In addition, there is the crowdsourced data from smartphones in the area. If you have the Project Monarch app—developed by Cape May Point Arts and Science Center, it is available for free for both Apple iOs and Android-based mobile devices—you can follow tagged Monarchs in real time. The app also allows you to search for individual butterflies (each with

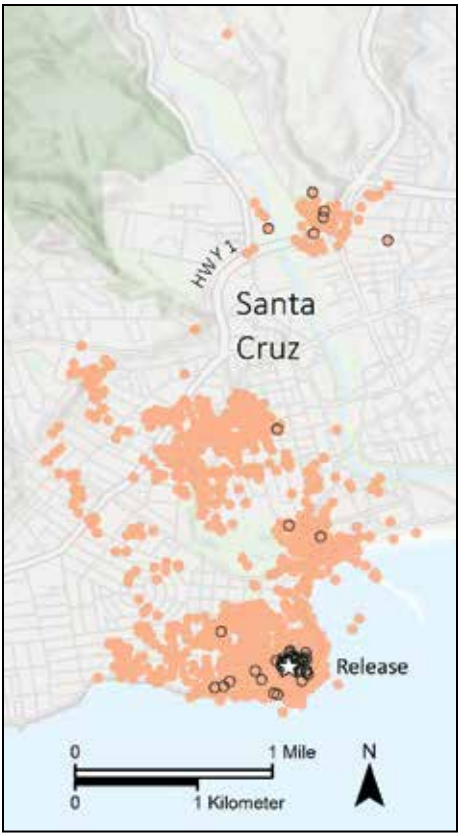
an identifying code or even a personal name) to see all the places where they have been detected, how long since the last detection, and more.

We actively tracked the Monarchs tagged in Santa Cruz through February (and they can continue to be tracked by others after they depart for breeding areas). With these data, we will be able to better understand the rates, extents, and timing of Monarch movements between overwintering sites during winter and early spring. The resulting dataset may also be used in the future to better describe the importance of habitat connectivity and to study how environmental conditions impact Monarch movement and what characteristics may influence site choice and fidelity.

As we learn how effective Blū+ tags may be as a way to track Monarchs, we are taking a cautious approach to this novel technique by closely assessing past research. We're working within a community of more than fifty researchers across the United States, Canada, Mexico, and Cuba who are using these tags and sharing knowledge and best practices, and we host regular meetings with collaborators and fellow researchers to coordinate our work. A major focus of our efforts is to determine the best tagging methods that minimize the potential impacts of tags on the survival and movement of Monarchs.

For example, the knowledge that eyelash glue is the best adhesive is thanks to Professor Leone Brown and master's student Helen St. John at James Madison University in Virginia, who have been working for two years to quantify the flight impacts of Blū+ tags on Monarchs. Their work included studying the toxicity and longevity of various adhesives to guide glue selection and application methods to avoid negatively affecting the butterflies.

With radio tagging being so new, not all of the impacts are known, but results so far are that tags do not appear to affect the lifespan, reproduction, or



Monarch LF043 was tagged at Lighthouse Field in Santa Cruz, and tracked for a month. The orange circles indicate the many places where it was detected, while the outlined circles show locations where the butterfly was first documented each day. Map by the Xerces Society / Lisa Merkhofer. (Sources: Esri, TomTom, Garmin, OpenStreetMap contributors, GIS User Community, FAO, FEMA, NASA, NGA, NOAA, and USGS.)

flight ability of Monarchs. In addition to our work in California, more than five hundred Blū+ tags were deployed this fall in Canada, the eastern United States, and Cuba. The number of radio-tagged Monarchs that made it to Mexican overwintering sites actually exceeded the predicted migration success rate of non-tagged Monarchs. We have also seen tagged Monarchs returning to the southern states.

Research in California is ongoing, but we have already accumulated thousands of detections from the Blū+ tags that are revealing important insights with real implications for conservation. We are learning how frequently some of the butterflies move between overwintering sites and across nearby towns. Several butterflies, including LF043 and LF006 (both tagged at Lighthouse Field), have been detected moving inland around a less-well-known overwintering site on the campus of the University of California, Santa Cruz, and in surrounding neighborhoods. One surprising discovery was that Monarch ML004 (tagged at Moran Lake) flew south more than a hundred miles in just two days!

