WINGS

ESSAYS ON INVERTEBRATE CONSERVATION

THE XERCES SOCIETY FALL 2018

CONTENTS

There are many threats to the invertebrates with which we share this planet. Habitat loss, disease, and pesticide use are immediate risks, but overlaying everything is climate change, the consequences of which may unravel the fabric of our environment.

Conservation in a Changing World

Scott Hoffman Black

Whether people call it climate change, global warming, or climate destabilization, the scientific evidence is clear that our global climate is shifting: temperatures are going up, spring is coming earlier, and we are seeing more droughts, torrential rainstorms, and other severe weather events. All of these conditions put additional stress on animals that already have lost habitat to development and invasive species and are threatened by diseases and pesticides.

Climate change can feel as though it is an overwhelming issue, so all-encompassing that it leaves people unable to respond, unsure whether anything they can do will have any effect. Fortunately, though, there are actions that we can take. This issue of *Wings* is dedicated to discussing solutions that will help ameliorate the impact of future warming.

Lowering your personal carbon footprint is a first step, of course, and as a conservation organization, the Xerces Society advocates doing so. We encourage our staff to use mass transit (everyone at our main office in Portland, Oregon, gets a free transit pass), to walk or bike to work, or to telecommute whenever possible. Our office thermostats are carefully calibrated. To reduce the need for travel, we increasingly use webinars and other technology to train farmers, agency staff, and others at a distance.

Xerces' plantings in California's Central Valley are planned with climate resilience in mind; training events such as this one expose these solutions to a wider public. Photograph by Jim Cairns / NRCS.

But there are additional actions that we can all take that will add resilience—and beauty—to our landscape. There is evidence that good-quality interconnected habitat helps animals adapt and move as the shifting climate affects both the quality and quantity of their native habitat, and it is increasingly important that we work on behalf of such connections. To demonstrate how this could be done on a large scale, the Xerces Society has initiated a new project to build climate resilience for the pollinators of California's Central Valley.

We have actually been working in the Central Valley for more than fifteen years. Our initial focus was on understanding how best to implement habitat projects that would provide support for pollinators themselves, and by extension aid the farmers who need them to pollinate their crops. Through applied-research projects, we identified plant species and developed methods for site preparation and planting that maximize the success of restoration efforts and bring the greatest benefit to pollinators. Over the years, we came to recognize that plants that germinated and persisted in drought conditions performed the best in our plots, and that drought resistance will be an essential characteristic for the success and persistence of crops in a future in which droughts in the Valley are projected to continue to get worse.

We designed our climate-resilience project at a scale large enough both to make a real difference for bee populations in a pollinator-dependent agricultural region, and to demonstrate practices that could be adopted elsewhere. Working on farms is a core part of this project, and we have been helped in this effort by General Mills and its supplier farms, on which we are implementing large-scale, climate-change-ready habitat projects. We are developing holistic plans for pollinator conservation by installing hedgerows and meadow plantings made up of drought-adapted native plants that will sustain pollinator animals and the farmers who depend upon them. Because these plantings are long-lived, they will support climate adaptation by pollinators into the future.

Building upon what we're learning from these farm sites as a foundation, we are employing land-use data and information gleaned from our partners and other restoration practitioners to plan habitat connections across the rest of the Valley. Where the hills rise from the floor on either side, the landscape is less dominated by agricultural development and there is considerably more natural habitat. There are also pockets of habitat in national and state wildlife refuges and other natural areas within the Valley. By connecting these with the farm habitat via roadsides, riparian areas, and parks, we can eventually straddle the entire Central Valley. This will move us toward the ultimate goal of not just providing high-quality, place-based habitat, but facilitating the movement of pollinators across the landscape as they respond to the changing climate.

Our planet is warming, and that will undoubtedly impact insects and other invertebrates as well as the many animals and humans that depend upon them. We must act now to make sure that we protect as many pieces of the web of life as possible. The good news is that you can make a difference by planting and protecting habitat wherever you live.

A Shifting Climate Creates Winners and Losers

Scott Hoffman Black

The best summer job I ever had involved hiking the high mountains of Colorado, one of the most beautiful areas of the world, in search of one of the world's rarest butterflies—and I got paid to do it! It was the mid-1990s and the Uncompahgre fritillary (*Boloria acrocnema*) had recently been listed as endangered under the Endangered Species Act. This fritillary, with one of the smallest ranges of any North American butterfly, is found only in Colorado's San Juan Mountains, my workplace for that summer. At that time, we knew of just three confirmed sites where the fritillary lived. My job was to help develop and implement a search strategy with the goal of documenting as many additional populations of the butterfly as possible.

The Uncompahgre fritillary is associated with large patches of snow willow (*Salix nivalis*), which provide food for the caterpillars and cover for the adults. The species lives almost exclusively on northeast-facing slopes, in very cold and wet microhabitats above twelve thousand feet (roughly thirty-seven hundred meters) and just below areas of year-round snow.

Together with other members of the survey team, I spent weeks hiking up to alpine areas to search out patches of snow willow and survey likely habitat. We found just a couple of additional sites that summer. More sites have been found since and there are now eleven verified populations of this fritillary species, but participating in this survey

The Uncompahgre fritillary (*Boloria acrocnema*) lives only in the San Juan Mountains of Colorado, and only in certain microhabitats above twelve thousand feet. Climate change thus puts it at risk of extinction. Photograph by the Xerces Society / Scott Hoffman Black.

was my first real-world introduction to the effects of our changing climate. Being an ecology student, I had, of course, read about climate change. But sitting in a large patch of snow willow surrounded by little orange-and-brown butterflies that live only where there is year-round snow upslope brought home to me the impact we humans were and are having on the natural world. Due to the precarious nature of this high mountain habitat and the association between permanent snow and the fritillary's host plant, "climatic stress" was identified as a factor in protecting this butterfly under the Endangered Species Act, one of the first times that this term was used in a listing.

