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A Look at the Science of Insect Conservation

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Monarch butterflies (*Danaus plexippus*) migrate great distances to gather in their winter breeding grounds. The species is currently under consideration (https://www.fws.gov/savethemonarch/ssa.html) for endangered species status in the United States. (Photo credit: Candace Fallon, Xerces Society)

By Evan Bourtis

As a teenager, conservation biologist Scott Black liked to drive down Nebraska roads in his 1971 Mustang Mach 1. Black was constantly cleaning his windshield from the insects that

splattered as they crossed his path in the country roads near Omaha. In the early 2000s, after becoming executive director of Xerces Society for Invertebrate Conservation, Black returned to his home and noticed something was missing. "I started to notice that, when I went back with my kids in 2004, I could drive all across Nebraska and rarely see an insect. Some insects would be splattered on the front of the car, but it seemed really different," he says.

Black became interested in insects from a young age after seeing the diversity of species in an undeveloped meadow near his house. When returning home, Black noticed that, rather than seeing hundreds of monarch butterflies as he did in youth, he saw dozens. He also noticed that other species that were once common were becoming rarer. "Around street lights where I used to catch big beetles when I was kid in the middle of summer, you didn't see nearly as many anymore," he says.



Evan Bourtis

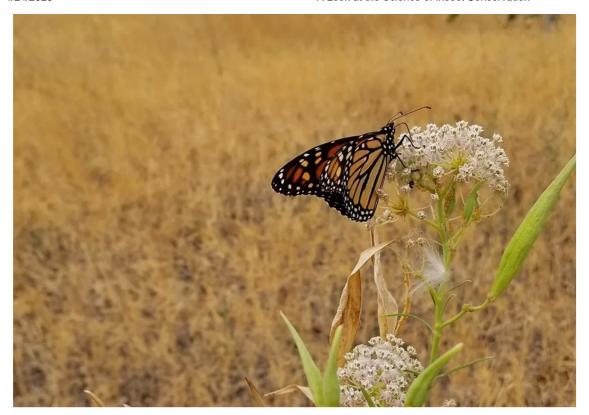
In 2004, Black started talking to members of the Xerces Society about his observations. Two years later, data revealed that beekeepers across the United States were beginning to suffer large-scale colony losses, known as colony collapse disorder. "At that point, it started to wake up not just the public but scientists to look at what was going on with insect populations," he says.

Since then, a series of studies have raised concerns about insect declines (https://onlinelibrary.wiley.com/doi/10.1111/csp2.80) and whether it might be happening at a global scale. This has added momentum to scientists' efforts to investigate the unanswered questions about the possibility of long-term declines in some insect taxa, as well as conservation strategies for vulnerable insect species.

One researcher who has helped to reveal declines in insect populations is Cheryl Schultz, Ph.D., associate professor of biological sciences at Washington State University Vancouver. Schultz used citizen science data to study populations of the western monarch, a subpopulation of the monarch butterfly (*Danaus plexippus*). Western monarchs migrate to California annually to overwinter in coastal groves. In her study

(https://www.westernmonarchcount.org/wp-content/uploads/2014/11/Western-monarch-PVA_Schultz-et-al.-2017.pdf), Schultz analyzed data reported by the Xerces Society, collected from 1997 to 2016, about monarch populations in the coastal groves, as well as some older data. Schultz found that the average abundance of the western monarch in 2016 was less than 5 percent of the abundance in the 1980s. "What we think we're seeing is a long-term decline related to threats of habitat loss and pesticides," she says.

Schultz explains that one of the most likely reasons for the declines is the destruction of overwintering groves and breeding areas. "They [monarchs] overwinter in these tiny coastal groves, and there's been continuous development along the coast," she says. In addition, as more of California and other parts of the west have been converted to agriculture, there has been more pesticide use and less space for the milkweed that monarchs depend on to complete their life cycle.



The monarch butterfly (*Danaus plexippus*) is currently under consideration (https://www.fws.gov/savethemonarch/ssa.html) for endangered species status in the United States. (Photo credit: Stephanie McKnight, Xerces Society)

However, Schultz believes there is hope for insects facing extinction risks, such as the western monarch. The key to conserving insects, she says, is combining scientific data with action through management. Research is critical to understand the characteristics of a species, but to preserve populations such knowledge must be combined with action from land managers, policy makers, and the public.

