WINGS

ESSAYS ON INVERTEBRATE CONSERVATION

THE XERCES SOCIETY FALL 2015

CONTENTS

Pesticides are often the first choice for dealing with a pest, or even with the prospect of one. This issue of *Wings* suggests that we reassess how we use them and why.

Rethinking Pesticides

Scott Hoffman Black

Pesticides have been used to control insects for millennia. We know that the ancient Romans burned sulfur to kill insect pests; centuries later, in the 1600s, people were using a mixture of honey and arsenic to kill ants. By the end of the nineteenth century, U.S. farmers were employing a variety of toxic chemicals to control pests, including copper acetoarsenite (known as Paris green), calcium arsenate, and nicotine sulfate.

In the 1950s, arsenic-based pesticides were replaced by DDT, promoted as an improvement because it was not as acutely toxic to humans; no one recognized the extent to which DDT would impact the food chain. Once that became understood, DDT was phased out. By 1975 it had been replaced by organophosphates and carbamates, although it took decades for bald eagles, ospreys, and other birds of prey to recover.

This cycle repeated itself in the 1990s, when yet another class of insecticides were introduced, neonicotinoids, once again touted as an improvement over prior chemicals. Neonicotinoids have two properties that seemed to jus-

Pesticides have become the first option for pest management in intensive agriculture, often applied prophylactically before pests even appear. The reflexive use of chemicals has unhealthy consequences for our ecosystems. Photograph by Tamina Miller, Flickr.com.

tify this claim. First, they are less acutely toxic to birds and mammals, including humans, which lessened the health impacts on people. The second potential benefit was that neonicotinoids were "targeted" to kill pests in that they are systemic—meaning that once applied they are absorbed by the plant, making the leaves, stems, and roots toxic to pests. It was thought that this would be a way to keep the insecticide from coming into contact with beneficial organisms, but that didn't turn out to be the case. The problem is that neonicotinoids are taken up into the nectar and pollen, and we now know that pollinators attracted to treated flowers can pick up these insecticides while feeding or gathering supplies for their nest. In some instances this can be directly lethal, while in others it leads to problems with flying, navigating, and finding food sources; it also may lead to lower production of young.

To compound this, neonicotinoids are long-lived and mobile in the environment, which is why they are being compared to DDT. Indeed, measurable amounts of residual pesticide have been found in woody plants up to six years after a single application. Neonicotinoids can remain in soil for months or even years after use, and plants planted the following year may absorb those chemical residues. Moreover, they move easily from soil to water, where they have been shown to negatively impact aquatic organisms that are the base of the food chain. These insecticides may be leading to declines in everything from aquatic insects to songbirds, and a growing body of evidence suggests that neonicotinoids are one factor in declining populations of pollinators.

But the real issue is not the revolving suite of chemicals we use. It is the way we use them. Humans constantly seek the easiest way to control pests and weeds. The complexity of ecosystems, however, means that no single method, whether it is a chemical or not, can solve a problem in its entirety, and each new silver-bullet solution is likely to lead to new and unforeseen problems.

We need to rethink the ways that we deal with nature and the ecosystems on which we and all other species depend. Farms, gardens, parks, and other such areas are complex systems, and we must treat them as such. If we hope to have healthy ecosystems we need a new approach, one that uses their complexity to our advantage. The vast majority of animals in the landscape—including insects—are beneficial, or at least benign. We can use this fact to our advantage by fostering habitats that support the predators and parasites of crop pests. We also need to spend more time understanding actual pests and at what level they will impact yield or kill a plant.

An equally important concern is that many farmers and gardeners use insecticides when they are not needed. Millions of acres a year are treated with neonicotinoids as a kind of "insurance policy," even though no pest problems are known to be present, and millions of pounds of insecticides are applied in urban and suburban areas in the quest for blemish-free landscapes. Simply moving away from such practices can save money and help pollinators as well as other beneficial insects.

Rather than seeking the next quick fix, we need to look at root causes and address those. By doing so, we can both produce the food we need and protect the environment we love.

Pursuing a Thoughtful Balance In the Management of Insect Pests

Thelma Heidel-Baker and Scott Hoffman Black

Looking across lush fields of corn or cabbages, or rows of ripe tomatoes ready for harvest, insect conservation may not be the first thing that comes to mind. Rather, thoughts of insects in relation to farming are more likely to be about how to control pests and limit crop damage. For farmers growing food for human consumption and feed for animals, insect attacks are a threat to their crops; and in addition to insect pests, farmers must deal with weeds and plant diseases. In seeking to control these problems—whether insects, weeds, or diseases—pesticides frequently come into play. Often farmers use pesticides prophylactically, applying insecticides (or fungicides or herbicides) to prevent the damage caused by "pests," regardless of whether pests are actually in evidence.

Unfortunately, pesticides, and insecticides in particular, can also harm the vast majority of invertebrates that are benign or even beneficial—the bees, flies, beetles, and other insects that live in and around agricultural fields and that often provide such important eco-

Integrated pest management (IPM) provides an alternative to the simple wholesale application of pesticides. This multi-faceted approach allows farmers to conserve the "good" insects while controlling the "bad" ones. Photograph by TumblingRun, Flickr.com.

system services as pollination and biological control.

Pest control and insect conservation are not mutually exclusive—but how does one create a balance between managing the few insects that actually harm crops while still conserving the good ones? Integrated pest management, or IPM, is one approach that brings conservation into the equation, employing a variety of pest control methods instead of relying solely upon chemicals.

There are many ways to describe IPM, but one of the most concise definitions is from the University of California at Davis: "IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties." What might these techniques look like in practice?

Biological control—usually shortened to "biocontrol"—makes use of predators (species that eat other species) and parasitoids (species that complete part of their lifecycle inside a host and in the process kill it) to suppress pest populations. In *classical* biocontrol, beneficial organisms are intentionally brought in from elsewhere and released to control a pest; examples include lady beetles that eat aphids, weevils that bore into roots or seed heads and stop plants from spreading, and nematodes that parasitize grubs.

