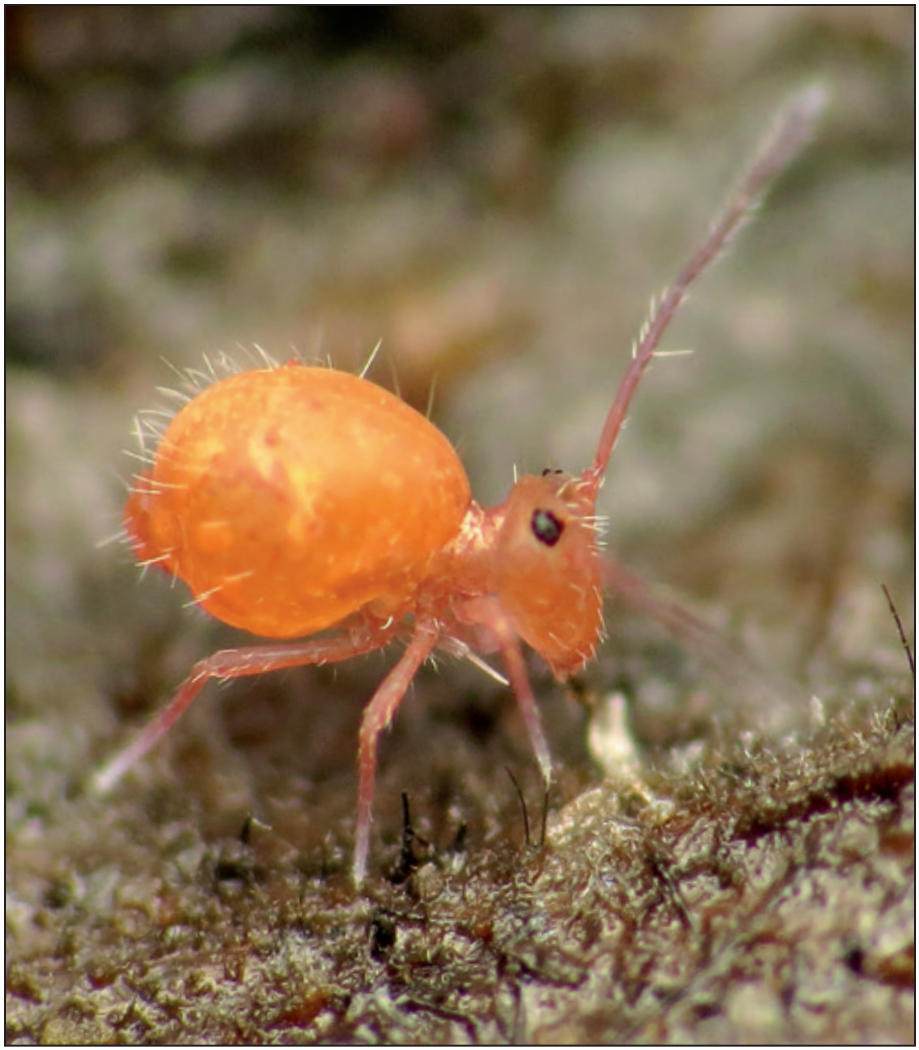
WINGS

ESSAYS ON INVERTEBRATE CONSERVATION



THE XERCES SOCIETY FALL 2021

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The Xerces Society marks its fiftieth birthday this December. This is a time to reflect on what has been achieved and the people who contributed to our success, but it is also important to look ahead at how we can continue this vital work. The articles in this issue of *Wings* describe initiatives that move us in new directions.

Celebrating the Past, Conserving the Future

Scott Black

As of 2021 it has been fifty years since Xerces was founded. Because of the dedication of our staff, volunteers, project partners, individual donors, and funders over this time, a great deal has been accomplished. It is important to take a moment to look back and celebrate what we have achieved, but for me what is really important is looking forward to how we can continue and expand on our critically necessary work.

The issues we face are large and daunting. Declines in insect diversity and abundance, the overuse of pesticides, and the climate crisis—all of these need to be addressed. The biodiversity and climate crises are only getting worse, and if we are going to be successful in the decades ahead, we need to think big and act fast. I envision a future in which all landscapes—towns, cities, farms, and natural areas—have thriving, diverse, and abundant native invertebrate populations. To achieve this goal Xerces will continue its work to create an interconnected network of biodiverse, climate-smart, pesticide-free habitats across North America. This means protecting those areas that remain, enhancing and restoring those that have been degraded, and creating habitat where it no longer exists. Providing resilient habitat can help species adapt to a changing climate, and can mitigate climate change itself through increased carbon sequestration by both plants and soil.

As we look to the future, the Xerces Society will continue its work of creating diverse, resilient habitats to sustain invertebrates. Photograph by the Xerces Society / Kelly Gill.

The mardon skipper is one of the many species protected due to Xerces' efforts. Photograph by the Xerces Society / Rich Hatfield.

I also envision inspired and empowered communities in which collective action, built by and for local participants, leads to a transformed landscape. By working together to re-create habitat in the many places where it has been lost and to protect what remains, more and more people will see these areas for what they are: integral pieces of a healthier world that we all need to survive, rather than as separate spaces somehow divorced from human needs.

As we move forward, we will continue to employ our holistic conservation approach. We work with academic researchers and other partners, as well as tens of thousands of community scientists who help gather vital data, to ensure that the best conservation science underpins all of our outreach, education, habitat guidance, species conservation, and policy work. This science-based approach has allowed us to protect and restore habitat for the animals that pollinate our plants, feed our birds and fish, improve our soil, and act as predators of crop pests. We protect the animals that are at the heart of a healthy environment, the life that sustains us.

Our strategy works. With partners, we have protected and restored habitat on two and a half million acres, resulting in flowering landscapes that are shielded from pesticides, changes in grazing practices that help restore rangeland habitat, increased funding to purchase habitat for some of the rarest animals on the planet, parks turning off lights at night to help fireflies and moths, farmers who are now using ecological pest management practices to minimize pesticide use—and much more.

We've also moved freshwater mussels out of harm's way when a project will imperil them, and saved dozens of other rare, at-risk, and endangered species. Animals we have helped to avoid extinction include the mardon skipper, Taylor's checkerspot, and island marble butterflies; the Salt Creek tiger beetle; the rusty patched bumble bee; Hawaiian yellow-faced bees; and the Bruneau hot springsnail, to name just a few.

Xerces has a track record of addressing difficult issues and stepping up on behalf of little-known species, and our efforts will need to continue to ramp up to address the magnitude of the challenges. That said, this is a society-wide issue. People need to lower their carbon outputs and do what they can to protect biodiversity. Government at all levels needs to become a leader in this effort. We must also remove barriers to participation and ensure that all communities are part of these solutions and benefit from them. By working together, we can face this challenge head on so that future generations will continue to inhabit a livable world.

Habitat Kits: Partnering to Support Monarchs and Pollinators

Kelly Gill

The legendary multigenerational migration of the monarch butterfly has been considered a threatened phenomenon since the 1980s, but the situation has grown increasingly dire in the intervening decades. The eastern monarch population has declined by 80 percent since the 1990s and, in the west, monarchs have nearly vanished, with the data from the most recent count showing a 99 percent decline in the migratory population of western monarchs over the last four decades. With monarch numbers plummeting, it is imperative that we do more to help this iconic and beloved animal.

Sadly, it's not just monarchs. A recent study found that butterfly abundance in the western United States is falling by some 1.6 percent annually. Bumble bees and many other pollinators are also declining at an alarming rate.

Habitat loss is a major factor contributing to these declines. Each year in the United States more than two million acres of open space—nearly six thousand acres per day—are lost to development or converted to other land uses. Widespread removal of natural or semi-natural areas continues to push the milkweed and nectar plants that monarchs and other pollinators rely on to the edges, or displaces them altogether. As migratory animals, monarchs are always on the move. The eastern monarch population recolonizes a million square miles of land every year, a process that takes several generations before the last generation of the summer makes the flight to overwintering sites in Mexico. To complete their life cycle, monarchs need to have the right plants in the right places at the right time throughout their breeding range and along their migration routes—and this requires landscape-scale conservation.

A high priority in this task is establishing habitat with locally adapted

Two years ago Xerces launched a habitat-kit program, in which native plants are distributed to local partners to create habitat for monarchs and pollinators. Photograph by kit recipient Bill Milligan.