These findings highlight the importance of smaller, lesser-known sites as part of the overwintering Monarchs' habitat, and have the potential to improve the conservation and management of Monarchs during a particularly vulnerable part of their annual cycle. Further analysis may help us identify where to prioritize conservation of western Monarch habitat, as well as provide us with a more accurate picture of their home range. In addition, thanks to high rates of tag retention, we also are able to document routes taken as dispersal to breeding habitat begins in the spring. For example, LF048 has been tracked for more than two hundred miles to a point north of Redding, at the top end of the Central Valley.

Advancing tagging technology may have opened a new window into how Monarchs move around, but it does not do away with the urgency for conservation of Monarchs wherever they travel. The overwintering sites need protection and management, but anyone who lives within the migration range of the western Monarch can help this butterfly. If you have space, grow locally native milkweeds to feed the caterpillars and nectar plants to fuel the adults—and keep them free of pesticides.

Load the Project Monarch app onto your phone to watch the movement of tagged individuals, or report sightings of any Monarch or milkweed on iNaturalist. Tell friends and neighbors about the importance of helping Monarchs in their own gardens, and urge your city council to create habitat in parks and other public spaces. Our lives are connected by the journey of Monarchs in their annual cycle away from overwintering sites and back, and their future is connected to us through the actions we take.

Ashley Fisher is a conservation biologist for Xerces, specializing in Monarch biology. She helps facilitate research projects and works with partners in California to manage and restore overwintering sites.

As the Xerces Society's western Monarch lead, Emma Pelton works to protect the western population of Monarch butterflies, including managing overwintering habitat in California and breeding habitat throughout the western United States.

STAFF PROFILE

Aaron Anderson, Pesticide Program Specialist

What got you interested in invertebrates? My love of being outdoors and in nature started when I was a kid. That led me to study ecology, but I wasn't necessarily a bug nerd. I fell into the insect world after getting a summer job in an entomology lab as an undergrad. I quickly learned how cool insects are, and kept finding my way back to working with them.

How did you hear of the Xerces Society? I heard of the Xerces Society at some point when I was in college. Doing a little digging, it looks like I cited a 2005 Xerces publication in a term paper, so I must have known of it then. I do remember the first time I visited the Xerces website, and thinking, "What an awesome organization this is!"

What made you want to work here? What drew me to working for Xerces is our focus on invertebrates and the fact that we work in all sorts of areas. We do research, technical support, outreach, and more. Sometime around 2015, I was reading an edition of *Wings* that had articles on roadside pollinator plantings, and I was impressed with how the organization integrates science with on-the-ground pollinator conservation. At the time, I had become interested in conservation in urban and suburban landscapes, so this type of work stuck out to me.

What do you do to relax? Spending time with my wife, Maura, and our two cats. Outdoors, I love all types of cycling and do plenty of cyclocross racing in the fall. Getting out to the coast or mountains for a hike is always fun, no matter the season. Indoors, I like to read, and I'm trying to re-learn how to play the viola after a hiatus of many years.

What music do you enjoy listening to? I like all sorts of music, but have been returning to Bob Dylan's *Nashville Skyline* album a lot recently. Watchhouse is a favorite band that's always in my listening rotation, and I have also been listening to Stravinsky's *The Rite of Spring*. Kind of a mixed bag right now.

Where did you receive your education? I attended Cornell University for undergrad. I did my PhD in Dr. Gail Langellotto's Garden Ecology Lab at Oregon State University. I can't say enough about Gail as both a teacher and a scientist!

Cincinnati Zoo & Botanical Garden

Founded in 1875, Ohio's Cincinnati Zoo & Botanical Garden is the second-oldest zoo in the United States. In addition to all the exhibits you'd expect—primates, elephants, big cats, tropical birds—the zoo has long been a leader in promoting education about and conservation of invertebrates.

In 1978, the zoo opened World of the Insect, the first habitat building devoted to insects in any U.S. zoo. For more than three decades, zoo staff have played a role in captive breeding of the American Burying Beetle as part of a multi-zoo program working to recover this species across its former range. In 2011, the zoo joined with regional partners to reintroduce the beetle into Ohio. The zoo also has programs that are more local, connecting with people in the greater Cincinnati region, such as Plant for Pollinators, which aims to increase pollinator habitat in neighborhoods.