Often, though, such released "natural" enemies of crop pests are not native, having been imported from a country where the pest species originated, and they may become pests in their own right. *Conservation* biocontrol takes a different tack, focusing instead on boosting populations of predators and parasitoids of pest species that are already present in the agroecosystem.

Potter wasps (*Parancistrocerus fulvipes*) provision their nests with caterpillars and other soft-bodied prey. Each nest may contain dozens of paralyzed insects. Photograph by Bryan E. Reynolds.

Habitat manipulation is an effective way to support beneficial insects, employing such strategies as planting hedgerows or flower strips alongside crops, or growing insectary flowers between crop plants. For IPM, this may include ensuring the presence of breeding or overwintering sites for beneficial species when crops are not growing, or providing alternative nectar sources while they are. Syrphid flies, for example, eat aphids as larvae but consume nectar as adults, and nectar-producing plants can help to fuel their search for aphid colonies within which to lay eggs.

Improved habitat can also bring with it benefits beyond conservation biocontrol, including enhanced pollination and the filtering of irrigation runoff into nearby creeks and ponds.

Cultural practices—the routine activities of farmers in caring for their crops—can have a significant effect on whether or not pests are present, as well as on the ability of crops to resist them. Crop rotation is a well-established way to limit the growth of pest populations by disrupting their food supply and lifecycles. Intercropping, or planting a repeating pattern of strips of different crops within the same field, increases landscape diversity and can make a field less attractive to pest species that are specialists on a particular crop plant. Irrigation can be managed in such a way as to control pests—as is done, for example, with the annual flooding of cranberry bogs—or to encourage the growth of stronger plants that are more resistant to attack.

The use of resistant varieties of crop plants is another technique for managing pests with a long record of success. For centuries, farmers have used breeding to improve their crops by selecting for larger fruit or more vigorous plants, and such efforts can result in traits that make some strains more resistant to pests or better suited to particular growing conditions. Careful selection of the varieties to be planted can reduce the likelihood of pest infestation or crop damage.

Hedgerows and flower strips provide habitat where beneficial insects can nest and complete their life cycle near to crop fields. Made from mud, these are cells of a potter wasp nest. Photograph by Bryan E. Reynolds.

In conjunction with these strategies, IPM may incorporate the use of pesticides, but only in ways that are carefully targeted through the choice of products and application methods. Although the thoughtful use of pesticides can be one part of an IPM program, IPM does not embrace chemicals as a primary means of control. Thus, a spray program that applies pesticides based on the date or season (often called calendar-based spraying) is not IPM, nor is simply monitoring a field for the presence of an insect pest and then applying pesticides when it shows up. Even though the use of pesticides may be somewhat judicious in such programs, integration of alternative control strategies into the pest-management plan is lacking.

While conservation biocontrol and the planting of resistant varieties are good practices under almost all circumstances, choosing if and when to undertake more intensive control measures against any particular pest—and initiating chemical intervention in particular—is one of the most important decisions a farmer has to make. In IPM, one of the core concepts is that such decisions are dictated by the economic threshold. In its simplest form, the economic threshold is a particular pest density—the number of insects per plant, for instance—that helps to determine when taking action against that pest will be cost-effective. Regular monitoring of a crop will reveal the presence and density of a pest as well as the degree of damage that it's causing, and only when the pest density exceeds the predetermined threshold will a control measure be recommended. The strength of this approach is that the decision to act is built upon a range of information, including the biology of the particular pest (growth rate, phenology) and the consequent potential for damage, as well as economic considerations (the cost of treatment, the value of the crop).

Identifying insects is important for successful implementation of IPM, since beneficial species and pest species can appear similar. Photograph by Debbie Roos.

To implement effective monitoring, farmers need to understand what pest insects might be present and know how to identify them. It is also vital to be able to differentiate them from their beneficial relatives, since some pests look very much like other insects that might help control them. Stink bugs are a good example of this: plant-feeding species can become pests at high population levels, whereas their cousins, carnivorous stink bugs, are generalist predators.

Integrated pest management does not seek merely to control existing pests, but, by addressing environmental factors that affect the pests' ability to thrive, it helps to keep them from becoming a serious problem in the first place. IPM is applied in five phases: first, identify potential pests; second, reduce the conditions that favor pest popula-

Ichneumon wasps can provide valuable pest control. They lay eggs inside other insects, and their growing offspring kill the hosts. Photograph by Bryan E. Reynolds.

tions; third, determine the economic threshold for damage; fourth, monitor the presence or absence of pest populations; and, finally, control pests when the economic threshold is reached. The underlying principle here is to create farm conditions that are not favorable for pests. Quite often this may not mean eliminating a pest altogether, but lowering the degree of threat that it presents and keeping its population below the level that results in economically significant crop damage. This can be accomplished by incorporating and selectively applying the preventive strategies described above, thus making pest management truly integrated.

The goal of every IPM program is to protect our natural resources while at the same time managing pests and the damage they cause, thereby creating a better environment for crops to thrive as well as a healthier place for all of us to live. Minimizing risks to wildlife in the farm landscape—including bees, flies, and other crop pollinators—and taking care to provide clean water and healthy soils are all crucial for sustainability and conservation. It just makes sense to protect these resources and the benefits they provide.

IPM is ultimately about taking a long-term, environmentally conscious approach to caring for crops. With ongoing research into pest species yielding new discoveries in ways to manage them, IPM plans can continue to be current and effective, allowing farmers to adapt and change in the light of new information. If implemented correctly, integrated pest management can both lower costs to the farmers and reduce harmful impacts on the environment, two goals that will help agricultural landscapes work better for all of us.