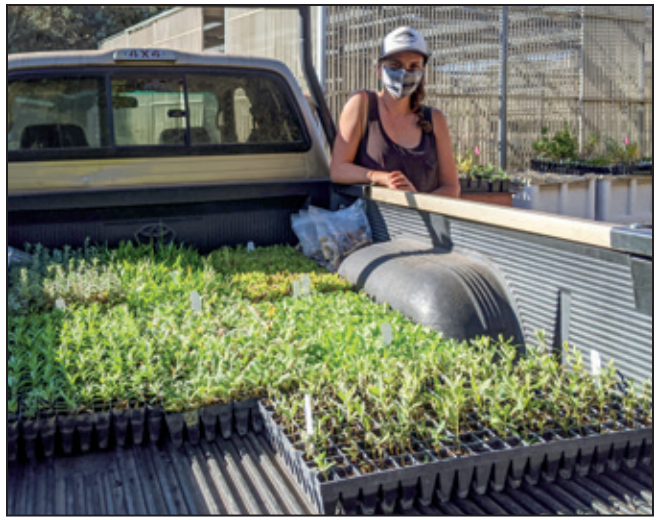
milkweeds and a variety of nectar plants—habitat that is protected from pesticide exposure and other harmful disturbances. Xerces conservation staff across the country collaborate with a broad network of partners, including scientists, government agencies, NGOs, farmers, and land managers, to restore habitat wherever we can—on working lands and in rights-of-way, natural areas and preserves, parks and gardens, and public spaces. Yet, faced with the disheartening news about monarchs, we had to ask ourselves what more we could do. How could we expand our efforts to increase pollinator habitat while continuing our larger-scale habitat-restoration projects?

We soon realized that one of the most efficient ways to accomplish this would be to provide more support to the many individuals and groups in our communities that already want to take action. It became apparent that the biggest hurdles facing these communities were the high costs of appropriate plants and the difficulty of finding suppliers, and therefore that providing the plants would help enormously in enabling them to act. Thus, the Xerces Society Habitat Kit Program was born: a partnership between Xerces, local residents, and native-plant nurseries.

Our habitat kits offer regionally appropriate plant materials grown to order by nurseries and supplied to our community partners. In return our partners provide sweat equity—the time, the labor—and land. The habitat kits not only help people plant and nurture habitats that support monarchs and other pollinators, but they also remove financial barriers for groups and individuals who want to help pollinators. And it assists Xerces in our efforts to create habitat across the landscape.

With many years of designing planting plans and implementing habitat projects under our belts, the first

Plants were contract grown by native-plant nurseries in each region. Here habitat kits are ready to be picked up and taken away for planting. Photograph by the Xerces Society / Angela Laws.



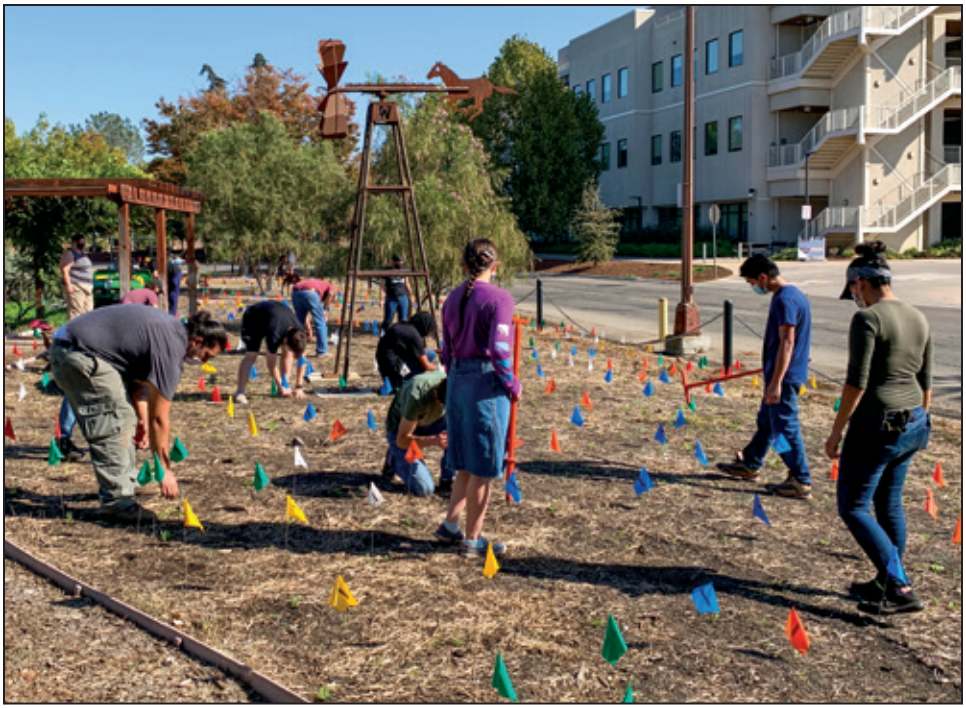
The kits distributed in California each include more than fifteen hundred plants. They have been used on farms, on school grounds, and in natural areas. Photograph by the Xerces Society / Angela Laws.

step in creating habitat kits—identifying the best native plant species for different regions and types of habitat—was straightforward. To fulfill such project goals as increasing milkweed for monarchs, host plants for other butterflies, and nectar-rich flowers that are useful for a broad range of pollinators, we selected species for their compatibility with local growing conditions, including ease of establishment, bloom times, and climate resilience.

We then found and contracted with local native-plant nurseries to grow the plants we needed. We took precautions to select partner nurseries that were able to offer plants that are not treated with systemic insecticides such as neonicotinoids, or with other pesticides that are highly toxic to monarchs and other pollinators.

Once we determined the contents of the kits and figured out who to work with to produce them, we had to find committed partners to raise the plants. Although we had numerous potential candidates, we wanted to be sure that they would be able to grow the plants successfully, manage them over the long term, and protect the resulting habitat from pesticides. We also wanted to meet our own equity targets for supporting underserved or diverse communities. To fulfill these multiple needs, we put out a call for groups and individuals to "apply" for a kit, and got many more requests than we could supply. In making the final selection of who would get kits, special consideration was given to projects that incorporated educational programs and outreach, contributed to community science projects, or engaged underserved populations.

The first kits, distributed in California in 2019, prioritized milkweed and nectar plants for monarchs and



Community partners provide the land and labor—the "sweat equity." Many of the projects have an educational component, increasing their utility. This kit was planted by students at San Joaquin Delta College. Photograph by the Xerces Society / Deedee Soto.

other pollinators. A variety of kits were designed for different habitat types and regions, and included flowers and shrubs for upland wildflower or hedgerow plantings and riparian buffers. Each kit contained more than a thousand plants—enough for a significant area of habitat—and were intended for use on both working lands and public lands in one of four regions: the Central Valley, the Sierra Nevada foothills, the Central Coast and coastal foothills, or Southern California. Xerces partnered with several nurseries—including Hedgerow Farms, Cornflower Farms, Floral Native Nursery, Moosa Creek Nursery of Lulu Farms, and S&S Seed—to ensure that the species are native to the particular regions and that plant materials are locally sourced and adapted to the local environments.

In the first two years, California habitat kits enabled fifty-five projects, adding to the landscape seventy-two thousand plants that support monarchs and other pollinators. Almost sixty more projects are planned for this fall, which will see an additional thirty-four thousand plants in the ground. Despite our strict criteria for giving a person or organization a kit, we had many more people interested in receiving one than we had kits available.

There are many stories we could share of local habitat projects, but here is one highlight. Bill Milligan was already

planting habitat on his farm, and he used the kit he received in 2020 to create fourteen hundred feet of hedgerow. He noted that the contents of the kit greatly helped him to create a more complex, diverse environment for pollinators, and that the experience made him understand the value of plants such as goldenrod and asters. Now they and the various milkweeds are everywhere, and that has him thinking about what else he can plant to augment them. Bill will be continuing this work, adding more milkweed and nectar plants to further increase habitat diversity—an ongoing commitment catalyzed by receiving the kit.

The first round of kits in California demonstrated that this was a successful way to create habitat in multiple places, as well as to meet other goals of our conservation programs: to engage a broader segment of the community and to remove barriers that prevent people from taking action. Not only did we immediately start planning for another year there—and indeed to continue our California effort forward into the future—we also began to consider how we could carry out similar programs in other regions.