When people contemplate the consequences of our changing climate, they may think of species, such as this fritillary, that live in mountains and have no place to go in a warming world. The fact is, though, that many kinds of insects, living in a wide variety of ecosystems, will be affected by the changes to climate and weather. We are already observing impacts on some species that are emerging earlier or whose distributions are changing, but, with the num-

During summer many aquatic insects rely on sustained flows of cold water, conditions that will be lost with the accelerated melting of snow patches. Photographed in Glacier National Park by Eric Gross / Flickr.

The parched conditions that have resulted from California's extended drought are impacting people as well as wildlife. Photograph by John Weiss / Flickr.

ber of named species now more than one million, it is difficult to characterize how insects as a whole will be impacted. We do know that it won't be consistent: some species will benefit while most will lose out. Even within a single group of insects, the Lepidoptera, there will be winners and losers. The 160,000 species of butterflies and moths around the globe occupy habitats from sea level to mountaintops and from deserts to rainforests. Some will be able to adapt to the changes and may even thrive, while others will disappear because they can neither adjust to their altered home environment nor move their range.

The United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has produced an assessment of pollinators (of which I was one of many authors) that provides a detailed review of the literature on climate change and pollinators. The report points out that, although there is still much to learn about the potential impacts on pollinators, current science suggests that many species will not be able to respond to warming fast enough and may go extinct. The rate of change across the landscape—especially under conditions at the middle or high range of greenhouse gas emissions—is predicted to exceed the maximum speed at which many bumble bee and butterfly species can adapt or disperse.

Studies predict that the warming climate will generate changes for many insect populations as well as for the ecosystems they inhabit, and that the higher the temperatures the worse those changes will be. And there is evidence that extreme weather, also caused by climate change, is likely to have implications for insect distributions over the coming decades.

These scenarios are not just theoretical. Here at Xerces we are already seeing

Research has shown that the distribution of bumble bees is shifting in response to the changing climate. Photograph by Bryan E. Reynolds.

the impact of extreme weather on our conservation work and having to adjust our approach. During the five years we worked with the Port of Portland to plan and create a fifty-acre pollinator meadow on Government Island in the Columbia River near Portland, Oregon, the site flooded twice. These were not typical floods, but rather both were of a magnitude that should occur just once every fifty to a hundred years. Luckily, these floods did not mean an end to the meadow. Our restoration professionals changed the seed mix to accommodate periodic flooding, and the site has been successfully restored. In California, in contrast, the problem is too little water. There, a decade-long drought required us to change our plant mixes to ensure that they would survive over time, including through prolonged dry periods. Such issues are becoming routine in our work across the United States.

Aquatic insects are especially sensitive to climate change and are particularly at risk from changes in precipitation, stream flow, and water temperature. It is expected that warming will cause the number of species in aquatic systems to decline, although some may be replaced by such invertebrates as those flies and oligochaete worms that tolerate degraded habitats. Some species may adapt by moving upstream to colder waters, but many do not have dispersal capabilities or will not have habitat in which to disperse. The imperiled western glacier stonefly (*Zapada glacier*), for instance, has nowhere to go to, because the glaciers that feed its stream habitat are themselves disappearing.

Certain insects are expected to benefit from a warming world. Some mosquito species that are vectors of human pathogens may move to new areas, carrying with them the potential to spread diseases. Pine bark beetles will likely continue to expand their range, because drought-stressed trees are easier for them to attack. Warming will also

enable bark beetles to move poleward into regions that historically have been too cold for them to survive year-round. On the positive side, it is reasonable to expect that, as conditions become more favorable for mosquitoes and bark beetles, circumstances will also improve for their predators and parasites. And it is important to note that extensive campaigns of spraying or logging do not work to control outbreaks of mosquitoes and bark beetles; Xerces promotes an integrated approach to managing such situations.

Having read this far you might just want to throw your hands up in despair! There is no doubt that climate change is adding stress to an already stressed system. But there are things that people can do to help. First, we must try to minimize the emissions of greenhouse gases into our atmosphere. A recent study published in *Science* by Rachel Warren and colleagues from the University of

This mile-long wash in California's Central Valley has been planted with drought-tolerant shrubs and wildflowers, creating eight acres of hedgerows and more than sixteen acres of meadow. Photograph by Peter Allbright / Woolf Farming.

East Anglia in Britain and James Cook University in Australia finds that holding global warming to an increase of 1.5˚C over what the temperature was prior to the Industrial Revolution could still save the majority of the world's plant and animal species.

Besides working to combat the causes of global warming, we can work locally to ensure that habitat is protected, enhanced, and restored. Studies suggest that animals will fare better the more we provide high-quality habitat through targeted conservation, management, and restoration. In addition to quality habitat, though, species need corridors and "stepping stones" to allow them to move across the landscape in response to warming conditions. Restoration and diversification of habitat are necessary, but it is also important to take advantage of opportunities to manage existing habitat better. Ecologically appropriate management of forests, rivers, rangelands, roadsides, and farms is urgently needed, which includes reducing such stressors as pesticides, diseases, overgrazing, and invasive species.

Linear habitats may be particularly important to aid species in their dispersal. Recent research indicates that features such as field borders, hedgerows, green lanes, and even tree-lined avenues can act as corridors for pollinators. Although roadsides are not a substitute for wildlands, they can be valuable habitat, and, with more than seventeen million acres of land in the United States stretching across agricultural and urban landscapes, roadsides can serve as linear refuges for insect species and connect remnant habitat patches. Evidence suggests that managing and restoring habitat along roadsides, as well as in powerline corridors and other linear habitats, may aid species in moving across the landscape as the climate changes. Similarly, we need to manage habitat in and along stream corridors better to allow aquatic species to move within these wet environments.