Behind-the-scenes tours at the Cincinnati Zoo's World of the Insect exhibit have raised donations for Xerces. American Burying Beetle, photographed by Mark Dumont (CC BY-NC 2.0).

The Cincinnati Zoo has been a partner and supporter of Xerces for several years. In addition to promoting conservation of Monarchs and bumble bees, zoo staff offer behind-the-scenes tours of World of the Insect to raise donations. Thanks to this initiative, we have received more than $17,000 since 2022.

This year our collaboration with the Cincinnati Zoo deepened, with the acceptance of Xerces' Detroit-based pollinator conservation specialist, Stefanie Steele, into the zoo's Coexistence Impact Fellowship Program. This two-year program enables participants to develop, with the help of the zoo's research scientists and staff, a place-based project that explores the intersection of conservation with the social sciences.

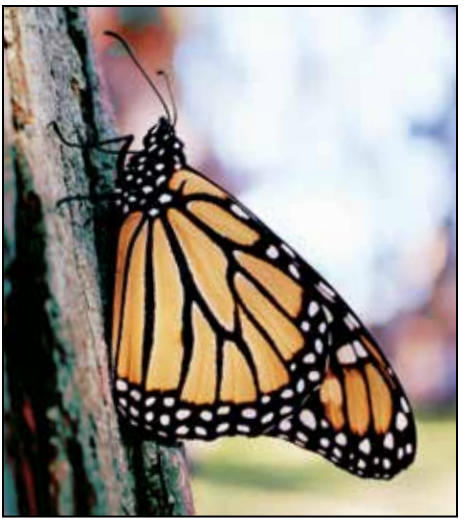
Stefanie will study perceptions that Detroit community members have of small-scale native-plant gardens. Such plantings are not the current cultural norm for many communities, and by listening to residents, urban growers, city officials, and others about what they feel are the benefits, opportunities, challenges, and drawbacks of these gardens, Stefanie will be able to develop new educational resources and share tips on being a good native-plant neighbor.

Monarch Numbers Remain at Historic Low

In the 1980s, millions of Monarchs migrated to California. The latest annual Western Monarch Count revealed just over twelve thousand Monarchs overwintering along the California coast, the third-lowest number seen in three decades of monitoring. The only counts lower than this were in 2020 and 2024.

Faced with historically low numbers, Xerces is acting to protect overwintering sites and expand habitat. We are sponsoring Assembly Bill 2254, introduced by Assemblymember Dawn Addis, which will protect overwintering sites within California's coastal zone. Our Monarch and Pollinator Habitat Kit Program is providing community partners with thousands of milkweed and nectar plants. Our staff also have worked regionally with state wildlife agencies to help update the Western Monarch Butterfly Conservation Plan, published by the Western Association of Fish and Wildlife Agencies. This plan presents ecosystem-based conservation strategies that will support a viable population across multiple states.

News of the eastern Monarch population that overwinters in Mexico is more encouraging—the area of overwintering habitat occupied by butterflies there increased 64 percent from last year—but the population is still well below historic norms. Staff scientists are conducting ground-breaking research into Monarchs in the Southeast, and we are working across the United States with farmers and others to plant more milkweed and nectar plants.



With numbers well below historic levels, urgent action is needed to help Monarch butterflies. Photograph by the Xerces Society / Candace Fallon.

Protecting overwintering sites is essential for the future of Monarchs, but there are also things that each of us can do, wherever we live within the butterfly's spring and summer breeding range (which extends across North America as far as southern Canada): plant native milkweeds to feed caterpillars; grow nectar-rich flowers to fuel adults; and protect these from pesticides. You also can speak up and advocate for policies and legislation at all levels, from your HOA to Congress, to encourage creation of more habitat and reduction of pesticide use. Visit xerces.org/monarchs for more information.

Your Legacy for Invertebrates

In 2017 a bumble bee queen moved into an empty birdhouse in my garden and changed my life. I felt responsible for her and I started paying more attention to the ecosystem in my yard. At that time, I didn't know the difference between bumble bees and other bees. Learning more inspired me to change my gardening habits to support the pollinators in my yard and educate others to do the same. I love animals and feel strongly that in order to help those at the top of the food chain we must first ensure the survival of those at the bottom. That's why Xerces is the primary beneficiary of my estate.