Schultz has seen how her research has driven conservation efforts to recover species, such as for the butterfly *Icaricia icarioides fenderi*, sometimes known as the Fender's blue. "For the Fender's blue, the low in the 1990s across the entire species was about less than 1,500. And now the numbers are fluctuating as high as 25,000-30,000 across their ranges," she says. "We've done that for Fender's blue through a combination of focused science and people working together to use that science."

What Drives Insect Declines

Scott McArt, Ph.D., assistant professor of entomology at Cornell University, has researched the decline of pollinators, particularly bumble bees, across the United States. He says he believes that a lot of the reasons why pollinators are declining also apply to other insects. "Often times, the first thing that I'll say in a presentation I'm giving on pollinator health is that these bee declines that people have been noticing for several years are not just for bees. Bees are likely just the canary in the coal mine for all or most insects," he says.

McArt explains that insect declines aren't typically caused by one factor but rather many factors interacting. One of these is habitat loss, as environments necessary for insect life

cycles are altered to fulfill human needs, like agriculture, extraction of resources, or commercial development.

The American burying beetle (*Nicrophorus americanus*)—a species famous for dragging the carcasses of small mammals into the ground, where a female lays her eggs—is one example of a species that's been impacted habitat destruction. The beetle was abundant across the United States before the 1920s, but has since declined by 90 percent from its historic range. "I think it's safe to say that one of the major impacts across its range is intensive agriculture," says Douglas Leasure, Ph.D., formerly a postdoctoral research associate at the University of Georgia and now a WorldPop Research Fellow at the University of Southampton in the United Kingdom, who has studied the beetle since he was an undergraduate. "And intensive agriculture tends to develop in prairie habitats, which are home to the beetle, rather than mountainous forest areas."



The American burying beetle (Nicrophorus americanus) is federally listed endangered species in the United States.

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Overuse of agrochemicals, such as insecticides, herbicides, and fungicides, is also a threat, as are the spread of parasites and pathogens, says McArt. A field study McArt helped to conduct (https://royalsocietypublishing.org/doi/10.1098/rspb.2017.2181) with a number of collaborators revealed how agrochemical accumulation and parasites can interact. Previous research revealed that bumble-bee range declines were associated with the fungal parasite *Nosema bombi*. McArt became interested in looking at why some areas were hit harder by the fungus than others and found a surprising correlation. "We found out that a very strong predictor of *Nosema bombi* infections was one particular fungicide being used, called chlorothalonil," he says. "And then

the strongest predictor of range contractions overall was total fungicide use." McArt was surprised by the data, since there weren't a lot of studies about the risks of fungicides to insects at the time. Researchers like McArt are only beginning to understand how fungicides, once thought to be nearly harmless, can interact with pathogens to harm insects.

According to McArt, the factor that's least known about is climate change, because it's difficult to analyze how climate change has impacted any particular species compared to a more quantifiable factor, such as the loss of habitat. However, climate change is predicted to affect insects in multiple ways. "For climate change, we really have no clue yet on its relative importance on pollinator declines or potentially insect declines," McArt says. "But we know that it is a stress to insects."

One way climate change has impacted species is via phenological mismatches, i.e., changes in the timing of natural processes. For example, the emergence of overwintering insects, like bees, is often in sync with the blooming of plants. With climate change, plants are blooming earlier, while insect overwintering periods aren't significantly changing. "We've got a great data set for that in New York, showing that apple blooms have been getting earlier and earlier for the past 35 years," McArt says. Flowering plants, like apple blossoms, are an important nectar source for pollinators, and, as they bloom earlier, insects have a more difficult time surviving after emerging in the spring.

Leasure explains that some species, like the American burying beetle, also face another threat: pressure from lobbyists to remove federal Endangered Species Act protections. If a species is listed as endangered by the U.S. Fish and Wildlife Service, the act prohibits individuals from taking actions that jeopardize the survival of the species. For the beetle, these actions include extracting oil and gas from the beetle's habitat. As a consequence, fossil fuel lobbyists have argued to remove the beetle from the endangered species list. "This species got tied up in the Keystone pipeline litigation that happened in Nebraska. So there's competing interests. There's a lot of money going in from [the fossil fuel] industry to try to show that this species doesn't need protection," Leasure says.

Research to Conserve Insects

As many experts have pointed out, robust research on at-risk species is critical to creating conservation plans. Errors or gaps in knowledge could lead to taking the wrong actions and ultimately harming the species.