To mitigate the impacts of climate change we need to increase the amount of high-quality and resilient habitat everywhere. Natural areas are the glue that holds all other habitat together, but for insects even small patches in connected networks within agricultural, suburban, urban, and other landscapes can be beneficial. Whether you are a gardener, a farmer, or the manager of a park or nature reserve, you can take action to protect and restore habitat. Xerces has resources to help on our website.

Insects are resilient, and improving the amount and quality of habitat for these small animals is often relatively easy compared to doing so for large or more-wide-ranging species. Moreover, by providing patches of intact habitat we are strengthening the base of food webs in ways that will help support vertebrate species as they are coping with climate change. It is likely that we will not be successful with all species, but, even so, although my grandchildren may not be able to see the Uncompaghre fritillary fluttering amid patches of snow willow in the San Juan Mountains, if we all do our part they may be able to see most of the other butterflies, bees, and other insects that help to sustain us all.

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

Are Freshwater Mussels in Hot Water?

Emilie Blevins

I still remember the very first mussel I ever picked up. It was a fatmucket—yes, that is its actual name—that I lifted from the bottom of North Elkhorn Creek, a tributary of the Kentucky River. The creek had been at flood stage just days before and the water was still too murky to see much of anything, but with my fingertips I could feel the animal tucked into the creek bottom.

Stepping into the creek, my goal had been to find a few freshwater mollusks—specifically, snails and mussels—for a research project in my undergraduate biology class. At the time, I knew nothing more than the most basic facts about the mussels I was studying: these bivalves burrow into the creek bottom using a muscular foot, breathe through gills, and filter oxygen and food from the flowing water. Only later would I learn about mussels' remarkable life history—that their larvae must attach to a fish for a brief time to complete their metamorphosis into juveniles. Nor was I aware that, of the fewer than a thousand species of freshwater mussels (order Unionoida) found globally, North America was once home to almost three hundred, and the Kentucky River system, where I stood that day, to as many as sixty.

North America has a remarkable diversity of freshwater mussels, and once supported nearly three hundred species. Photograph by Kaegan Scully-Engelmeyer.

Freshwater mussels are among the estimated 150,000 species of invertebrates inhabiting freshwater ecosystems, including insects, worms, crustaceans, mollusks, and myriad other animals. Although freshwater habitats cover a miniscule portion of the Earth's surface (less than 1 percent), they are biodiversity hotspots for vertebrates and invertebrates alike.

Water is one of our most important natural resources, and human communities depend on access to clean water to support agriculture and industry, as well as to sustain daily life. Researchers have estimated that, globally, 90 percent of the world's population lives within six miles (ten kilometers) of a lake or river. Our reliance on water is also evident in our use and management of water bodies, with, for example, dams affecting an estimated 60 percent of large river basins worldwide. Humans have had a profound effect on freshwater ecosystems and the species that rely on them. Of these, mollusks are the most threatened, particularly freshwater mussels: about thirty North American species have already gone extinct and around two hundred more are thought to be imperiled. In the Kentucky River system where I found the fatmucket, the number of different species of mussels has declined by nearly a third over the last century.

Conservation efforts for freshwater mussels, already challenging because of the demands upon fresh water from farming, industry, and human settlements, must now also contend with the threats posed by the warming climate. The impacts will result both from the changing environment and from our response to those changes, including

When streamflows are reduced, freshwater mussels are left exposed and vulnerable to drying out and predation. Photograph by the Xerces Society / Emilie Blevins.

our choices for managing water bodies and associated habitat.

You might wonder how climate change could affect freshwater mussels. To help answer this question, researchers have observed and evaluated how mussels respond to increasing water temperatures, decreasing river flows, drying habitat, and the increasing severity and variability of flooding events and drought—all of which are happening as a result of the warming climate and shifting patterns of precipitation.

Higher water temperatures can stress freshwater mussels by reducing their ability to burrow, which they need to be able to do in order to prevent emersion (becoming exposed to the air when water is low), escape predation, or avoid fast flows that can wash them into unsuitable habitat. High water temperatures can also affect their ability to breathe, feed, grow, and reproduce, and ultimately lead to higher rates of mortality. It can be hard to anticipate the full consequences of rising water temperatures because the upper thermal limits that most mussels can withstand are largely unknown. Complicating our understanding is the fact that not all mussels are alike, with some species better adapted than others to warmer water temperatures. Unfortunately, research led by Tamara Pandolfo of North Carolina State University suggests that water temperatures in some places may already be at or above temperatures that threaten the survival of various species of freshwater mussels.

Droughts are also expected to increase in severity, and not only do they lead to reduced streamflow and the consequent warming of water temperatures, they also contribute to lower levels of dissolved oxygen (which is critical to gill-breathing species, including fish, snails, and freshwater mussels), and the drying of habitat. Droughts are thus a major concern for freshwater mussels: researchers with the U. S. Forest Service found that a severe drought that occurred in the year 2000 in the southeastern United States led to reductions of as much as 83 percent in mussel density in small streams, with rare species among those hardest hit. Even mussel species that were common were affected when the streams in which they lived ceased flowing. In comparison, mussel communities in larger streams that maintained flow during the drought did not suffer similar losses in abundance or species.

Freshwater mussels feed and breathe by pumping water through their bodies. Photograph by Roger Tabor / USFWS.