Both authors work for the Xerces Society. IPM specialist Thelma Heidel-Baker works with farmers to develop successful pest-management programs for a variety of crops. Scott Hoffman Black is executive director; his background includes experience with sustainable agriculture.

Mosquitoes, Wildlife, and People: Crafting an Integrated Management Plan

Celeste A. Searles Mazzacano

The Bandon Marsh National Wildlife Refuge, established in 1983 on Oregon's southern coast near the mouth of the Coquille River, sits on land that has a long history of human habitation. As many as three thousand years ago, native tribes built weirs to harvest the abundant coho and Chinook salmon that thrived in the estuary's constantly changing network of tidal channels. The Europeans who came in the 1800s, though, had a different approach. To them, the marsh, ill-suited for the production of crops and livestock, was a problem that needed to be drained, ditched, diked, and dammed. These early settlers destroyed thousands of acres of tidal wetlands that were critically important habitat for fish and frogs, otters and oystercatchers, pelicans and plovers, and a host of other wildlife species; ultimately much of the marsh became home to grazing cattle.

In 2009, hoping to restore the habitat to some of its former function, the U.S. Fish and Wildlife Service began extensive restoration of this damaged land by removing tidal gates and dikes, filling in ditches, and re-opening the historic web of tidal channels in an area re-named Ni-les'tun, which in the language of the Coquille people means "small fish dam in river." The project was successful at improving habitat for denizens of the marsh, but, by 2011, it had also inadvertently created habitat for what is generally seen as a less desirable member of the marsh community, the saltmarsh mosquito, *Aedes dorsalis*—and thereby opened the floodgates to a whole new kind of problem.

Salt marsh restoration often facilitates natural mosquito control; larval and adult mosquitoes are eaten by the myriad fish, birds, amphibians, and invertebrates that return to the habitat, and the daily flushing action of the tides prevents mosquito breeding and development. At Bandon, unfortunately, the large equipment used in the restoration work left behind ditches and depressions, which expanded the breeding habitat for the saltmarsh mosquitoes. Monthly high tides filled these depressions with water, and, when the weather grew warm, mosquitoes developed from egg to adult before the next high tide could flush them out.

Aedes dorsalis adults can fly several miles from the sites where they first emerge, so increased mosquito populations on the refuge soon made themselves known to area residents. In 2012, people in nearby Bandon experienced unusual—some said unprecedented—biting by hungry female mosquitoes. While the Bandon area has no recent history of mosquito-borne disease, and although *Aedes dorsalis* is not a vector for West Nile virus, the saltmarsh mosquito is a persistent biter and its bites are painful; by 2013, angry neighbors were demanding that the refuge deal with "its" mosquitoes.

Refuge staff had begun monitoring and they knew which pools contained mosquito larvae, but they had never needed to manage mosquitoes before, and the county in which the refuge is located has no mosquito abatement district (a public agency tasked with mosquito control). Delayed action, increasing hostility from neighbors, fears about impacts to a valuable tourism industry, and a lack of knowledge about mosquito physiology and management all combined to create a recipe for disaster. By late summer 2013, even though mosquito populations were already decreasing with the approach of fall and the drying down of the pools in which the larvae developed, a hasty and ill-advised plan was assembled. The refuge declared an emergency due to the abundance of mosquitoes, and the Coos County Board of Commissioners proposed to spray ten thousand acres in and around the refuge with two broad-spectrum insecticides, Dibrom and MetaLarv S-PT.

Dibrom is an organophosphate insecticide that is sprayed to kill adult mosquitoes, but it is also highly toxic to other insects—including natural enemies of mosquitoes—as well as to fish, birds, and mammals. The application of adulticides such as Dibrom is widely recognized to be ineffective, as they do not control the source of the mosquito problem, and adults of species with good dispersal ability, such as *Aedes dor-*

The Ni-les'tun Unit of the Bandon Marsh National Wildlife Refuge lies on the Coquille River, near its mouth on the southern coast of Oregon. The U.S. Fish and Wildlife Service recently removed dikes and dams, filled old drainage ditches, and re-opened stream channels to allow the tides to return to the land. Photograph by Roy W. Lowe, USFWS.

salis, continue to emerge and then reoccupy previously treated sites. MetaLarv is a slow-release formulation of methoprene, a compound that mimics the naturally occurring juvenile hormone in insects and thereby prevents mosquito larvae from developing into adults. While more targeted than Dibrom and other organophosphate insecticides, MetaLarv is highly toxic to a wide array of aquatic insects and crustaceans that are at the heart of aquatic food webs.

Matters came to a head at a public meeting convened in early September 2013 by Coos County commissioners and attended by staff of both the Bandon Marsh National Wildlife Refuge and Jackson County Vector Control, who had been called in to advise the county and helped create the spraying plan. The intention was to begin spraying immediately. Some Bandon-area residents welcomed this proposal as a way to end the mosquito problem, but more than two-thirds of the residents who spoke at the meeting opposed the spraying plan. Organic gardeners wanted assurance that their plants and soil would not be contaminated; beekeepers were alarmed about die-offs; and cranberry growers feared that if their ripening crop contained pesticide residues it would be rejected by buyers.

As director of the Xerces Society's aquatic conservation program, I joined the concerned citizens at this meeting. Xerces objected to the use of broad-spectrum insecticides on a federal wildlife refuge that houses a diversity of non-target organisms, including several federally listed endangered species. Our concern was heightened by the fact that this action was being implemented in the absence of a thorough investiga-

Old drainage ditches were filled slowly to ease fish downstream out of the construction area. USFWS and Oregon Department of Fish and Wildlife biologists monitored the work, capturing and relocating fish when necessary. Photograph by Roy W. Lowe, USFWS.

Bandon Marsh is home to thousands of shorebirds—particularly during migration—and the Coquille River supports salmon (including the threatened coho) and steelhead. Photograph by Roy W. Lowe, USFWS.

tion of alternatives and likely impacts, and without the consultations required under the National Environmental Policy Act and the Endangered Species Act.