In 2020 we started the planning process for offering Xerces' plant kits in the Northeast. We worked with Pinelands Nursery and Supply, a native-plant nursery in New Jersey, to design four different kits that included selections of plants of local provenance. As in California, the kits were designed with monarchs in mind—they include native milkweeds and nectar plants that bloom during the period that monarchs are present in the region—but the plants we are using support a broad

Habitat kits supported community projects in nine states in the Northeast. Many of the kit recipients were in urban areas, including the New Roots Community Farm in New York City. Photograph by Dina Garcia.

variety of bees and butterflies. The different kits include ones with wildflowers and grasses and ones with wildflowers and flowering shrubs, each with options suited for upland meadows or hedgerows and for plantings in wetter sites such as rain gardens and wetland buffers.

This spring a total of forty-six kits — nearly thirty-six thousand native plants —were distributed to agencies, conservation districts, nonprofit organizations, nature centers, community groups, Bee City USA and Bee Campus USA affiliates, and other eligible organizations across nine states. Plantings were completed on working lands and in natural areas, parks, preserves, schoolyards, and community spaces, creating habitat in a wide range of places. Sites where kits are installed are also used for education and outreach events, outdoor classrooms, learning labs, urban farms and gardens, inner-city youth programs, community science, and more.

New Jersey's Friends of Hopewell Valley Open Space received a kit. They worked with three different schools to incorporate habitat plantings into their outdoor-classroom curricula, with the students involved in the planning and implementation of the project. Lisa Wolff, executive director of the Friends, observed that, in addition to beautifying the school space and creating habitat for the monarch butterfly, the kits instill in the students "a sense of wonder and stewardship for the natural world."

In 2021 we also distributed kits in Santa Fe, New Mexico. The kits there are very different from those offered in California and the Northeast, because instead of being for natural areas or working lands, these are mostly for home gardens along Xerces' Santa Fe Pollinator Trail. The Pollinator Trail project has been developed with local agencies and nonprofits to create connected, climate-resilient pollinator habitat across the urban landscape. Each kit includes a few dozen wildflowers, plus a single shrub or small tree; all the species have low or low-to-medium water requirements. Xerces partnered with the Santa Ana Native Plant Nursery to grow plants from locally sourced seeds of wild plants. Three hundred and fifty kits are being distributed this fall to residents and local organizations, adding 11,500 plants to yards and gardens within the city of Santa Fe.

The Xerces Society has a long history of partnering to protect pollinators. Thanks to the new direction offered by the habitat kits, we have had the rewarding opportunity to form fresh partnerships and to further expand our support to local communities. While coordinating the habitat-kit projects takes work by Xerces staff, this effort is multiplied by our dedicated community partners. They are the true champions, and they deserve the credit for bringing the habitat-kit program to fruition.

On behalf of the Xerces Society, thank you to all of our kit partners for creating habitat and being ambassadors for pollinator conservation in your communities. You are making a difference for the little things that run the world.

As a Xerces Society pollinator conservation specialist and a partner biologist with the USDA Natural Resources Conservation Service, Kelly Gill provides technical assistance on pollinator conservation in the Mid-Atlantic and Northeast regions.

Taking Invertebrate Conservation Underground

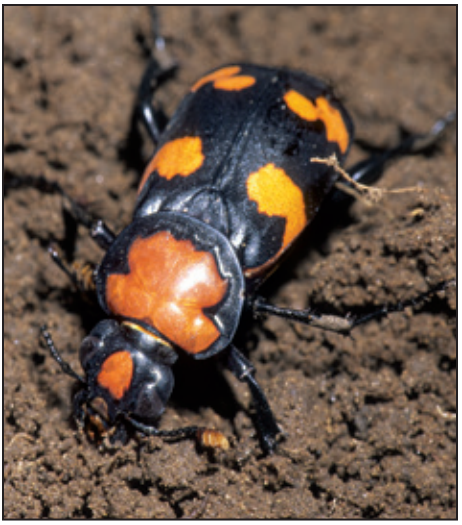
Stephanie Frischie and Jennifer Hopwood

The origin story of the Xerces Society is rooted in butterfly conservation. The organization is named for the Xerces blue, the first butterfly in North America recorded to have gone extinct due to habitat loss, last seen on the wing in the early 1940s in the dunes of San Francisco. And the Society's founding in 1971 was inspired by what at that time was the impending loss of a similar butterfly, the large blue, from Britain. In the fifty years since, the work of the Xerces Society has expanded to address a broad array of invertebrate groups, including fireflies, freshwater mussels, native bees, dragonflies, moths, snails, beetles, and so many more—a task that our founder, Robert Michael Pyle, has described as "the biggest job in the world."

Most of the invertebrate groups that are the focus of our conservation programs live above the soil surface or reside in fresh water. We have worked on such species as ground beetles and the Oregon giant earthworm—animals that make soil their home—but in general the earth beneath our feet is a realm that has not been given consistent attention. The launch of our soil life initiative is changing that.

Whether we are on a farm, in a natural area, at a park, or in a garden, there is soil underfoot. It is everywhere; it is full of life; and it is essential to the air we breathe, the fresh water we depend on, and the foods we eat. But soil remains largely unseen, unconsidered, and underappreciated.

Soil is an environment into which we cannot readily enter, and we get only occasional glimpses into the diverse and abundant life that dwells there. When it comes to soil health, cover crops and other above-ground plantings are helpful, but microbes such as bacteria and fungi are the superstars. They aren't working alone, however. A host of animals also contribute by improving soil structure, increasing fertility through the decomposition of organic matter and the mixing of soil layers, and functioning as predators or prey in food webs. Soil contains a vast diversity of life: the animals therein comprise more



The soil beneath our feet is home to a remarkable diversity of life, from the microscopic to the large and obvious, such as this American burying beetle. Photograph by Bryan E. Reynolds.

than a quarter of all species on our planet. And of these animals, 99 percent are invertebrates. From microscopic nematodes in water films and soil pores, to tiny springtails that navigate through existing tunnels, to millipedes that create their own burrows, soil life is a complex, fascinating web that ultimately supports life above ground.

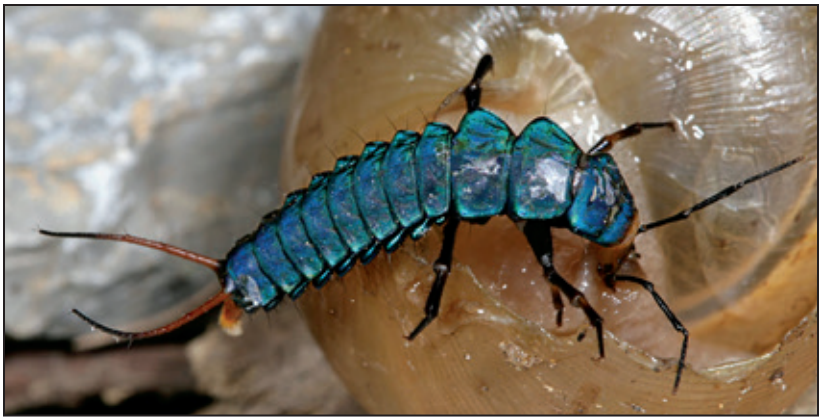
Soil is inhabited by a diverse group of invertebrates, the vast majority of which live their entire lives out of sight below our feet. Here we highlight just a few of these many amazing animals.

Among the smaller of soil animals are tardigrades, which can be brown, white, green, orange, pink, or even colorless, and are usually found within the top inch of the soil or in leaf litter or moss. Were you to have them under a hand lens or microscope, you would see that they appear to be segmented and have eight stubby legs that end in several short claws, which, with their affinity for moisture, is the genesis of their common name of "water bear."

There are an estimated fifteen hundred species worldwide; as a group they have a diverse diet, with different species consuming plants, algae, fungi, protozoa, and such small animals as nematodes and rotifers—microscopic creatures that live in water, including in the film around soil particles.

Despite their tiny size—the largest species are less than a twelfth of an inch (two millimeters) long—tardigrades have some notoriety, thanks to their ability to survive in extreme environments. They can remain in a state of suspended animation for decades, an adaptation that allows them to cope with long periods of drought. Tardigrades are among the animals used in space research. In several experiments, they have shown some ability to survive and reproduce after exposure to the severe environment of radiation, microgravity, and the vacuum in outer space.

Springtails are small—less than two-tenths of an inch (five millimeters) long—but are several times larger than water bears and can be seen without



Ground beetles are predators of all sorts of invertebrates as both adults and larvae, and are valuable for pest control. This larva of a notched-mouth ground beetle is eating a snail. Photograph by Patrick Coin, Flickr.