—Pamela Bilderbeck of Salem, Oregon: Xerces Society monthly donor since 2019, whose favorite invertebrates are bumble bees (and who dreams of someday going to Chile to see the Patagonian Bumble Bee).

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

Awards Given to Support Student Researchers

We are proud to announce the winners of the new Deborah BanDrosky awards and the long-standing Joan Mosenthal DeWind awards. Both of these awards fund college-level research, and together they enable Xerces to support a new generation of conservation scientists.

The Deborah BanDrosky Award is named in honor of a scientist, musician, and artist who dedicated her life to the study, protection, and awareness of insects and other wildlife. These awards are given to students studying invertebrates and who intend to continue in a field related to conservation.

The winners of the two inaugural awards are Michael Adu-Brew (University of Maryland), who will evaluate pesticide risk to listed and at-risk lycenid butterflies using the Eastern Tailed-blue as a surrogate; and Rachel Laura (University of Arizona), who will study the distribution and habitat use of the Southwest Spring Firefly in central Arizona.

Honorable mentions go to Alexa Hershberger (University of Massachusetts, Amherst), assessing short-term impacts of dam removal on freshwater mussels in Massachusetts; and to Grace Lovett (University of Arkansas), studying the biogeography of fireflies in the Arkansas River Valley.

The winners of this year's DeWind awards—which are focused on butterfly and moth research—are Elena Adams (Ohio State University), who will look into whether mosquito management practices are harming moths in residential areas; and Claire Berdik (University of Illinois Urbana-Champaign), who will assess environmental DNA as a tool for monitoring moths.

The honorable mentions go to Konstantina Nasiou (University of Ioannina, Greece), examining the effect of grazing and aridity stress on moth communities in Mediterranean mountain grasslands; and to Brevan Wagner (University of Alberta), evaluating the uniqueness of the at-risk Makah Copper butterfly.

Congratulations to all, with our gratitude for advancing conservation through building our knowledge base.

BanDrosky Award recipient Michael Adu-Brew will use the Eastern Tailed-blue as a surrogate to evaluate pesticide risk to other butterflies. Photograph by John Flannery (CC BY-ND 2.0).

Policy Successes Help Drive Conservation Forward

Conservation progress doesn't come only from direct action. It can also come from creating the conditions for others to act or from generating the resources to support their work.

In 2021, the Xerces Society helped draft legislation that led to the creation of the Monarch and Pollinator Highway Program to provide grants each year to support roadside restoration. A new round of pollinator roadside grants was announced by the federal Department of Transportation in early April. Two dozen grants, worth a total of $3.8 million, will be awarded to state departments of transportation and to tribes.

In landscapes denuded of natural areas by agriculture or urbanization, the ten million acres of federal and state roadsides are increasingly important for the habitat they support, providing refuge for wildlife and connecting fragmented habitat. Restoring roadsides is a win-win that helps wildlife, beautifies the landscape, and can reduce maintenance costs over time. Xerces is working with U.S. Representatives Jimmy Panetta, Blake Moore, and Salud Carbajal and U.S. Senators Jeff Merkley and Mike Rounds to reauthorize this program.

In another policy achievement that will unlock years of funding for conservation, Xerces was part of a coalition that recently secured monies for implementation of Oregon's State Wildlife Action Plan (SWAP). This success came in March, when a bipartisan vote of state legislators passed HB 4134, the "1.25% for Wildlife" bill, which has now been signed into law by Governor Tina Kotek.

The bill will increase the state's transient lodging tax by 1.25 percent, raising an estimated $38 million annually, a transformative amount for wildlife conservation across the state. The

Roadsides can support extensive habitat. Grants to fund such habitat are available from the U.S. Department of Transportation. Photograph by Kelly Gill.

Western Giant Swallowtail, photographed by Bryan E. Reynolds.

Tax-Wise Ways to Make an Impact for Nature

Every donation to the Xerces Society helps protect species and their habitat. As you plan your philanthropy, here are smart, tax-wise gifts to consider:

- ♦ Donating gifts of appreciated securities or publicly traded stock can offer donors significant tax advantages over giving cash. Account transfer information can be found at xerces.org/donate/stock.
- ♦ For tax year 2026, if you are 70½ years or older, you may give up to $111,000 per person each year without incurring income tax on your withdrawal from your Individual Retirement Account (IRA), provided your donations are made directly from your IRA to Xerces Society. These Qualified Charitable Distributions (QCDs) may also satisfy your Required Minimum Distribution.
- ♦ Establishing a donor-advised fund (DAF) gives you flexibility and control over your philanthropy. You can recommend a gift to Xerces through a DAF now and in the future.