Xerces urged the adoption of an integrated pest management (IPM) plan that would be more effective at dealing with the problem and at the same time more environmentally sustainable. As we pointed out, the refuge already had all the pieces in place to launch such a program. With adult populations diminishing at the end of summer, nuisance biting had begun to decline. The females had left behind a large number of eggs, which spend the winter in a dormant state until they are triggered to hatch by spring water levels and warming temperatures.

Xerces Society staff advocated for refuge staff to begin monitoring the mosquito "hotspots" they had already pinpointed in early spring of 2014, to detect the first newly hatched larvae and then to treat the pools as needed with a formulation of the biological mosquitocide Bti. Bti is based on the bacterium *Bacillus thuringiensis israelensis*, which produces a crystalline toxin that, when ingested by the larvae of flies such as mosquitoes and midges, disrupts their stomachs and kills them before they can become adults. Bti is toxic to other types of true flies (order Diptera), but it affects far fewer non-target invertebrates, and is safe for fish, birds, and mammals, including humans. Because true flies are consumed by a variety of wildlife, though, regular repeated use of Bti can have food web impacts through there being fewer flies to eat. By targeting the ponds where mosquitoes were known to be breeding, monitoring consistently to assess larval numbers and developmental stages, and treating only when larvae were present, the existing population could be controlled, and fly-offs of new adults could be prevented while the refuge staff worked to remove the pools left behind from the initial restoration.

This aerial view shows the flooding that now takes place across the Ni-les'tun Unit during a high tide. Formerly, hollows and ditches that didn't drain as the tides ebbed gave saltmarsh mosquitoes a place to breed. Photograph by Roy W. Lowe, USFWS.

Xerces was not alone in propounding such a plan. When mosquitoes had first been a problem around Bandon the previous year, a similar recommendation had been made to the county commissioners by vector control specialists from Klamath County. At Bandon, Xerces Society staff met with community activists, provided information based on our publication *Ecologically Sound Mosquito Management in Wetlands*, and reached out directly to refuge biologists.

The result? Two days after the public meeting the plan for widespread spraying was cancelled, the proposed use of organophosphates was dropped, and only three hundred acres of the marsh were treated with MetaLarv. While this effort was an improvement over the original proposal, it was still undertaken without reference to either mosquito physiology or good IPM practices. In the months that followed, the refuge worked to develop a more comprehensive plan not only to manage mosquito populations, but also to conduct habitat modifications to remove the pools in which mosquitoes were breeding.

The Xerces Society continued to advocate for a rational, environmentally sound, and effective IPM approach, including educating the public about the lack of risk for mosquito-borne disease and the importance of personal protection against biting; carrying out a consistent monitoring program to pinpoint microhabitats that are mosquito hotspots, assess seasonal patterns of abundance, and gauge the effectiveness of management actions; and developing and implementing a site-specific management plan that would preserve the ecological integrity of the national wildlife refuge and its surroundings.

In March 2014, the Oregon Coast National Wildlife Refuge Complex issued a draft of its "Integrated Marsh Management Plan and Environmental Assessment for Mosquito Control" for public comment. The plan set forth several options for mosquito control, including the one for which Xerces had advocated: to carefully monitor mosquito populations; to develop explicit thresholds for larval abundance that would trigger treatment; and to use only Bti products to control mosquito larvae, and then only for as long as needed until restoration work obviates the mosquito problem. The Xerces Society strongly recommended this course of action during the public comment period, and the Center for Food Safety also weighed in with support. This option was ultimately adopted, and mosquito monitoring began in April 2014.

That monitoring confirmed the presence of mosquito larvae in the Niles'tun Unit in early May, and Bti was applied at those sites. Continued monitoring throughout the summer revealed a pattern of mosquito larvae appearing after monthly high tides, but targeted Bti treatments administered when larvae were young and particularly vulnerable were effective in reducing the subsequent adult populations. While pools were being treated with Bti as needed, the work of creating additional tidal channels to drain the mosquito habitat was also begun; by mid-summer the new channels were working so well that fewer acres required Bti treatment.

Very few mosquito larvae were found in the marsh in the spring of 2015, and the refuge reported that "all indications suggest the implementation of our Integrated Mosquito Management Plan was successful at keeping the numbers of biting mosquitoes leaving Bandon Marsh Refuge at tolerable levels, and eliminating the vast majority of the breeding habitat on the Refuge."

Public wellbeing and taking care of the environment are all too often portrayed as being at odds with each other, but that does not have to be the case. Developing a site-specific integrated management plan that uses multiple methods of control targeted at the most vulnerable life stages of the pest while causing the least harm to non-target organisms and the environment requires time and expertise, but in the end everyone wins.

In Bandon, residents are once again free to go about their daily business without being tormented by clouds of biting mosquitoes; meanwhile, at the nearby refuge, mosquitoes continue to play their normal role in an ecosystem that includes a diversity of other aquatic invertebrates, all providing sustenance for the foraging fish and waterfowl that call this vulnerable estuary home.

Celeste A. Searles Mazzacano is the director of aquatic conservation at the Xerces Society. She has collaborated with communities nationwide to develop successful mosquito-management plans.

Neonicotinoids: Silver Bullets that Misfired

Aimee Code

It was National Pollinator Week 2013. We had been getting the usual inquiries at the Xerces office: What type of bee is this? How do I make a bee nest? Can you recommend the best plants? Then the telephone started ringing with reports of dead bees—lots of them. Xerces staff members rushed to the scene, a big-box store in Wilsonville, Oregon, a half-hour drive from our office. We were startled to find the parking lot littered with bees—several species, including honey bees, although the great majority were bumble bees—with more falling from the branches above every minute. Xerces staff contacted the Oregon Department of Agriculture (the agency with legal responsibility to investigate), and then helped organize an effort to net the trees in order to stop the carnage.