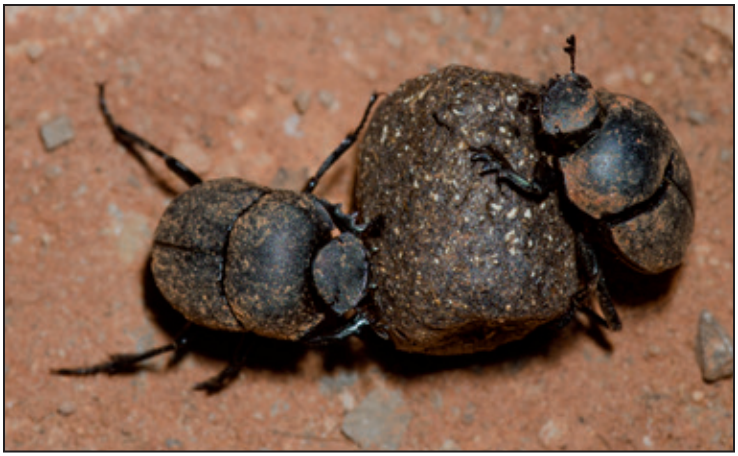
Entomobyrid springtails such as the one shown here live among soil surface litter, decaying logs, and fungi. These springtails are detritivores, consuming organic matter and thus contributing to nutrient cycling in the soil. Photograph by Katja Schulz, Flickr.

magnification. Species differ, but their bodies may be elongated or rounded, and white, purple, brown, or gray. They get their common name thanks to their furcula, a tail-like structure that is held under tension beneath the abdomen. When released, such as in response to an approaching predator, the furcula propels the animal more than twenty times the length of its body.

Some springtails live in the leaf litter on the soil surface, or in decaying logs, under bark, and within fungi. Others live within the soil; these species have a reduced furcula (or none at all), and are blind, lacking the simple eyes that are present in some of the surface-dwelling species.

Springtails consume decaying plants, fungi, bacteria, and pollen. Some are predators of other springtails as well as of rotifers and nematodes. When they decompose, springtails assist nitrogen mineralization, a key step in converting organic matter into a form of nitrogen that plants can use. Their selective consumption of fungi can also alter fungal communities and may help to manage fungal diseases of plants, and it contributes indirectly to nutrient cycling and the decomposition process.

Although it would be distasteful to us, animal dung is a food resource for which there is a great deal of competition, and dung beetles are particularly adept at locating and utilizing it. In order to minimize competition with flies that also want to lay their eggs in the dung, these beetles will slice off a chunk and bury it. The best-known species shape the dung into a ball and roll it away before burial. An egg is laid on the dung, which the larva consumes after emerging, digesting the dung with the help of gut microbes. The burying of dung and the excavation of chambers for dung beetle young influences soil both physically and chemically. Dung beetles mix nutrients from dung with the soil, help reduce soil compaction,



Mated pairs of dung beetles pack, roll, and bury dung—sometimes a foot or more deep—on which to rear their young. This helps recycle nutrients and reduces livestock pests and parasites that would live in dung left on the surface. Photograph by Bryan E. Reynolds.

and facilitate the further breakdown of the dung by microorganisms.

Fireflies, lightningbugs, and glowworms are not actually flies, bugs, nor worms, but rather are beetles. Best known for the nighttime light shows of some species, adults live in open fields, yards, and woodland edges, but their life cycles (and survival) are closely tied up with soil. Eggs are laid just under the surface or among grass roots. The larvae reside under decaying logs, in leaf litter, and in damp soil, where they are predators—hunting snails, slugs (tracked by following their mucus trails), earthworms, caterpillars, and other soft-bodied invertebrates. They pupate in soil, under rocks, or in leaf litter, and are becoming increasingly rare as lands are more developed and more disturbed.

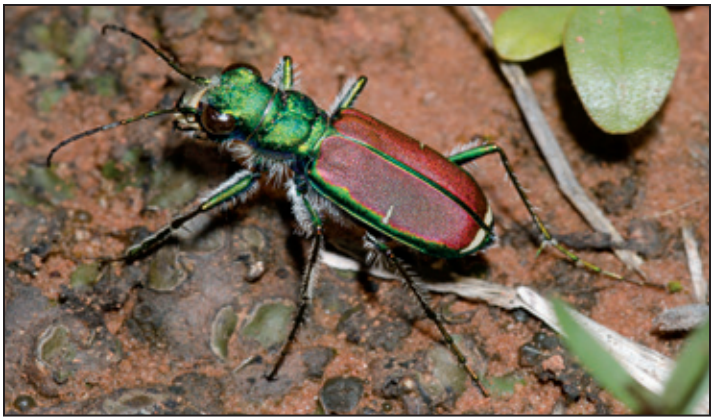
Other groups that live in the soil include tiger beetles and bees, both of which spend their early life stages in the ground. Tiger beetle eggs are laid in the soil and, after hatching, the larvae dig vertical burrows in which they live, waiting to grab passing prey. They pupate in the ground. Most bee species, around 70 percent, also spend their first three life stages—the majority of their lives—in the soil. Females excavate tunnels, connected to which they dig brood cells. The female stocks the cells with a mixture of nectar and pollen and lays a single egg in each. The bees develop in the cells, where they may remain until the following year before emerging.

These are just a few examples of soil invertebrates. Typically, if soil gets much attention, it is simply for how well (or poorly) plants grow in it. Soil science—a rich, complex, and multifaceted discipline—has long recognized that Earth's soils are home to a dynamic interaction of physical, chemical, and biological properties. Luckily, our understanding of and thinking about soils continues to change. Farmers, conservationists, scientists, and others have started pushing all of us to ask questions about what

lives in the soil, giving rise to a broader conversation about the paramount importance of soil biology.

Soil ecology is key to many environmental and economic issues. Increasingly, we recognize that healthy, productive, and resilient soil helps sustain abundant crops with fewer costly inputs. For reasons that we are just beginning to understand, the biology of certain soils can also suppress plant diseases, much in the same way a healthy gut biome in people helps to prevent human diseases. There is also mounting evidence that we can harness the root systems of plants and their microbial allies to store vast quantities of atmospheric carbon dioxide in Earth's soils, at rates that could help offset human-generated greenhouse gasses. And, as we continue to face a striking global loss of wild plants and animals, we are becoming more aware that soil is fundamental to the ecological wellbeing of all species, serving as a living platform for tigers and crickets, bacteria and bees, and oaks and wildflowers, as well as providing the minerals that build the cells not only of those species but also our own.

Xerces staff members are part of the nationwide discussion about soil health, and in keeping with a half-century tradition of stepping up to campaign for underappreciated wildlife, we are embarking on a soil life initiative. As part of this effort we have developed *Farming with Soil Life: A Handbook for Supporting Soil Invertebrates and Soil Health on Farms*, released earlier this year. It is impossible to tell the story of every living species connected to the ground beneath us, and with that in mind we centered this guide on soil invertebrates—animals such as ground beetles, woodlice, and worms, as well as tardigrades, springtails, and their many companions—which have often been left out of discussions around the health of temperate agricultural soils. Although we focus on groups of organisms and soil-health practices from North America, similar groups are present in soil around the world, and the same management principles apply.



Adult tiger beetles are high-speed predators on the soil surface. Their larvae live in burrows, but are also predators, grabbing anything that comes too close. Photograph by Bryan E. Reynolds.

Ants are among the most widespread, abundant, and diverse insects that live in soil. And their diets are also diverse: they are scavengers as well as predators of smaller invertebrates, and they consume parts of plants. They also move and mix a great deal of soil, increasing drainage, aeration, and fertility. Photograph by Bryan E. Reynolds.

In addition to the handbook, we've presented a dozen online short courses for farmers, agricultural advisors, and agency staff. These workshops cover the basics of soils, life histories of many soil invertebrates, the threats affecting those invertebrate populations, methods for observing and identifying them, recommended land-management practices that support soil life, and case studies and research that demonstrate the benefits of these practices. Additional short courses are scheduled for 2022, along with field events where we can observe the life in soil firsthand (depending, of course on Covid-19). We will also develop training material for urban farmers and gardeners, and will be offering the short courses in Spanish.