Complicating matters further is the critical link between freshwater mussels and their host fish. Some species of

As larvae, freshwater mussels must attach themselves to fish such as this cutthroat trout in order to complete their metamorphosis. Photograph by Roger Tabor / USFWS.

mussels are generalists, and during the larval stage could use any of a number of different species of fish to complete metamorphosis. Other mussel species, in contrast, require particular fish species or species groups. Where climate change reduces the abundance of host fish, shifts their distribution, or alters the time of year when they are present, mussels that specialize on those fish will suffer consequences in future generations, and this is particularly the case for mussels that are already rare or are confined to a small range such as a single river system.

These are just some of the impacts on mussel populations and species that may be brought about by the changing climate, and this is concerning for many reasons. Freshwater mussels provide important ecosystem services to natural aquatic communities and to human populations as well, including improving water quality by removing chemical contaminants and such disease-causing organisms as *E. coli* bacteria. Mussels also filter and concentrate nutrients in ways that can make them available to other aquatic species throughout entire food webs, from microorganisms

to aquatic insects to fish. As researchers in Oklahoma found, when freshwater mussel communities are impacted by drought and associated human decisions about water management, their ecosystem services are also diminished.

Given this potentially bleak outlook, it might be easy to forget the many ways that we can act now to conserve freshwater mussels and the ecosystems in which they live. Key to this action is management of our freshwater resources, which must be geared toward providing water for natural communities as well as human ones. This extends to both the quality and quantity of water and includes maintaining appropriate water levels, flows, and temperatures.

At an individual and community level, good management means reducing pollutant inputs as well as decreasing water consumption. (For example, you could ask yourself how green your lawn needs to be.) Other practices can also be implemented to restore freshwater ecosystems, such as removing defunct dams to reconnect aquatic habitat, and converting water rights to increase instream flows for the benefit of fish and wildlife. Now and into the future, there will be growing pressure to pump groundwater and impound or capture surface water for agricultural, industrial, and residential uses, especially during droughts. With inclusive planning we can ensure that wise water decisions are made to protect our natural heritage while supplying immediate human needs.

We are already considering the changing climate as part of our work at Xerces in conserving freshwater mussels of the western United States. Datasets are now available that predict water temperatures under future climate scenarios, provide information on existing threats to mussel resiliency (such as dams, culverts, roads across creeks, and other barriers that may limit movement and connectivity of populations), and help to inform priorities for restoration and conservation.

Using this and other information—including data from the Western Freshwater Mussel Database developed by Xerces together with our partner, the Confederated Tribes of the Umatilla Indian Reservation—we are conducting an analysis to identify watersheds with the potential to serve as future climate refuges for freshwater mussels. When complete, this analysis will guide our conservation efforts toward key areas that will have the greatest benefit for western mussel species.

We have also identified other strategies to focus our conservation efforts for freshwater mussels in the western part of the continent. For example, we share location information from the mussel database with agencies and other organizations for inclusion in impact assessments, restoration or construction plans, and biological survey initiatives, to help ensure that existing mussel populations are protected. Through our recently released conservation guidelines for freshwater mussels, we provide best management practices for existing populations in western watersheds and beyond. So here's to preserving these species for the next generation, whether in the western United States, North Elkhorn Creek, or anywhere else.

Emilie Blevins is a conservation biologist in Xerces' endangered species program.

Mitigating the Effects of Heat On Urban Pollinators

Angela Laws

In June, in Sacramento, California, I participated in the presentation of a Xerces short course on creating urban pollinator habitat. Before the class started, we spent some time netting pollinators to show to the participants. It wasn't long before we had found sweat bees, wool carder bees, mining bees, bumble bees, and, of course, honey bees—all in the middle of the city.

Indeed, many urban environments are home to large and diverse communities of native bees. A recent study by Paul CaraDonna and colleagues shows that bumble bees have higher survival and reproduction rates in towns and cities compared to farmland. But we also know that bees are sensitive to temperature, and that temperatures in cities are higher than they are in more natural areas, due primarily to large expanses of impervious surfaces, such as concrete and asphalt, that cause an "urban heat island" effect.

Climate change will continue to bring higher temperatures and greater extremes in weather, as well as increases in the frequency and intensity of heat waves. Thanks to the urban heat island effect, these variations will be exacerbated in cities in ways that may spell trouble for bees. Increasing temperatures can affect bee performance by changing phenology (the timing of biological events such as the rate of development or the date of emergence), and reducing survival rates, body mass, fat storage, and reproduction—and can ultimately result in fewer bees. Research by April Hamblin and colleagues at North Carolina State University, for example, showed that bee abundance in the city of Raleigh declined 41 percent with every 1˚C increase in temperature.

Pollinators are affected by climate change in a variety of ways. Some species will shift their ranges to track more optimal conditions, provided that they have habitat to move to and through. Other shifts could be problematic if pollinator emergence times or rates of development become misaligned with the flowering times of their host plants. Plants will also respond to the changing climate, and alterations in available flora, including plant diversity and community composition, are likely to have knock-on effects on pollinator populations. Increasing temperatures and greater drought frequency can affect the number of flowers a plant produces as well as the amount of nectar and pollen in each flower, thereby reducing the number of pollinators that an area can support. Moreover, the effects of climate change will combine with other drivers of species declines, such as habitat loss, pesticide use, and disease, which can interact in unexpected ways that may be difficult to predict. The combined interplay of multiple drivers may lead to outsized negative effects on pollinators.

Notwithstanding the potential for the effects of climate change to be amplified in cities, urban habitats can also present unique opportunities. Several years ago, I came across Michael Rosenzweig's book *Win-Win Ecology*, in which he points out that nature preserves alone are not sufficient to safeguard the Earth's biodiversity and suggests that we should change the way we design human habitats so that those areas serve to protect biodiversity as much as possible. In other words, we have to get better at sharing spaces. Urban environments provide a perfect opportunity to put this idea into practice.