As an undergraduate, Leasure conducted research on the American burying beetle in the Arkansas military base Fort Chaffee. When he started the project, Leasure says that the U.S. Fish and Wildlife Service assumed that military training was harmful to the beetle's populations. And yet beetle populations were thriving in a number of military bases across the southern U.S., which got Leasure interested in researching why.

"The more I studied it, the more I came to realize that wildfires are common on military bases and maintain these early successional habitats—grassland, prairies, and savannas—that

beetles use," he says. "And it's hard to defend these things, but there's a lot of evidence to show that military training and the fires they cause do good things to the habitat that helps these beetles." As Leasure explains, habitat fires allow nutrients to recycle in prairies, which attracts animals the beetle needs to start its life cycle on, like hispid cotton rabbits and quail.

During his undergraduate research, Leasure also helped to design a more effective baited trap (https://doi.org/10.1649/072.066.0305) to assess American burying beetle populations. That trap method used a bucket placed above ground, with chicken on the inside to attract the beetle. Leasure helped create a mechanism to ensure that raccoons didn't steal the meat on the inside and that beetles in the trap won't drown when it rains, which were two problems with older trap methods. "Because of that study, the Fish and Wildlife Service adopted that trap method and it's now used across the country," he says.

During and after his Ph.D., Leasure has continued to conduct studies that provide critical data on the American burying beetle. Leasure says most of his studies have two goals: first, to map the distribution of beetle populations to understand where conservation efforts need to be focused; and, second, to understand what aspects of the habitat allow it to support beetle populations. This can allow land managers to create habitats to better support beetles or to discover new beetle populations based on what habitat characteristics they are attracted to.

In a 2017 study, Leasure also used satellite images to look at fire disturbance (http://doi.org/10.1111/icad.12233) near the area where he first fell in love with the beetle, Fort Chaffee. He found that, in the year after a fire disturbance, beetle populations in those areas tended to thrive. "It's really interesting because this is an annual species, so they only live for one year. And they get that one chance in reproduction," he says. "And this suggests that they're finding these areas that have been fire disturbed and going to those specific areas."

Schultz also conducted research on the effects of fire disturbance on the Fender's blue butterfly. She explained that one of the goals of her study, published in 2017 (https://besjournals.onlinelibrary.wiley.com/doi/pdf/10.1111/1365-2664.12983), was determining how to conduct a prescribed burn, an intentionally set wildfire to improve habitat. "We knew that prescribed burning would most likely be beneficial from the earlier work that we did in the late '90s, and so this really takes it a step further. Like how much to do and in what point in the life cycle is it an advantage to the butterfly," she says.



Icaricia icarioides fenderi, sometimes known as the Fender's blue, is an endangered species in the United States. In the 1990s, the species numbered less than 1,500, but managed recovery plans have raised its numbers to as high as 25,000-30,000. (Photo credit: Candace Fallon, Xerces Society)

Schultz explains that habitat fires often require balance. Too much fire can destroy insect populations, a particular concern for Fender's blue, which is not a migratory species. However, if the right balance is reached, burning can improve habitat quality by reverting it back to an early-successional structure. In her study, two years after the prescribed fire, the habitat quality, followed by the fecundity of Fender's blue, significantly increased compared with unburned areas.

Schultz also discovered something interesting about the interaction between the butterfly larvae and some ant species that have been observed to protect the larvae from predators in exchange for sugary secretions from the butterfly larvae. Schultz found that, in habitats that better supported these mutualistic ant species, there was an increase in eggs laid by butterflies, most likely from more larvae surviving into adulthood.



Cheryl Schultz, Ph.D., associate professor of biological sciences at Washington State University Vancouver, and postdoc Norah Warchola, Ph.D., conduct research on the endangered butterfly *Icaricia icarioides fenderi*, sometimes known as the Fender's blue. Here, in 2017, they examined conditions during a fire study at Baskett Slough National Wildlife Refuge in Oregon. (Photo courtesy of Cheryl Schultz, Ph.D.)

To create conservation plans for insects, like the Fender's blue, Schultz stressed the importance of recording not just the number of individuals but, more important, their demography and movement. Demography includes birth rates, death rates, and fertility, while movement analyzes how individuals disperse in response to a disturbance, such as a fire. In a 2019 report (https://doi.org/10.1146/annurev-ento-011118-112204), Schultz suggested that more data like this needs to be collected to curb the global insect declines. "There are many butterfly taxa that we would have substantially better understanding of how to effectively conserve if we could learn more about the demography and movement behavior," Schultz says.