Soil health is vital for all terrestrial and aquatic life on the planet. Managing soil in a way that maximizes biodiversity and carbon capture is vital if we hope to address the environmental crises we face. The tiny animals living in soil are key foundational components of food webs, transferring energy from plants and microbes through and among invertebrates, amphibians, reptiles, birds, and mammals. Caring for the soil in which they make their home yields benefits for all living creatures.

Based in northwest Indiana, Stephanie Frischie is Xerces' agronomist and native plant materials specialist. She provides habitat guidance to farmers and also works with the native-seed industry to develop seed supplies of important plant species for habitat restoration.

Jennifer Hopwood is a senior pollinator conservation specialist based in Nebraska, working with land owners and managers in a variety of landscapes to promote habitat management and restoration.

How Grape Juice and Vacuums Can Help Save the World

Aimée Code

There was a teacher at my high school who started every class with the key take-home message he wanted to be sure we all heard. Following his example, here is a message I hope you'll take to heart: *If we are to bring back pollinators and restore the biodiversity that our world needs to survive, we must curtail the excessive use of pesticides—at home, on the farm, and everywhere in between.*

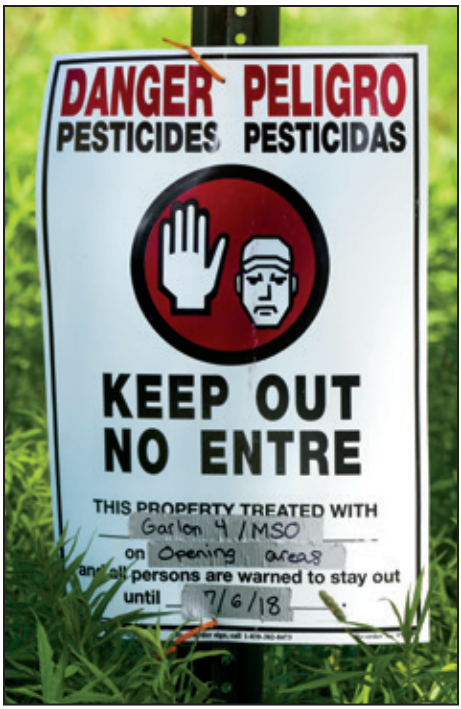
Almost every day I connect with fascinating people who recognize the interconnections between humans, invertebrates, and the health of the planet—people who are figuratively and literally rolling up their sleeves to make the world a better place. Being a part of this movement confirms my belief that we can cut back on harmful pesticide use and achieve our biodiversity goals. That isn't to say that we've got an easy road ahead. The use of pesticides, which include insecticides, herbicides, fungicides, acaricides, and other "cides," is woven into the fabric of people's thinking about how they protect their plants from pests. The norm in pest management is to reach for a pesticide. But pesticides are not a silver bullet for dealing with unwanted insects, diseases, or other "pests"; if it were, would we still have pest problems? The fact is that the

An ever-growing number of people are rejecting pesticides and seeking out more-sustainable ways to garden. Photograph by Mike Licht, Flickr.

widespread use of chemicals has led to pervasive contamination.

Pesticides are found almost everywhere we look: high mountain lakes, rainwater, honey collected from bee hives, home gardens even where pesticides are not used, field edges, the milkweed plants monarch caterpillars feed on, the pollen of nursery plants marketed as pollinator attractive—the list goes on. Even the Arctic isn't safe from pesticides, since some long-lived, highly mobile pesticides are found there, thousands of miles from where they are used.

Sometimes the pesticides detected in the environment are at levels high enough to kill beneficial insects outright. More often lower levels are found, and we refer to those levels that might not immediately kill a bee, butterfly, or other beneficial insect as "sublethal." But that term can be misleading, because even if they don't kill, these lower levels of contamination can have devastating effects. Imagine a monarch that can't migrate, a queen bumble bee that can't survive hibernation, or a bee that is unable to fight off parasites because it used its energy reserves to detoxify from a pesticide exposure.



Pesticides have been so broadly used that residues are now found nearly everywhere. Photograph by Bryan E. Reynolds.

Moreover, sublethal impacts can be compounded, since it's rare for just a single pesticide to be found in isolation. Environmental samples, whether in water, soil, pollen, or other substances, generally contain multiple pesticides, and the effects of these mixtures are largely unstudied. We do know that, when used together, chemicals often have an additive effect. Indeed, sometimes they are synergistic, with their combined impact greater than the sum of that of the individual compounds.

We also know that, because multiple chemicals may be applied, residues can contain several products. In 2019, Xerces partnered with researchers from the University of Nevada, Reno to study pesticide levels in milkweeds growing in California's Central Valley. Every one of the more than 225 milkweed samples tested had at least one pesticide, and one plant had residues from twenty-five pesticides. There was an average of nine per plant.

This troubling pesticide contamination across the landscape isn't caused by misapplications or a few rogue applicators using too many chemicals. Rather, a number of factors are at play here, starting with the existing regulatory structure. Current federal pesticide reg-

Many of these plants at a garden center might appear to be good for pollinators, but quite often they have been treated with insecticides that can harm bees and butterflies. Photograph by the Xerces Society / Sharon Selvaggio.

ulation is riddled with loopholes. The fact that each pesticide is regulated individually, without regard for the compounding impact when multiple chemicals are applied, is a perfect example of how regulations fail to protect. But the troubles with pesticide regulation go much deeper. A recent investigative-journalism report published in *The Intercept* spotlighted an entrenched regulatory structure and culture that values profits over safety. Many pesticide products are put on the market without sufficient research into their risks—and sometimes in spite of research warning of severe repercussions. The push to get pesticides to market, even when they could cause significant harm, is in part due to the mindset that pesticides are necessary and that the benefits of their use outweigh the risks.

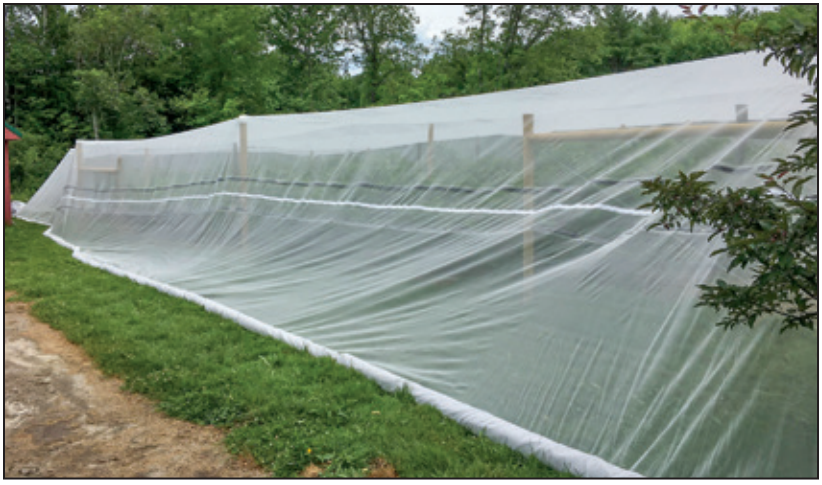
This mindset isn't unique to the regulators who rubber-stamp pesticide registrations. All too frequently people see pesticides as their go-to option. And, although home gardeners, farmers, park managers, and others often want to limit pesticide use, they don't trust that they can respond to such concerns as yellowjackets, invasive weeds, or plant diseases without them.

So here is where we get to the grape juice and vacuums: both are employed in non-chemical pest management. People are definitely getting creative in managing the places where we live, work, and play to make them safer for everyone. Take, for example, the work of Xerces' integrated pest and pollinator management specialist in New Hampshire, Alina Harris, who is joining with partners to respond to the economi-

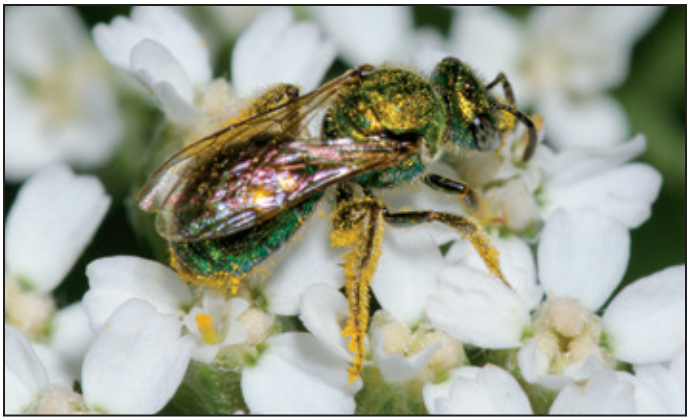
cally damaging and hard to control—and recently introduced—spotted wing drosophila (*Drosophila suzukii*). If you are a farmer or a home gardener growing fruits, you may have heard of this fruit fly, which lays its eggs in a number of crops, including raspberries, cherries, grapes, and blueberries. The developing larvae shorten the shelf life of the fruit by causing it to soften. Also, most folks do not appreciate the added protein of the developing maggots in their fruit.