What actions can we take to help urban pollinator communities become more climate-resilient? The first is to create and preserve habitat. Enhancing and restoring habitat is crucial to protecting biodiversity because high-quality patches, particularly when connected, have many benefits for wildlife. Connections enable individual insects to move among populations, increasing genetic diversity and perhaps helping to rescue declining populations. These patches also provide habitat for species to move to and through as they shift their ranges in response to climate change. Finally, increasing habitat and connectivity can allow populations to grow, which is important because small populations are more likely to disappear than are large ones. You can create habitat by adding a pollinator garden to your yard or balcony. If you don't have a yard, consider talking to local park managers about installing pollinator gardens. Many schools, churches, and businesses are also planting gardens on their properties, and you can offer them encouragement and support.

Your pollinator habitat will be most beneficial if it contains a variety of different flowers and includes native species. Aiming to have a few different species blooming at all times from early spring to late fall will support a diversity

Bees thrive in warm, sunny conditions. The combination of climate change and the urban heat island effect, however, may make conditions too warm and, ultimately, result in fewer bees. Photograph by Bryan E. Reynolds.

Seemingly small actions, such as planting pollinator gardens in whatever spaces are available, will have a significant impact on making our towns and cities better for bees. Photograph by the Xerces Society / Matthew Shepherd.

of pollinators and may help buffer the effects of timing mismatches between pollinators and host plants. It is ideal to incorporate native plants into your garden as much as possible; they typically are better adapted to local conditions, and research indicates that they may attract more native bees than do ornamental and nonnative plants. Check out Xerces' pollinator plant lists to find ideas for native plants that will attract pollinators in your area. Be sure not to forget butterflies and moths and to provide host plants for their caterpillars.

Native bees will benefit from the inclusion of nesting habitat in your pollinator garden. Leaving some bare soil will be helpful for ground-nesting bees, while retaining snags and downed logs, and growing pithy-stemmed shrubs such as elderberry, help to create natural sites to harbor wood-nesting and cavity-nesting bees.

Reducing the use of pesticides should be part of planning your garden or habitat, including avoiding the use of plants that have been pre-treated with neonicotinoids (widely used insecticides that are absorbed by plants and remain in their tissues long after application). Pesticide reduction is important for mitigating the effects of climate change, because multiple stressors can build upon each other. While exposure to some particular pesticide may not be lethal to pollinators, exposure to that pesticide in combination with a heat wave or reduced flower availability may become deadly. Reducing pesticide use in our communities helps to alleviate one of those stressors for pollinators as well as other organisms, making these

populations more climate-resilient.

Beyond creating habitat, look for ways to mitigate the urban heat island effect. Cities can reduce temperatures by installing rooftop gardens and by planting more vegetation and trees. In some regions, painting rooftops white can help. Policies that promote green infrastructure—ecoroofs, bioswales, etc.—in your community can mitigate some of the heat island effect as well, all of which can help pollinators and other wildlife. Depaving—removing impervious surfaces and replacing them with gravel or plants—reduces temperatures, increases infiltration when it rains, and has the added advantages of lowering flood risk and lessening the amount of pollutants that make it into our waterways. The organization Depave has a variety of resources for people interested in reducing the amount of impermeable surfaces in their communities.

These steps can help offset some of the negative effects of climate change on urban pollinators, but it's also imperative that we work to constrain the magnitude of climate change itself. A team of scientists from Britain's University of East Anglia and Australia's James Cook University, led by Rachel Warren, analyzed the effects of limiting future warming to 1.5˚C, 2˚C, and 3.2˚C above preindustrial levels. Recently published in *Science*, their study found that insect biodiversity is strongly affected by the amount of warming. If temperatures rise 3.2˚C—the level we will reach if no further emissions reductions are made beyond those set for 2030 in the Paris Agreement—then an estimated 49 percent of all insects will suffer a reduction in range of more than half. The effect of restricting warming to 2˚C or 1.5˚C dramatically cuts the number of insects predicted to suffer such reductions: at 2˚C, it is 18 percent of insects, and at 1.5˚C, just 6 percent. Reduction in range and the corollary loss of available habitat is an important metric because reduced range means smaller populations, which make a spe-

Native plants are typically preferable for supporting native insects such as this common buckeye (*Junonia coenia*). Photograph by Bryan E. Reynolds.

cies more vulnerable to extinction. You may be wondering how such a seemingly small temperature difference can have such large effects, but it's important to remember that these differences are not actually small. The numbers do not refer to changes in average local temperatures, but to changes in average *global* temperatures. To give context to those numbers, the difference in average global temperature between a warm period and an ice age is only around 5°C.

Recently, I was talking with our director of communications and outreach, Matthew Shepherd, about our work toward boosting the climate resilience of pollinators in California's Central Valley by increasing habitat connectivity. Matthew pointed out that we're not just connecting habitats, we're also connecting people and communities. He's right about how important this is, because the challenges posed by global climate change are enormous—and those challenges can only be met by a large number of people working together to overcome them. There are small actions that we can take every day to make a difference and, over time, our small actions, combined with those of our neighbors, add up to become substantial. It is valuable to keep this idea in mind as we each find ways to reduce our carbon footprints and advocate for action. By coming together with others in our communities who care about climate change—and working to increase the numbers of those who care—we will be able to bring about the changes that are needed before it's too late for our pollinators.

Angela Laws has a background in climate-change research and is a monarch and pollinator ecologist with Xerces' endangered species program.