Turning Research Into Action

"The good news is that insects respond very well to conservation. There are solutions and that's where we're focusing," Black says. "We base our conservation work on science. We work with well over 100 scientists from around the world to take research and put it into practice."

For example, the Xerces Society has organized a national pollinator conservation program (https://xerces.org/pollinator-conservation/), driven by data collected on the declining pollinators, like western monarchs and bees. Since 2008, the program has helped to conserve more than 900,000 acres of pollinator habitat. The Xerces Society has also reached out to more than 100,000 farmers and land managers to teach them how they can better protect pollinators from

habitat destruction and pesticide exposure. Black explains that the program is a collaborative effort between citizens, state agencies, restoration professionals, and the U.S. Department of Agriculture. One other group of collaborators also includes large companies, like General Mills. "Pollinator loss is an issue that really resonates with food companies and farmers. So, one of our biggest partners is General Mills, which is implementing really large-scale habitat restoration to make their supply chain better for pollinators," he says.

Another part of the Xerces Society's efforts is requesting policies for conservation. This includes petitioning to list insects under the Endangered Species Act, which not only provides legal protections but also provides funding to research conservation strategies. Black explains that it has been the job of the Xerces Society to use scientific data to identify any species that may be at risk of extinction and presenting the data in the form of a petition to the U.S. Fish and Wildlife Service. Both Black and Schultz believe that the federal listing of Fender's blue has helped populations to recover by driving conservation efforts forward. Leasure also says that the American burying beetle's listing has required industries to conduct surveys to make sure their business won't damage the beetle's habitat. These surveys have been a major source for data collection for his studies.

However, Black explains that listing a species as endangered often takes years of review, so it's important to take conservation action even before approval. For example, in 2002, the Xerces Society created a petition for the butterfly *Polities mardon*, sometimes known as the mardon skipper. Rather than waiting for the species to become listed, the organization began working to study the species niche, published its findings

(https://www.sciencedirect.com/science/article/abs/pii/S0006320709005394), and worked with local forestry services to protect the species. Ten years later, the listing ended up being rejected because of how much the conservation efforts had already helped the butterfly recover. "Listing is a long-term endeavor," Black says. "So, we're willing to put on our boots and start working now as the process is going through the U.S. Fish and Wildlife Service so we can ensure these insects don't go extinct."



The butterfly *Polites mardon*, known as the mardon skipper, has been petitioned for federal endangered species status in the United States but has not received such designation. It is, however, listed as endangered in the state of Washington. (Photo credit: Rich Hatfield, Xerces Society)

According to Black, one of the most critical parts of insect conservation is engaging the public. This includes encouraging people to think about how their actions, like pesticide use and fossil fuel emissions, can affect the habitat of insects, as well as raising funding for insect conservation. It also includes encouraging more people to become involved with citizen science efforts to collect data, like the Western Monarch Count, Migratory Dragonfly Partnership, and Bumble Bee Watch. "Our Bumble Bee Watch program has really harnessed data records collected by thousands of people that has better helped us understand the locations of our most rare bumble bees," Black says. "When you're talking about species that may have lost 90 percent of their range, understanding where they are still extant allows us to focus our conservation efforts much more efficiently."

Black says he believes there is hope for conserving America's most at-risk insect species through collaborative efforts between the public, government, and scientists. "Every time one of these studies [on insect declines] comes out, I just shake my head," Black says. "But I absolutely think there's hope. But it's not without everyone stepping up. It has to happen at a government level, and it has to happen at a local and more individual scale, where people make changes in their own lives. If we do that, there's certainly hope."

Evan Bourtis is an undergraduate biology student at St. John Fisher College in Rochester, New York. He became interested in insect conservation after conducting a research project investigating insecticide accumulation in honey bees. Evan is also a staff writer at his college's news source, The Cardinal Courier, where he has written several articles about science. Email: emb04651@sjfc.edu (mailto:emb04651@sjfc.edu).

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1 Comment »

Great article, but I think there may be more to explore. I am also an entomologist and have been wondering how the increased VOCs and EMFs in our atmosphere are affecting insects' ability to find mates, nectar and host plants, as well as avoid potential predators. Numerous new papers on aerial pollutants have been published; a paper by Scott Black suggests that we know enough now to start taking action...but I wonder if we aren't missing a very real, but virtually invisible threat. I have written to several highly respected entomologists and other biologists, but no one seems to know how to go about figuring this one out. So I am putting the thought out there for some outstanding graduate to consider!

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