To control this pest species, some growers spray insecticides multiple times throughout fruit development. Alina is working in collaboration with berry growers, conservation districts, the University of New Hampshire Cooperative Extension, and the New Hampshire Natural Resource Conservation Service to conduct trials on the use of insect-exclusion netting to cover crops and keep the drosophila out. Funding was provided by the New Hampshire NRCS to offset some of the initial costs of buying the netting. Alina recommends other ways to minimize fruit damage caused by the flies, such as frequent picking and basic sanitation measures to remove and destroy infested fruit from the field. She is also excited by the work of researchers at the University of Massachusetts, who are conducting trials on the use of traps baited with grape juice to attract and kill the fruit flies.

While this work on controlling infestations through non-chemical means is relatively small in scale, it doesn't need to stay that way. Out of the blue, a friend of mine who lives here in Oregon—and who, with the help of neighbors, has converted almost all the available greenspace on her block to gardens—told me they were losing their cherries to this drosophila. Alina's pest-management recommendations, based on her work on the other side of the country, is helping my friend break the pest cycle and save her cherries without



In New Hampshire, farmers facing a recently introduced fruit fly pest are experimenting with non-pesticide methods to protect crops, such as exclusion netting. Photograph by Jeremy DeLisle, University of New Hampshire.

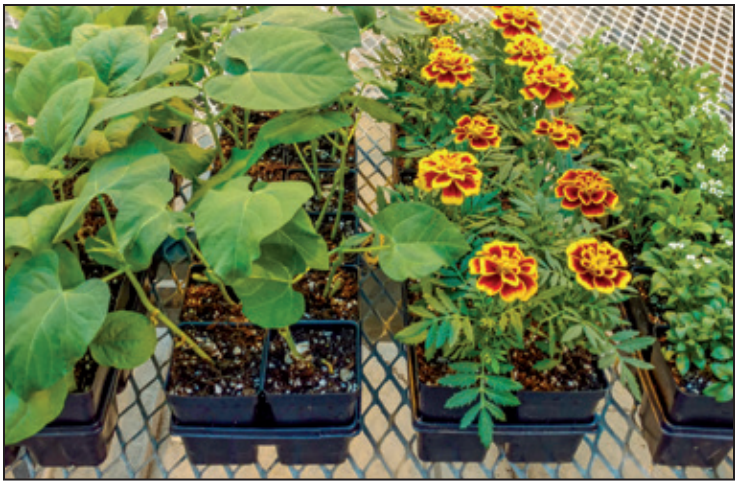


Metallic sweat bees are one of the thousands of species of native bees that can be harmed by insecticide residues in flowers. Photograph by Bryan E. Reynolds.

the use of pesticides. Now my friend is sharing these practices with other local fruit producers who are struggling to respond to spotted wing drosophila.

By building connections between people working on similar issues, we are turning isolated efforts into mainstream ideas. That is true no matter what landscape we're working in. Xerces' Bee City USA initiative recently started presenting webinars to promote the exchange of information among the more than 270 city and college campus affiliates. At a recent webinar, attended by hundreds of people from across the country, the parks and open space manager in Eugene, Oregon, explained how he and his staff are able to maintain city lands sustainably. He described how reducing pesticide use starts in the project-planning phase. When, for example, a new playground is being designed, staff select hardy, climate-resilient native plants that are resistant to common pest pressures. The city has also experimented with and adopted a number of effective non-chemical pest-management techniques. In the past when yellowjackets built a nest in a location that sees a lot of human traffic, the city would spray insecticides into the nest. Now staff members don bee suits and vacuum out the nest. City staff were skeptical at first, but once they were convinced that the suits would protect them they were quick to accept the technique. When peers exchange stories like these, they are also sharing practical knowledge about ways to expand the use of sustainable land-management practices.

Another area where Xerces is encouraging dialogue around biodiversity and smarter management techniques is in the growing of nursery plants. As an industry, ornamental-plant production is heavily reliant on inputs, including insecticides, fungicides, and other pesticides, but fortunately there is a growing movement of people transitioning away from that chemical-intensive model. In California, long-time native-plant nursery Hedgerow Farms employs disinfectant foot baths for visitors, as well as self-draining metal slatted tables to



These trays of eggplants and marigolds are used as "trap plants" to monitor the presence of crop pests. Insecticides are used only when pests occur at problematic levels. Photograph by Kathleen Holman.

avoid *Phytophthora* pathogen. The Iwasaki Brothers Greenhouse in Oregon uses "trap plants" such as eggplants and marigolds that are highly attractive to certain pests, to serve as early indicators of growing infestations. With interest in pollinator gardening skyrocketing, Xerces and our partners are encouraging large-scale adoption of these and other innovative practices. More information about how to find pollinator-attractive plants that are free from harmful pesticides can be found on the bee-safe plants page on Xerces' website.

No matter who you are or what size land you manage—from a few potted plants to a large farm—you can be part of the effort to protect the invertebrates that support the ecosystems on which we all rely. There are many inspiring examples beyond the stories shared in this article: neighbors courageously engaging neighbors in thoughtful conversations about non-chemical landscaping; public-health researchers promoting effective and ecologically sound mosquito management to replace the use of insecticide sprays; farmers improving soil health and planting insectary strips to draw in beneficial insects that act as natural pest control.

We greatly appreciate the work of those of you who have already adopted conservation-focused ways to manage the space you occupy in this world. Keep it up! Your efforts are providing a roadmap for others to follow. And for those of you haven't already, we hope you'll join us and the many others around the globe who are quietly transforming land management.

Aimée Code directs Xerces' pesticide program. In that role, she has built a team focused on practices and policies that promote ecologically sound pest management. She provides technical guidance and advocates for actions that reduce reliance on and risks of pesticide use.

The City of Boulder: A Leader in Invertebrate Conservation

Boulder, Colorado, is situated where the Great Plains and the Rocky Mountains meet. To the west, the land rises to mountain peaks; to the east it falls to the rolling prairie; and in between it is carved by ephemeral and perennial creeks into a landscape of cliffs, canyons, and foothill mesas. The diversity of landforms is reflected in the diversity of plants and animals. For example, more than 550 species of bees and 200 species of butterflies have been documented in Boulder County.

Fortunately, City of Boulder staff have long been leaders in invertebrate conservation, taking action both to provide habitat and to curb the use and impact of pesticides. Pesticides have been eliminated or restricted on city-owned lands, and staff have worked to educate the public about the benefits of moving away from using pesticides at home. The city's innovative program in mosquito management is based on ecological principles of protecting and enhancing biodiversity to naturally keep mosquito populations low. It focuses on monitoring to understand mosquito populations, and education to protect local residents.

The city also has a major focus on climate mitigation and adaptation. In 2018, Xerces Society executive director Scott Black was invited to facilitate a discussion with city staff from multiple departments to identify the most urgent ecological issues facing the city, and to develop a strategy to address them. The city then conducted a similar process within its advisory boards. This effort has deepened the partnership between the city and Xerces, and in 2022 we will launch a community-based effort to create connected corridors of native plants to support biodiversity and climate mitigation and adaptation across the city.

Although there are many staff at the city working on this effort, a special thank-you goes to Rella Abernathy, coordinator of applied ecological programs, and Brett KenCairn, senior policy advisor for climate and resilience. Through their efforts and those of other city staff and city residents, Boulder will continue to be a conservation leader.