Even in densely developed areas, room can be made for natural habitats. Tanner Springs Park in the Pearl District in Portland, Oregon, incorporates prairie and wetland. Photograph by the Xerces Society / Matthew Shepherd.

STAFF PROFILE

Angela Laws, Monarch and Pollinator Ecologist

What got you interested in insects? I've wanted to be a scientist since I was five. First I wanted to be an astronomer, then a paleontologist. There was a brief spell where I wanted to be a geologist. By high school, I had settled on ecology. I loved spending time outdoors and I cared about environmental issues, so it felt like a perfect fit. But I didn't really think much about insects until college. As an undergraduate I had the opportunity to do a Research Experience for Undergrads project, studying grasshoppers at the National Bison Range in Montana. It's a beautiful place. I loved doing field work and discovered that I also love insects. They are fascinating and they make such great study organisms! You can do a lot of neat manipulative experiments with insects that you can't do as easily with vertebrates. I was hooked.

How did you hear of the Xerces Society? I first heard about Xerces when I was in graduate school. My advisor's wife, who organized and ran his lab, was a member. One day she showed me the newest issue of *Wings* and told me about Xerces, which put it firmly on my radar.

What's the best thing about your job? Xerces has such a fantastic reputation for science-based conservation and has been doing such terrific work for decades now. I love being part of that. The people I work with are great—everyone is so knowledgeable and easy to work with. I love that I get to do outreach, which is something I've always enjoyed.

I also love that I get to work on conservation related to climate change, which is an issue that is really important to me.

Who is (or was) your environmental hero? I have a huge nerd-crush on David Attenborough. I think that the work he's done to get people excited about all the wonderful biodiversity out there goes a long way towards getting people to care about protecting it. In the ideal version of my life, David Attenborough and I are BFFs and we travel the world together looking for cool plants and animals.

Who's in your family? My husband, Eric, and two elderly cats, Nigel and Bean.

What music do you have on your iPod? Mostly rock and blues. I love Stevie Ray Vaughan and Muddy Waters. My favorite album is Eric Clapton's *Unplugged*. There is no country music on my iPod.

Lincoln Brower: A Life Well Spent

Scott Hoffman Black

I first met Lincoln Brower in 2002, when both of us were presenting at a conference. He was speaking about monarch butterflies and I was talking about the Xerces Society and insect conservation. Earlier, as a young student of ecology, I had known of Lincoln and his work from reading many of his papers. The most memorable was the 1967 study with the famous cover showing a blue jay throwing up after eating a monarch caterpillar. Monarch caterpillars feed on milkweeds, plants that contain chemicals called cardiac glycosides that the insects absorb. While the toxins do not harm the butterflies, they give monarchs a bitter taste that can cause vomiting in birds that feed on them.

Although the "barfing blue jay" cover had grabbed my attention, it was the substance of Lincoln's work that really made me take notice. His early research on insect adaptive coloration led to collaborations with chemists and ecologists in exploring the chemical ecology of milkweeds, monarch butterflies, and bird predators. He authored or coauthored more than two hundred scientific papers.

Lincoln first began studying monarch butterflies as a graduate student at Yale in the 1950s. He maintained a focus on monarchs throughout his career in teaching and research, first at Amherst College, then at the University of Florida, and finally at Sweet Briar College, where he remained until his death. After the overwintering sites in Mexico were located in the mid-1970s, his attention shifted to understanding the monarch migration and then to protecting this remarkable phenomenon.

In addition to being a great scientist, Lincoln was also an ardent conservationist. As an idealistic graduate student, I had been talking at conferences about why scientists needed to speak out on conservation and policy issues and make sure that their scientific ideas and data were infused into the conservation debate. I had some teachers, though, who felt that scientists should not take positions and should try to be "neutral." Lincoln was an example of a top-notch scientist who also felt it important to speak out about conservation issues—someone I very much looked up to even before I met him.

As one of the first scientists to advocate on behalf of monarchs, Lincoln pushed to end excessive logging at overwintering sites. In the 1980s he worked with community groups and nonprofit organizations in Mexico and with the Mexican government, to establish sanctuaries to protect the crucial Oyamel fir forests where the butterflies overwinter. This was also the time during which he became involved with the Xerces Society, joining founder Robert Michael Pyle in helping to guide the Society's early monarch efforts. Lincoln was a staunch

defender of the butterflies, never shy about speaking up if he felt that they were not being adequately protected, whether it was calling out the Mexican government for failing to prevent illegal logging in the sanctuaries, or railing against the large-scale use of "Roundup-ready" corn and soy in the United States, which, because of their role in the loss of milkweed in midwestern fields, are implicated in the precipitous decline in monarch populations.

Lincoln Brower's advocacy for monarchs continued throughout his life. In 2014, he joined with the Center for Biological Diversity, the Center for Food Safety, and the Xerces Society in submitting a petition seeking federal protection for the butterfly. We do not yet know whether monarchs will receive federal protection, but the petition has resulted in an unprecedented effort to conserve them.

I was a little nervous when I met Lincoln all those years ago. I need not have been, as he was an incredibly nice and generous person. These are the qualities that I will remember most. Here was a man who did so much, but who in person was just very selfless and down to earth.

We at Xerces are all saddened by Lincoln's passing, and many staff and colleagues have been sending emails expressing what he meant to them. This message from Sarina Jepsen, director of our endangered species program, sums it up well: "I have had the good fortune of working with Lincoln on monarch conservation and meeting him in person on a few occasions. In addition to being an amazing—even legendary—scientist and a passionate advocate for monarchs, I found him to be genuine, approachable, and not at all pretentious. He will be missed."

Photograph by Linda Fink.