The Xerces Society does not provide tax or legal advice. Please consult with your professional advisor for guidance on your situation. Noncash gifts should be initiated in advance of the end of the calendar year to ensure that the gift falls into the tax year that you intend. You can notify us of your plans by emailing us at membership@xerces.org. Thank you for your support!

SWAP provides a blueprint for statewide conservation action to maintain healthy wildlife populations and address declines of more than three hundred at-risk species in the state, including the Western Ridged Mussel.

The coalition that achieved this ranged from cattlemen and anglers to environmental groups and conservation voters, underscoring the fact that supporting wildlife and habitat is something that can unite people.

Individual efforts such as creating a pollinator garden help transform our landscapes. Photograph by Xerces donor Pamela Bilderbeck.

Conservation Campaigns You Can Help With

Thanks to the incredible support of our individual members and donors, as well as that of the many foundations, businesses, and agencies that provide funding, Xerces has grown as an organization and has built a reputation for high-impact programs that are a template for protecting and conserving insects and other invertebrates. Thank you to everyone who has made this possible.

Invertebrate conservation has been described as "the biggest job in the world." And it's one that we can all be directly involved with in myriad ways, from growing habitat in our backyards to contributing observations to community-science projects, to speaking up on behalf of the tiny wildlife with no voice. We have three campaigns that you can join as an individual or a community.

Bring Back the Pollinators is built around a simple framework: grow pollinator-friendly flowers; provide nesting sites; avoid pesticides; and spread the word. Refreshed and relaunched this spring, the campaign encourages grassroots activity and provides support through webinars, expert panels, informational materials, and more. Sign the Pollinator Protection Pledge and join us at bringbackthepollinators.org.

The Western Monarch Call to Action focuses on ways to help the declining population of Monarch butterflies in California and adjacent states. Securing overwintering sites will take effort at multiple levels, but across the places that Monarchs travel and breed there must be milkweed for caterpillars and nectar flowers for adults, and we must protect them from pesticides. Find what you can do at savewesternmonarchs.org.

If you want to get your community to work towards a cleaner, safer environment, the twin programs of Bee City USA and Bee Campus USA can help. Learn how to add your community to the nationwide network at beecityusa.org.

Short Bites

Xerces Represented at COP30: Thanks to the Yale Student Environmental Coalition, invertebrates and our work had a presence at the United Nations Climate Change Conference, held last November in Belém, Brazil.

Known as COP30, the meeting drew more than fifty thousand participants from nearly two hundred countries, including a party from Yale University that was led by political science major Phoenix Boggs.

The YSEC group secured a coveted space in the "blue zone," where organizations have direct access to government delegations. The booth displays were developed in collaboration with the Xerces Society and featured our materials and graphics.

Mosquito Spray Study Published: A study conducted by Xerces scientists in partnership with the Forister lab at the University of Nevada, Reno, and published in December found that backyard mosquito sprays can cause insecticide contamination at levels high enough to kill pollinators.

Samples were collected from yards in Georgia, Iowa, and Massachusetts. On average, those properties directly sprayed by private companies had insecticides at concentrations more than six times the level lethal to Honey Bees, with a maximum of more than thirty-four times the lethal dose. Contamination levels in yards next to sprayed properties varied from none to twice the lethal level.

Become a Xerces Member to Receive Your Biannual Copy of *Wings*!

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.

Monarch caterpillars have two pairs of tentacles that serve as sensory organs. The longer pair, just behind the head, can be almost half an inch long on a mature caterpillar—and may droop shortly before pupation. Photograph by Bryan E. Reynolds.

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

On the cover: Found in the dynamic interplay betwen sea and land, tidepools give us a glimpse into a different realm. Time spent looking into them may be rewarded with sightings of animals such as this Opalescent Nudibranch. Photograph by Candace Fallon.

XERCES SOCIETY
for Invertebrate Conservation