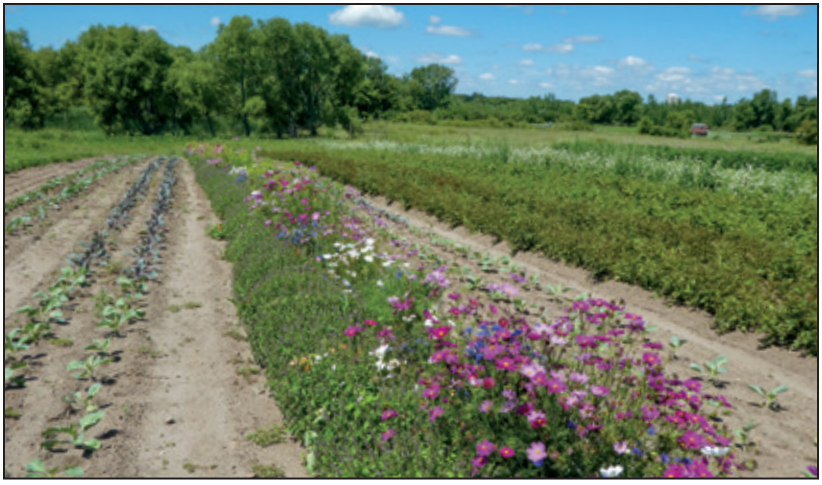
Photograph courtesy City of Boulder.

Xerces and the NRCS: Seventeen Years of Conservation Partnership

A chance meeting seventeen years ago has blossomed into a nationwide partnership and resulted in the creation of more than a million acres of habitat. Xerces' Mace Vaughan and Wendell Gilgert, at the time the California state biologist for the USDA's Natural Resources Conservation Service, quickly realized that Xerces' history of pollinator conservation (then three decades long, now half a century) and its relationships with pollinator researchers perfectly complemented Wendell's and his colleagues' efforts to integrate invertebrates into wildlife conservation at the NRCS.

Xerces and the NRCS have benefited from a steady deepening of this collaboration. We now have many staff members, from California to Maine, who are partner biologists with the NRCS. This team has developed a huge number of habitat-guidance documents, plant lists, seed mixes, and conservation specifications for NRCS staff, and has worked directly with growers to create hundreds of farm conservation plans.

We have helped to stand up several national and regional efforts to promote pollinator conservation, monarch butterflies, and honey bee habitat, and have articulated ways that conservation programs and practices can support pollinators and other beneficial insects. Xerces and the NRCS have also partnered on training and outreach events that have reached tens of thousands of farmers, ranchers, NRCS staff, and other conservationists.



Habitat created through our partnership with the NRCS ranges from insectary strips in fields like this one, to hedgerows, to meadows. Photograph by the Xerces Society / Sarah Foltz Jordan.

Queen Quest Helps Find Where Bumble Bee Queens Overwinter

Bumble bees follow an annual cycle. Colonies are founded in the early spring and grow through the summer, at the end of which they produce new queens and males, which then mate. Newly mated queens leave their colonies to overwinter, while the rest of those colonies die off. Although we know a lot about the summer activities of bumble bees, we know very little about where queens go to overwinter. This is a critical data gap that we need to fill in order to increase effective conservation efforts.

People have reported finding queens in loose soils, mossy ground, and leaf litter, and near tree trunks or walls. Some species even seem to dig into sod, and it is likely that queens overwinter by burrowing into loose leaf litter beneath conifer trees, but it has yet to be shown that this is truly common or that we can reliably find these individuals. In fact we don't know how common any of these strategies are. With Queen Quest, you can help find the answers.

Queen Quest is a collaboration between the U.S. Geological Survey, the Xerces Society, the University of Vermont, and the University of Nebraska–Lincoln, as well as other universities. Having run for a couple of years, the project is initiating a push to gain more data. There was a focal effort in October, but searches can be done and observations submitted at any time. You can also submit anecdotal or incidental records of overwintering queens you may have found. For more details, including a full protocol and photos, visit queenquest.org.

Eight Species of Freshwater Mussels are Declared Extinct

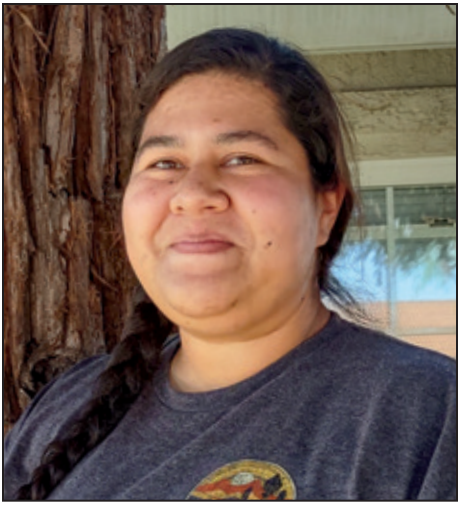
The U.S. Fish and Wildlife Service recently announced plans to remove nearly two dozen plants and animals from the list of endangered and threatened species—not because they have been "recovered," but because they are believed to be extinct. For these species, the protections of the Endangered Species Act came too late, with most of them having been extinct, functionally extinct, or in steep decline at the time they were listed.

Many of the recent media reports focused on the ivory-billed woodpecker and several species of birds from Hawaii, but a third of the delisted species were freshwater mussels: flat pigtoe, southern acornshell, upland combshell, turgid blossom, and four others. All of them are from the Southeast, America's biodiversity hot spot for freshwater mussels.

These creatures keep streams clean, provide habitat for other invertebrates, and support fish populations. Despite these ecosystem contributions, freshwater mussels are among the most threatened group of animals. It is critical that we consider them as we determine which landscapes or riverscapes matter to us, which in turn will help us to make informed decisions when it comes to water use, habitat restoration, water quality, and fisheries management. All of these considerations gain ever more significance as we face the challenge of increased urban and agricultural development and the threat of climate change.

STAFF PROFILE

Deedee Soto, Farm Bill Pollinator Conservation Planner



What got you interested in insects? I have a deep love of and respect for plants, and that is really what got me interested in insects: plants and pollinators go hand in hand. Growing up, I enjoyed gardening, so I would encounter insects on a regular basis. I also have fond memories of insects from my childhood summers spent in México. I recall being fascinated by dung beetles the very first time I encountered them near Puerto Vallarta. My grandmother would take us out to collect dry cow patties to burn as mosquito repellent. Seeing the beetles rolling their dung balls was incredible and sparked a curiosity to learn more. And I remember seeing the forest in Nayarit lit up at night by flickering fireflies and catching them in jars. Insects are so diverse and beautiful, they are like winged jewels flying through the air—how could you not love them!

How did you hear of the Xerces Society? I first heard about Xerces when I was working as a botany technician at the Gifford Pinchot National Forest. Part of my job was conducting bumble bee surveys; to do this properly we needed training, which was provided by Xerces conservation biologist Rich Hatfield, and I remember being thoroughly impressed by how knowledgeable he was. It left a lasting impression and desire to work with Xerces.

What music do you enjoy listening to? My parents were really into the Putumayo World Music series when I was young, and my dad enjoyed classic rock, not to mention that both of them are diehard mariachi and rancheras fans. Naturally, I too developed a love and appreciation for all kinds of music. Lately I've been listening a lot to DakhaBrakha, John Craigie, and KALEO.

What do you do to relax? I like to go botanizing! I love plants and will take any chance I can get to see and learn about them. I also enjoy reading, photography, snail mail, and cooking for my friends and family.

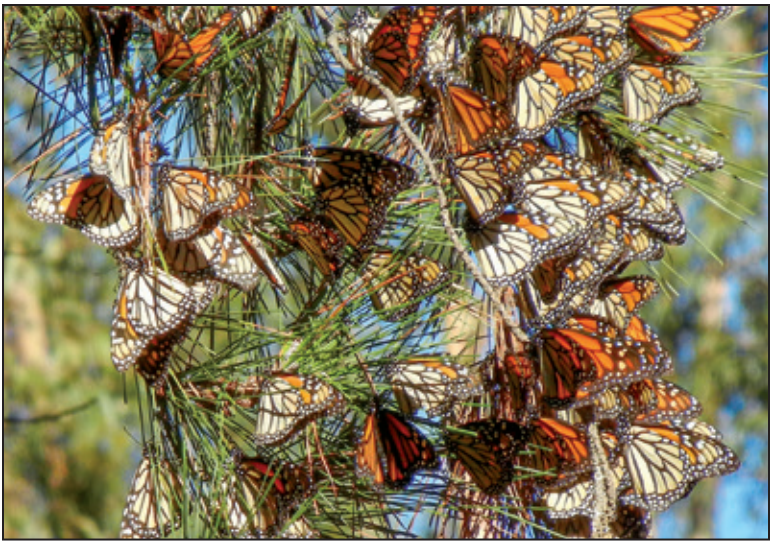
What's your favorite place to visit? So far, my favorite place to visit is Canada. I love the Canadian Rockies, the western coast, and the boreal forest. I was lucky enough to experience the northern lights while road-tripping through Canada and it was magical!