American Public Supports the Endangered Species Act

Congress passed the Endangered Species Act in 1973 on a bipartisan vote, and it was signed into law by President Richard Nixon in December of that year. Since then, 99 percent of species listed under the ESA have been saved from extinction. Despite such success—or maybe because of it—demands have persistently been made for the act to be revised. Every year at least one member of Congress advocates revising the Act, with the number of proposals increasing in recent years. This July the current Administration put forward significant changes, despite the fact that the great majority of Americans support the ESA in its present form.

The Karner blue has been helped toward recovery, thanks to the Endangered Species Act. Photograph by aecole2010 / Flickr.

A study led by Jeremy Bruskotter of Ohio State University and published in *Conservation Letters* looked at how opinions have changed in the last two decades by reviewing previously published research and commissioning a new survey. The researchers found that the percentage of people supporting the ESA varied from a low of 79 percent in 2014 to a high of 90 percent in 2015, and that opposition was highest in 1996 (16 percent) and lowest in 2015 (7 percent).

The level of support from people who identified themselves as liberal was higher (90 percent) than from those who self-identified as conservative (74 percent). Overall, the data showed that roughly four in five Americans support the ESA and only one in ten want changes. This degree of support has been consistent over the last two decades.

Balancing Housing and Wildlife in Britain

The British government has a target of building a million new homes in the next four years. This is challenging in a country that is already densely developed and that has a tradition of protecting countryside and wildlife. To help guide how such growth can be accomplished in a sustainable manner,

the Royal Society of Wildlife Trusts has published *Homes for People and Wildlife: How to Build Housing in a Nature-Friendly Way*. The report highlights the losses in habitat and declines in wildlife populations over the last half century or more, and provides a framework for meeting the need for additional housing in a way that also provides homes for wildlife.

The Royal Society urges developers to retain existing meadows, hedgerows, woodlands, and wetlands by designing housing around them; to create new habitat to buffer and connect existing areas; and, when loss of habitat or damage to it is unavoidable, to compensate by replacing it with more than was lost. The result is a "network of natural green and blue corridors weaving through the development and beyond, into the surrounding urban or rural landscape and contributing to the wider ecological network," which benefits the developers, the new residents, and wildlife.

Are Towns or Farms Better for Bumble Bees?

By measuring the growth in colonies of bumble bees in a variety of landscapes, a team of scientists lead by Ash Samuelson at Royal Holloway, University of London, showed that bumble bees in villages and urban locations fared better than those on farms.

More than forty newly founded colonies were placed on farms, in villages, and in urban areas from downtown business districts to suburban gardens, and then monitored throughout the summer. Each week the number of bumble bees, the status of the queen, and the presence of food stores were measured. Farm colonies were found to have fewer bees and less stored food, to produce fewer reproductive queens and males, and to reach the end of their life cycle more quickly.

Two Important Passages

Two giants of invertebrate conservation passed away this summer.

Dr. Thomas C. Emmel died in his sleep on May 26, during one of his many trips to Brazil. Among his massive contributions to butterfly studies, Professor Emmel worked for decades to restore Schaus' swallowtail, the Miami blue, and other rare species. In 2004, Tom founded the McGuire Center for Lepidoptera and Biodiversity at the University of Florida, one of the premier locations in the world for the study of butterflies and moths. A former board member, he was always a great supporter of the Xerces Society.

Dorothy McKey-Fender passed equally peacefully on July 24, at the age of 102. Widow of lepidopterist Kenny Fender (namesake of the Fender's blue), Dorothy was herself an important biologist. After assisting James McNab of Linfield College in his foundational ecological studies of Oregon's Coast Range, she went on to spend decades studying worms. She and her son, Bill Fender, became the greatest authorities on West Coast earthworms; the efforts to locate and conserve the Oregon giant earthworm owe directly to their work on the native annelids and their habitats.

—Robert Michael Pyle

Year-Round Impact

Advocacy, education, training, and habitat restoration are at the core of the Xerces Society's efforts to protect and restore populations of insects and other invertebrates. These activities are often intertwined. Our work in advocating for species using the Endangered Species Act often leads to real protections, and we also facilitate habitat restoration projects specifically to help recovery.

Our education and training events help us to meet farmers, land managers, elected officials, and gardeners who are ready to take action to create, protect, and restore habitat, and to work to change habits with regard to pesticide use. By collaborating with others, we can make the biggest gains for these small but vitally important animals. Here are just some of the outcomes from the last year.

- 270,000 acres of pollinator habitat were created or restored with the Xerces Society's support. Since 2008, we have restored 692,000 acres.

- Our effort to protect the rusty patched bumble bee has led to better protection and management for this species on more than 570,000 acres.

Xerces collaborated with staff and students at the North Carolina A&T State University research farm to plan and plant a 160-foot-long hedgerow. The planting supports pollinators and natural enemies of pests, shelters the farm from winds, and showcases native plants to inspire visitors interested in enhancing diversity on their farms. Photograph by the Xerces Society / Nancy Lee Adamson.

Wildflower strips along field borders bring habitat far into Sarah Woutat's organic vegetable farm, supporting pollinators and other beneficial insects. Photograph by the Xerces Society / Sarah Foltz Jordan.

♦ More than twenty-one thousand people learned how to protect pollinators and other beneficial insects.

♦ Our advocacy in conjunction with a coalition of groups has led to the restoration of more than a million acres of monarch butterfly habitat on public and private lands.

♦ Xerces' pollinator conservation staff provided more than three hundred farms with technical assistance to support their conservation projects for pollinators and beneficial insects.

We would not be able to accomplish our work without the support of our members and partners. Thank you!