The inquiry undertaken by the Oregon Department of Agriculture found that the bees had died from the application of a neonicotinoid insecticide, dinotefuran, to the linden trees (genus *Tilia*) that lined the parking lot. The trees were being treated against aphids, which drip honeydew that can coat sidewalks and parked cars below. With flowers rich in nectar, though, linden trees are a bumble bee magnet (honey bees may also gather honeydew), and the insecticide had lethal consequences far beyond its intended victims. An estimated fifty thousand or more bumble bees were killed.

This is the largest native bee kill ever recorded. The authors of some science blogs dismissed the number of bumble bees that died as being of small significance in that they were no more than the population of a healthy hive of honey bees, but an understanding of bumble bee biology leads to a different conclusion. Bumble bees live in small colonies, typically no larger than two to three hundred bees even at their maximum size; thus the deaths of fifty thousand bumble bees is equivalent to the destruction of more than 150 complete colonies. And the impact is not limited to those colonies directly affected by the loss of worker bees. Rather, the effect carries forward into the following years as a result of fewer queens being produced to establish new colonies.

In the intervening two years, the Oregon Department of Agriculture has investigated and confirmed six more incidents of bee kills caused by the application of neonicotinoids (or "neonics") on *Tilia* trees. The department has now acted to reduce the use of neonics, banning their application to linden, basswood, and other *Tilia* species in the state. While the large bee kills might have propelled neonics into the spotlight and brought some incremental gains in protection for bees, the scale of the risk posed by the use of these insecticides is huge and threatens a broad range of wildlife.

Neonicotinoids began to be used in the mid-1990s. The U.S. Environmental Protection Agency was seeking less-toxic alternatives to replace organophosphate insecticides, which had been linked with a variety of risks to human health and the environment. These new neonicotinoid chemicals were characterized as "reduced risk" by the EPA and some were brought to market through an abridged registration process. They quickly became the most heavily used class of insecticides, and they now make up about 30 percent of the insecticide market worldwide. Neonics are used on farms, in parks, on street trees, and in gardens. They are generally present in all landscapes.

Dinotefuran, the product responsible for the Wilsonville bee kill, is one of seven chemicals that are classified as neonicotinoids. The others are acetamiprid, clothianidin, imidacloprid, nitenpyram, thiacloprid, and thiamethoxam. (Use of imidacloprid and nitenpyram for flea control in animals is generally excluded from discussions about neonic impacts on wildlife.) Neonicotinoids are synthetic insecticides similar in chemical structure to nicotine, and all of them control pests through the same mode, binding to receptors in the insects' nervous systems and blocking nerve impulses.

Although each neonic poses its own unique risks, there are several overarching characteristics that are cause for concern: they persist in plants and soil for months to years after an application and can accumulate from one season to another; they are highly toxic to a broad spectrum of invertebrates, including beneficial insects; they are water soluble and readily move into rivers, lakes, and

Bumble bees have been shown to be far less efficient at foraging when exposed to neonicotinoid insecticides. They bring much less food to the colony, leading to fewer new queens and new colonies. Photograph by Nancy Lee Adamson.

This bucolic scene, complete with red barn, belies the reality of many modern farms. The widespread use of neonicotinoids, especially as a seed treatment, affects pollinators, beneficial insects, and aquatic systems. Photograph by Don Graham, Flickr.com.

other water bodies; and because they are absorbed by plant tissues and become systemic (even when sprayed on foliage), they move into pollen and nectar, thereby following a direct route to exposure for pollinators.

In 2012, the International Union for Conservation of Nature passed a resolution calling for a comprehensive review of the impacts of systemic insecticides on biodiversity and ecosystems. The review was carried out by the Task Force on Systemic Pesticides, a multidisciplinary group of independent scientists, who studied more than a thousand research articles and reports. The task force's analyses, published in a series of articles in 2014, concluded that the current degree of use of neonics and other systemic insecticides is not sustainable. It found that these insecticides are causing significant damage to a wide range of beneficial invertebrate species, thus threatening the natural infrastructure that supports farming productivity and broader ecosystem health.

The threats from neonics and similar chemicals go well beyond high-profile bee kills. At low levels, neonics don't kill invertebrates but instead can impair their functioning to the point of weakening populations over time. A 2014 study performed by researchers from Scotland's University of Stirling, for example, showed that bumble bees exposed to neonics were less efficient at foraging, bringing back 31 percent less food to the colony compared to unexposed bees. As with the reverberating effect of the bee kills at Wilsonville, such a decline in food supply would lead to fewer new queens and, consequently, fewer colonies in following years.

There is strong evidence of neonicotinoids harming beneficial insects that serve as natural pest control for agriculture. Researchers from Penn State University found that the activity and density of the ground beetle *Chlaenius tricolor* were lower in soybean fields planted with neonic-coated seeds. The beetles were harmed by neonic residues passed up the food chain from the crop-damaging slugs they were eating. The result was fewer beetles eating the slugs and thus a larger population of slugs damaging crops: soybean yield was reduced by 5 percent in treated fields. Over the past twelve years the introduction of neonicotinoid products applied as a seed coating has rapidly increased the use of these chemicals. Penn State researchers also determined that for corn, cotton, and soybean alone, at least 42 million hectares (104 million acres) are planted with neonicotinoid-coated seed. That is roughly the size of California. On such a large scale, the use of neonics can translate to far-reaching detrimental impacts on natural pest-management services.

The cascading impacts of these insecticides go beyond crop fields. Their solubility means that they leach into the soil and then migrate into neighboring water bodies. A study from the Netherlands found that populations of insect-eating birds were declining in areas where there were increased concentrations of neonics in surface water. Swallows, starlings, and sparrows were the most affected, with the survival of these insectivorous birds jeopardized by the loss of aquatic insects, one of their major food sources. Worryingly, the latest research from the United States found neonics in more than half of the streams sampled in both urban and agricultural areas.