Returning Monarchs Offer Hope for Western Population

Migratory western monarchs are being reported at their overwintering sites in coastal California in greater numbers than last year, with hundreds at some sites and thousands at others, giving hope for the struggling population. These reports are particularly welcome after the population reached an all-time low of fewer than two thousand butterflies last year.

By late October of this year more than sixteen thousand monarchs had been seen at Pacific Grove and Pismo Beach, two sites that last year hosted fewer than three hundred butterflies between them. In addition, smaller estimates and observations have started to pour in from the Bay Area, Santa Cruz, Monterey, Big Sur, Ventura, Los Angeles, and elsewhere, with numbers ranging from a few to dozens to hundreds of monarchs. Altogether, there appear to be some fifty thousand monarchs accounted for at the overwintering sites, many times more than were counted last Thanksgiving.

This year's official survey begins in mid-November, with more than a hundred community scientists contributing to the annual Western Monarch Thanksgiving Count, which assesses the number of monarch butterflies overwintering at groves of trees on the Pacific coast of California and in northern Baja. Coordinated by the Xerces Society and Mia Monroe, the founder and



As more western monarchs return, we hope to see more clusters like this one from 2012. Photograph by the Xerces Society / Candace Fallon.

longtime volunteer coordinator of the annual count, it is the primary way that the status of the western monarch migratory population has been assessed for a quarter of a century.

Why are numbers looking a little better so far this year? It is almost certainly due to a combination of reasons, including favorable conditions on their breeding grounds. Populations of monarch butterflies, like those of other insects, can fluctuate from year to year, in response to temperature, rainfall, the availability of food, and other factors.

Although we are seeing an increase in the western monarch population this year, the butterfly is still dangerously close to extinction. We are a long way from being able to say that the population has recovered, and there remains an urgent need to address the threats that face monarch butterflies.

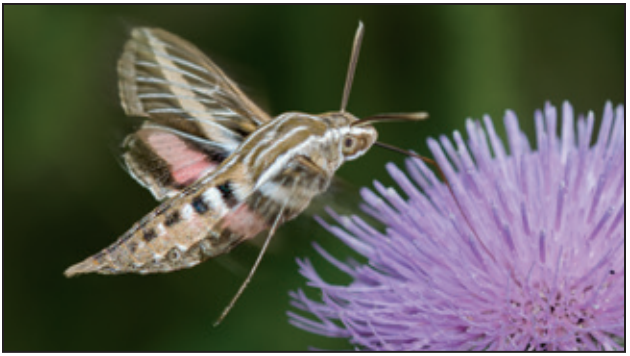
Bumble Bee Atlases Expand in the West and Midwest

More than a decade ago, the Xerces Society recognized the potential benefits that community scientists could bring to tracking bumble bees throughout North America. At that time, we were interested in four species whose conservation status was uncertain and potentially concerning: the rusty patched, yellow banded, western, and Franklin's bumble bees. The observations that were submitted confirmed what scientists had believed: the patterns of decline were troubling, and action was needed. Partially due to our advocacy informed by community science efforts, two of those species (rusty patched and Franklin's) are now officially recognized as endangered by the U. S. Fish and Wildlife Service.

Protection of the rusty patched bumble bee was made possible, in part, by the work of community scientists. Photograph by the Xerces Society / Sarina Jepsen.

Working with partners, in 2014 we launched Bumble Bee Watch to track all species of bumble bees and take advantage of a growing team of bumble bee observers. Since then Bumble Bee Watch has attracted thousands of participants who have submitted tens of thousands of observations throughout North America. This information helps conservation biologists and ecologists address questions about how we can help conserve these important animals.

While Bumble Bee Watch is definitely a success story, one thing we noticed as the database grew in the early years was that observations were following a pattern that tracked human population density and transportation corridors—a common feature of crowdsourced data. While this information



White-lined sphinx moth (*Hyles lineata*), drinking nectar in flight over thistle. Photograph by Bryan E. Reynolds.

Your Legacy for Invertebrates

A charitable bequest is one of the simplest ways to provide continuing support to the Xerces Society beyond your lifetime. Your gift will have a lasting impact on the conservation of essential invertebrates and help preserve these creatures for future generations.

We highly recommend that you discuss your planned giving options with your professional advisor in order to choose a gift that works best for you and your family. If you have questions or would like to inform us of your plans, please complete our online planned giving form at xerces.org/donate/planned-giving or send an email to membership@xerces.org.

Thank you for considering Xerces in your planning.

is useful, it is not a complete picture of how bumble bees are doing in natural areas far from human influence, places where habitat might more closely match the conditions we hope to re-create.

Therefore, in concert with a variety of state and federal agencies and university partners, we have launched a series of regional bumble bee atlas projects that enable more comprehensive surveys. The first of these, in 2018, covered the Pacific Northwest (Idaho, Washington, and Oregon) followed by Nebraska in 2019, and Missouri in 2020. In 2021 we joined with the University of Minnesota Cooperative Extension on a Minnesota bumble bee atlas, and next year we will start bumble bee atlases in California, North Dakota, South Dakota, and Kansas. These comprehensive surveys are valuable now for conservation management, and will continue be so in the years ahead as a clear baseline to which future conditions can be compared.

We are incredibly grateful for our amazing partners, as well as for the dedication of the atlas volunteers who have spent many hundreds of hours planning and doing surveys. Their time is well spent, as ultimately the bumble

bees will benefit greatly. These surveys and bumble bee observations will help land managers throughout North America make more-informed conservation and management decisions as we continue our sustained efforts to protect, conserve, and restore habitat for bumble bees and other pollinators.

Gaining Protection for At-Risk Species

In recent months, Franklin's bumble bee has been protected under the Endangered Species Act and there has been progress towards protection for three other invertebrates that Xerces staff have worked on.

Franklin's bumble bee (*Bombus franklini*) has one of the most restricted ranges of any bumble bee in the world. It is known only from three counties (Douglas, Jackson, and Josephine) in southern Oregon and two (Siskiyou and Trinity) in northern California. Its entire range is within an oval of about 190 miles north to south and 70 miles east to west. Sadly, this protection may have come too late, as the bee hasn't been seen since 1996. But it occupies a remote and rugged region with few human inhabitants, and even fewer people who are looking for it. The protected status means more funding and resources will be put toward intensive surveying of its range—including the Finding Franklin's initiative launched by Xerces and partners.

The species that have moved closer to protection are the western ridged mussel, the Siuslaw hairy-necked tiger beetle, and the American bumble bee. Each of these have received a positive ninety-day decision from the U. S. Fish and Wildlife Service. This seemingly bureaucratic action is significant because the service recognizes that protection may be warranted and thus initiates a status review of the species, an essential step in the journey toward protection.

Western ridged mussels have been dying off in rivers and creeks in Oregon and Washington. A recent announcement by the USFWS moves it closer to protection. Photograph by the Xerces Society / Katie Hietela-Henschell.

The western ridged mussel (*Gonidea angulata*) inhabits rivers and streams in Oregon, Washington, Idaho, Nevada, California, and British Columbia, but it has been lost from more than 40 percent of its range, including suffering an approximate 475-mile contraction northward in California.

The Siuslaw hairy-necked tiger beetle (*Cicindela hirticollis siuslawensis*) once lived on coastal beaches from northern California to Washington. The most recent surveys found the beetles at just seventeen sites in Oregon; in Washington, they're known to survive at only three sites. At nearly all sites, fewer than fifty individuals were located.

The American bumble bee (*Bombus pensylvanicus*) has one of the widest ranges of all North American bumble bees: the East Coast from Florida to Canada, through the Great Plains, and out into the Desert West (including parts of Mexico) and southern California. Many studies, however, suggest that this bee is declining, especially in the northern part of its range. It is listed as vulnerable on the IUCN Red List.

The American bumble bee is widespread but its population is in decline. Photograph by the Xerces Society / Ray Moranz.

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For information about membership and about our conservation programs for native pollinators, endangered species, and aquatic invertebrates, as well as our efforts to reduce the impacts of pesticides, please visit our website.

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THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

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These other-worldly creatures are rotifers—microscopic predators and scavengers that live in water films near the soil surface. Photograph by Specious Reasons, Flickr.

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On the cover: A sminthurid springtail. Springtails are tiny insects that live in the soil and can occur in densities of up to forty thousand per cubic foot. Photograph by Katja Schulz, Flickr.

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