Working with farm director Ashley Minnerath and farmer Clay Godbolt at Cascadian Farm in Washington state's upper Skagit Valley, Xerces designed the site-preparation process for this quarter-acre meadow using only organic practices. Photograph by Mari Lee-Mäder / Northwest Meadowscapes LLC.

Cloudless sulphur (*Phoebis sennae*), photographed by Bryan E. Reynolds.

Your Legacy to Protect the Life that Sustains Us

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 to preserve these creatures for future generations.

We highly recommend that you discuss your planned giving options with your financial or legal advisor in order to choose a gift that works best for you and your family. The Xerces Society does not render tax or legal advice. To notify us of a gift you have planned, please email us at membership@xerces.org or call 503-232-6639, option 2.

Bequests can be made to: The Xerces Society, Inc., 628 NE Broadway, Suite 200, Portland, OR 97232. Our 501(c)(3) Tax ID number is 51-0175253.

Thank you for your support!

Xerces Society Has Its Busiest Summer Ever in 2018

Technology allows us to reach a vast number of people across a large geographic area, but there is still no better way to share information and enthuse individuals than through events, and this summer has been the busiest season ever for Xerces staff to present workshops, lead walks, and give talks. Even with our growing staff, it is difficult to accept all the invitations we get, but we have been at multiple events every week.

Xerces' pollinator conservation short course is a day-long workshop that covers all aspects of pollinator protection, from understanding the natural history and habitat needs of bees to ways

to create flower-rich meadows and manage pesticides. We continue to offer this presentation to farmers and farm agency staff in many states, and we now also have a companion short course on conservation biocontrol, with instruction on techniques for supporting predators, parasitoids, and other beneficial insects (as well as spiders!) as part of a program of integrated pest management.

We began a new series of pollinator short courses in towns and cities, presenting to gardeners, park managers, and others who care for urban or suburban greenspaces. And we gave a number of briefer presentations to audiences from community groups and garden clubs to attendees at professional conferences for managers of power lines and roadsides. We also led farm walks and other participatory activities.

This summer has seen our first series of workshops about bumble bee conservation in the Pacific Northwest. We partnered with the Idaho Department of Fish and Game, Oregon State University, and the Washington Department of Fish and Wildlife to launch a three-year project to create a regional atlas of bumble bee distributions. Our biologists have been traveling the Northwest, providing conservation guidance and training community members to survey and record bumble bees.

Xerces' work goes far beyond beneficial insects, and so do our events, including workshops focused on freshwater mussels in the Pacific Northwest and surveys in local streams.

There are many more activities in the coming months. See the events page on our website for more information.

Reflecting the growing concern about invertebrate populations—and made possible by our growing staff—Xerces was able to attend or present at more events than in any previous summer. Photograph by the Xerces Society / Laura Rost.

Much is known about where monarch butterflies overwinter, but for monarchs west of the Rockies little is known about their migration routes or where they breed. New research is helping to change that. Photograph of a monarch caterpillar on milkweed by the Xerces Society / Stephanie McKnight.

Monarch Conservation in the Western United States

It might seem that monarch butterflies have been well studied, but there are significant gaps in knowledge, particularly about those in the western United States. In the summer months, monarchs can be found across the West from California to Washington state, inland through the intermountain west to Montana, and south to New Mexico and Arizona. In contrast to monarchs in the eastern United States, though, we have had no comprehensive picture of where western monarchs go in summer, including which areas they use for breeding and the routes they take during migration.

That situation is changing thanks to a partnership between the Xerces Society, the U.S. Fish and Wildlife Service, and the University of Nevada at Reno. Together we have developed models for monarch breeding and the suitability of milkweed habitat. This process did not come about overnight, as it was necessary to assemble a tremendous amount of information on monarchs and their milkweed host plants just to begin to understand habitat suitability. The Xerces Society began compiling records of milkweed and monarchs from biologists, land managers, and herbaria in 2011. Since 2015, we have collaborated with the Pacific Region of the USFWS, the Idaho Department of Fish and Game, the Washington Department of Fish and Wildlife, and others to gather additional data.

The modeling demonstrates that suitable breeding and migratory habitat is widespread across the West, and that there are notable concentrations of habitat that is potentially highly suitable in California's Central Valley as well as in southern Idaho and eastern Washington. The Central Valley and the adjacent foothills of the Sierra Nevada are particularly important, because it is likely that monarchs pass through these areas on both their spring and fall migrations between overwintering areas in coastal California and states in the interior West and the Pacific Northwest. Northern Nevada, southern Arizona, parts of Utah, and most low-elevation lands in eastern and southern Oregon also offer potential habitat.

These models have a practical application. States agencies and the USFWS are incorporating monarch habitat into planning efforts and identifying important areas for additional monitoring and data gathering. The Western Association of State Fish and Wildlife Agencies is using the models to inform its monarch conservation efforts and to guide the work of several states.

The models have also been invaluable in helping Xerces identify areas in which to invest in monarch conservation across the West. We have initiated a large project to develop and implement restoration plans at overwintering sites along the California coast, and we work with farmers, agencies, and others to restore breeding and migration habitat in California's Central Valley and other key areas.

Western monarchs have declined by more than 95 percent over the last thirty years, and having this type of information is vital as we work to target available resources to achieve the greatest benefits for monarch conservation.

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

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In the Swiss Alps, the six-spot burnet moth (*Zygaena filipendulae*) is moving upslope in response to warming conditions, although in some areas it is blocked from doing so by towns or other development. Photograph by Rolf Dietrich Brecher / Flickr.

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On the cover: Climate change is leading to warmer waters, dried-up creeks, and increasingly severe floods, all of which impact freshwater mussels, such as the floater (*Anodonta*) shown here. Photograph by Roger Tabor / USFWS.

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