The Xerces Society takes a precautionary approach in response to neonicotinoid concerns. At the heart of the precautionary principle is the concept that, when there is evidence of a plausible risk, there is a social responsibility to protect the environment or people from exposure to harm. (This is the same idea that lies behind the adage "better safe than sorry.") Furthermore, the protections cannot be lifted or changed until scientific studies are completed that provide reliable evidence that no harm will result from any changes. The precautionary principle has been widely embraced around the world in the decades

This planter is filled with corn seed made green by its neonic coating. Photograph by Lance Cheung, USDA-NRCS.

since it was written into the Rio Declaration of the 1992 United Nations Earth Summit. In Europe, the precautionary principle has been adopted into the policies and laws of the European Union. In the United States, the principle underlies environmental policy in San Francisco and many other communities.

Within the world of pesticide regulation, the precautionary principle would shift the burden of proof onto the pesticide manufacturers. They would need to show that their products would not cause undue harm—rather than merely, as now, showing how the risks can be managed.

At the core of our work are efforts to promote ecologically sound pest-management practices that shift away from chemical-intensive crop production. Recognizing that farmers and pest-management professionals need feasible alternatives if they are to change their practices, Xerces is involved in research, including working with Iowa State University to design integrated approaches to managing common soybean and corn pests. This project, which has the potential to affect millions of acres of production, will help growers understand what pests are problematic and when control measures are needed,

Pothole wetlands are scattered across the corn fields of the northern Great Plains. Neonicotinoids leach from the fields into the wetlands, reducing the populations of aquatic insects that may support breeding birds during the summer, as well as migrating flocks such as the white spots seen above. Photograph by Krista Lundgren, USFWS.

Swallows were among the birds found to be declining in areas where there were increased levels of neonicotinoids in surface water. Photograph by The-Gecko, Flickr.com.

thus shifting away from the prophylactic use of neonicotinoid-coated seed. It will also promote ecologically sound management methods once pests are identified.

Xerces also presents short courses on conservation biological control, the practice of supporting the native beneficial insects that prey upon crop pests. And we've worked with local communities and governments across the United States to develop city or county regulations banning the use of neonicotinoids on publicly owned lands; to date, we have helped thirteen cities and counties halt the use of neonics and have assisted two others in creating plans to protect pollinators from pesticides.

The scale of the problem posed by neonics is sufficient to warrant immediate action. When they first appeared on the market, neonicotinoids were touted as reduced-risk products, but our current knowledge paints a very different picture, and government policies must change to reflect the greater risk that we now know exists. Indeed, the story of neonics is a cautionary tale about an inadequate regulatory system that allows pesticides on the market before understanding their impacts, and a chemical industry that promises easy solutions to solve complex pest problems.

Neonics were touted as silver bullets and sped to market to replace other harmful insecticides. They may have resolved some of the problems caused by the older insecticides, but neonicotinoids brought their own array of negative consequences. In order to break this cycle of replacing one problem with another, Xerces works to increase understanding and implementation of more-sustainable practices with the greater goal of protecting the natural systems on which we all depend.

Aimee Code directs the Xerces Society's pesticide program.

CONSERVATION SPOTLIGHT

USFWS Pacific Region: A Champion for Monarchs and Milkweeds

Too often these days, when the work of a U.S. federal natural resource agency is seen in the news it is about fighting a wildfire, or a dispute over grazing or logging. This is particularly true in the western states, where large swaths of land are managed by the Bureau of Land Management, the Forest Service, or the Fish and Wildlife Service. The reality is that the events that catch the interest of the media represent only a small part of the work of these agencies. On a daily basis, they are involved in managing and conserving such treasured landscapes as wilderness areas and national wildlife refuges—and protecting the wildlife that these lands support.

The U.S. Fish and Wildlife Service Pacific Region, which covers Washington, Oregon, and Idaho (as well as Hawaii and other Pacific islands), is working to understand and conserve monarch butterflies and the native milkweeds upon which they rely. The monarchs in these states are less well known than their relatives east of the Rockies; those monarchs have been tracked for years and their annual migration to Mexico studied in detail.

The majority of monarch butterflies in western North America migrate to coastal California for the winter. Annual counts of butterflies at their overwintering sites have revealed a decline of nearly 50 percent since the late 1990s, but there is little information about where western monarchs spend their summers and on which species of milkweeds they breed. These gaps in the data limit the ability of the Fish and Wildlife Service —as well as other organizations in the region—to prioritize areas for habitat restoration, and make it more difficult to efficiently undertake surveys of monarchs and milkweed. The USFWS Pacific Region is seeking to remedy that situation.

The first step has been to develop a Habitat Suitability Model; this effort is being undertaken with the leadership of the regional refuge biologist, Joe Engler, and project GIS lead Madeline Steele, in partnership with the Xerces Society's endangered species program. When completed, this model will allow USFWS biologists to narrow in on key areas, such as particular national wildlife refuges and important migration corridors, in order to conduct detailed surveys or to identify sites that could benefit from habitat restoration. The USFWS and Xerces are also partnering to create a "Natural Lands Pollinator Habitat Assessment Tool" to enable the USFWS to evaluate refuge lands for suitability for monarchs and to plan and implement restoration projects.

As part of this effort, the Pacific Region and Xerces are working with the other Fish and Wildlife Service regions across the western states (Pacific Southwest, Mountain-Prairie, and Southwest) to inventory key milkweed species locations and collect breeding observations for monarchs in the states west of the Rocky Mountains. Data gathering is coordinated by a jointly funded regional monarch conservation specialist, Ashley Taylor. She divides her time between the Xerces office and that of the USFWS, and, during this last summer, spent considerable time in the field organizing surveys on nine national wildlife refuges and three national fish hatcheries in the Pacific Northwest.

Milkweed was found on three refuges where it had not previously been recorded, and on two of the refuges monarch butterflies themselves were seen for the first time. Information from the surveys is being compiled in a database and added to the distribution maps as part of the Xerces Society's Western Milkweed and Monarch Survey. The new data has helped inform the Pacific Region's forthcoming "Five-Year Conservation Action Plan for the Monarch Butterfly" and will help prioritize monarch habitat restoration and further surveys on refuges.

The Fish and Wildlife Service is addressing monarch conservation nationwide, spurred on by the petition for Endangered Species Act listing currently being considered and the *National Strategy to Promote the Health of Honey Bees and Other Pollinators* issued by the White House in May 2015. That strategy set three major federal targets, one of which is increasing monarch butterfly numbers in order to protect the annual migration. The USFWS Pacific Region is actively working toward that goal.

Monarch butterflies (*Danaus plexippus*) cannot survive without milkweeds. The USFWS Pacific Region is leading a project to understand and conserve both the butterfly and its host plant across the western United States. Photograph by John Anderson, Hedgerow Farms, Inc.

INVERTEBRATE NOTES

Study Looks at Effects of Climate Change on Bumble Bees

How is climate change impacting bumble bees? Many other species' geographical ranges have expanded toward the poles while remaining relatively stable along their equatorial edges, but a new study from a team of European and North American researchers found that bumble bee species on both continents were experiencing pronounced losses of range from their southern edges while simultaneously failing to expand their ranges northward.

The researchers used observations gathered over 110 years to discern climate-change-related range shifts across bumble bees' thermal and latitudinal limits, as well as their movements along elevation gradients. They found these effects to be independent of land-use changes and pesticide applications. Based on their findings, the authors believe that, across continents, climate change distinctly and consistently contributes to the compression of range for bumble bee species.

As this study suggests (and as Xerces' Rich Hatfield recently noted on our blog—"Climate Change Driving, Not the Only Passenger," July 16, 2015), it is important to recognize that not all species react to the changing climate in the same way. Moreover, bumble bees confront a large range of stressors in addition to climate change; if we can work to reduce these, perhaps we can buy these species more time to adapt. (http://www.sciencemag.org/content/349/6244/177.short.)

New Books

The fall weather has arrived in northern latitudes, heralding the beginning of several months with limited contact with insects. Instead, we must enjoy a more vicarious relationship through the pages of books.

Dave Goulson is back with a follow-up to *A Sting in the Tale*, a charming chronicle of his bumble bee conservation efforts (featured in the spring 2014 issue of *Wings*). His new book, *A Buzz in the Meadow*, transports readers to his rural farmhouse and meadow in France, recounting his efforts to transform the meadow into a home for wildlife.

With Goulson's characteristically congenial style, he tells a story in three parts. He begins by introducing the meadow's myriad life, follows that with an exploration of the creatures' intricate interrelationships, then caps the narrative with a sobering look at the environmental changes—including widespread pollinator declines—that humans have wrought upon the landscape.

While the book brims with delightful anecdotes, Goulson also allows us a glimpse into the mind of a field biologist and the complexities of the scientific process, and ultimately infuses the story with a powerful message about conservation.

What could be more different from the residents of a sun-drenched meadow than the plankton in the darkest depths of the sea? Although they form nearly 98 percent of the biomass of ocean life, plankton are invisible to the naked eye—and thus many people might find it hard to envision them at all. But in marine scientist Christian Sardet's *Plankton: Wonders of the Drifting World*, these delicately beautiful life forms get their moment in the spotlight. Minuscule jellyfish, mollusks, tadpoles, and others are shown in all of their multihued and vaguely alien glory.

The book goes beyond photography and micrography, as Sardet delves into the life histories of different groups of plankton, then connects them to the larger world and explains their impact on our own lives. This colorful glance at the frequently overlooked foundation of the aquatic food web might just change the way you picture the ocean.

Rare Nautilus Reappears After Three Decades

This July, off the coast of Papua New Guinea, the nautilus *Allonautilus scrobiculatus* made its first appearance in thirty years. It was spotted by University of Washington researcher Peter Ward, who with a colleague first discovered the elusive cephalopod near Nidrova Island in 1984. Initially, Ward says, they were taken aback by the "thick, hairy, slimy covering on its shell," a characteristic that sets this species apart.

On a recent expedition, Ward and his team observed *Allonautilus* while using baited traps to observe and capture nautiluses. Their research has helped uncover more information about these "living fossils."

Nautiluses have specific requirements for depth and temperature; since the area they can inhabit is narrow, most populations are isolated, and they vary from one area to another. These geographical limitations make conservation of the species difficult: in Ward's words, once they are gone from an area, "They're gone for good."

Many species are currently threatened by the international trade in nautilus shells. Ward hopes that this year they may become a protected species under the Convention on International Trade in Endangered Species of Wildlife Fauna and Flora (CITES) treaty. (http://www.washington.edu/news/2015/08/25/rare-nautilus-sighted-for-the-first-time-in-three-decades.)

Not seen since the 1980s, the nautilus *Allonautilus scrobiculatus* was spotted off Papua New Guinea in July. Photograph by Peter Ward, University of Washington.

STAFF PROFILE

Aimee Code, Pesticide Program Director

What got you interested in insects? I was one of those kids who could spend hours outside digging for worms, watching fireflies in the evenings, and, yes, squishing the Japanese beetles that flocked to our raspberry plants. Sometime during middle school, I stopped noticing the insects around me. When my daughter started to toddle about and explore, I rediscovered my love of invertebrates. She delighted in watching a skipper nectar on an aster, or quietly observing a spider wrap up its prey. With her, I again took time to appreciate these extraordinary creatures.

What made you want to work here? While working at the Northwest Coalition for Alternatives to Pesticides, I often crossed paths with Xerces Society staff or made use of its resources in doing research, and I was always impressed. When I saw a job announcement from Xerces stating that after many years of working on pesticide issues it had decided to create a dedicated program, I immediately knew I wanted to be part of that team.

Where did you study? I earned my undergraduate degree in international relations from Northern Arizona University, and then an MS in environmental health from Oregon State University. The education I've valued most, though, was not the one I received during my formal schooling; the years I spent working in Africa and Central America provided me with greater perspective than any university education could have.

Who is (or was) your environmental hero? I'm inspired by such people as Jacques Cousteau, Vandana Shiva, and Chico Mendes, as well as less-well-known leaders. Norma Grier, my former director at NCAP, is a woman who quietly moved mountains by empowering others.

What's your favorite place to visit? While I love exploring new cultures, the place I most want to return to is Mongolia. The small dose I received of Mongolian life, culture, and nature piqued my interest: throat singing, Genghis Kahn, sacred springs in the middle of vast open spaces, wolves howling at night. I am excited to get back there someday.

What do you do to relax? I often wind down by reading a book while curled up in the wingback chair my grandmother gave to me. I also do yoga, garden, hike, and when alone in the house often push aside the furniture and dance.

Rusty Patched Bumble Bee Now One Step Closer to Protection

September was a good month for the rusty patched bumble bee (*Bombus affinis*). After decades of declining populations and a nearly 90 percent contraction in range, it was given a glimmer of hope for a future. The U.S. Fish and Wildlife Service issued a positive ninety-day finding in response to an Endangered Species Act petition requesting the bee to be listed as "endangered." This ESA petition was authored by Xerces Society staff and bumble bee scientists Dr. Robbin Thorp, professor emeritus at the University of California at Davis, and Elaine Evans, a Ph.D. candidate at the University of Minnesota.

The rusty patched bumble bee faces a variety of threats, including diseases, pesticides, habitat loss, and climate change. The recent declines of this and some closely related bumble bees may be attributable to the spread of pathogens from commercial bumble bees to wild ones. Bumble bees are raised and sold commercially to pollinate greenhouse tomatoes and many other types of crops worldwide, and very few regulations currently exist to ensure that the bees that are sold are free of diseases.

The ninety-day finding by the USFWS means that the agency agrees that there is evidence that this bumble bee is in trouble and that it will now take an official look at whether or not the bee deserves ESA protection. An ESA listing would result in the designation of critical habitat and the writing of a recovery plan for the bumble bee, and could make federal funds available for conservation efforts by individual states.

The rusty patched bumble bee (*Bombus affinis*) is one significant step closer to protection. Photograph by Rich Hatfield.

Seven Native Hawaiian Bees Proposed as Endangered Species

The rusty patched bumble bee isn't the only species that received good news this fall. After six years of consideration, the U.S. Fish and Wildlife Service proposed that seven species of Hawaiian yellow-faced bees be listed as "endangered" under the Endangered Species Act. When the proposed rule is finalized, these will be the first bees to gain federal protection in the United States.

This diminutive bee, *Hylaeus assimulans*, is one of seven Hawaiian yellow-faced bee species that are the first bees to be protected under U.S. federal law. Photograph by John Kaia, Lahaina Photography.

Yellow-faced bees are the only bees native to the Hawaiian islands, and, since many of Hawaii's native plants are not well adapted to pollination by nonnative pollinators, are a keystone species in the islands' ecosystems. The USFWS recognized multiple threats to these bees—from the loss of habitat to land conversion, development, and recreation (especially in coastal and lowland areas) to the impacts of such nonnative species as wild pigs, bigheaded ants, and invasive plants. The agency also recognized that climate change, fire, and the small populations of these bees are factors that threaten them with extinction.

Conservation of these Hawaiian yellow-faced bees will require the active management of natural areas with known populations. We hope that this ESA listing will act as a wakeup call, spurring recognition of the critical role that pollinators such as these play in ecosystems and the taking of necessary steps to conserve their habitats.

Xerces Supports Implementation of National Pollinator Strategy

In May, the White House released the *National Strategy to Protect Pollinators and Their Habitat*, which identified three priorities: reduce honey bee losses, protect monarch butterflies, and create millions of acres of habitat. Thanks to this directive, pollinator conservation has become embedded into the work of every federal agency.

The Xerces Society participated in meetings with White House staff that helped guide creation of the national strategy and our pollinator specialists and conservation biologists are now working closely with federal agencies as they implement it. Scott Hoffman Black is an ex-officio member of the High Level Federal Monarch Working Group and participates in a U.S. Geological Survey effort to assess monarch populations and direct monarch conservation priorities.

Our pollinator program has a longstanding partnership with the Natural

Resources Conservation Service, training agency staff and providing technical support. We are also working with the U.S. Fish and Wildlife Service to improve knowledge and conservation of monarchs in the western United States (see pages 22–23 for more details) and with the Federal Highway Administration to improve roadside management for pollinators (see below). This latter work has placed us at the center of the I-35 "Monarch Highway" initiative to create monarch habitat in a broad swath up the middle of the United States.

Working Together for Pollinator-Friendly Roadsides

Pollinators and roadsides might seem like an unlikely pairing: roads can fragment habitat, aid in spreading invasive plant species, and contribute to animal mortality. But an immense amount of land is dedicated to them, forming a vast network of linear habitat. Roadsides in urban and intensely farmed landscapes are often the only natural or semi-natural habitat around; for pollinators, they can serve as places to refuel, reproduce, or overwinter. (For more on this topic, see the spring 2015 issue of *Wings*.)

The Federal Highway Administration was one of the agencies tasked by the Obama administration with identifying conservation approaches to help halt pollinator losses under the national pollinator strategy. The FHWA contracted with the Xerces Society and environmental consulting company ICF International to develop best management practices to enhance roadside habitat for pollinators. As part of this project, staff from the Xerces Society and ICF produced a comprehensive review of the technical literature. The review, released in May, included a thorough treatment of the status of pollinators, causes of decline, potential mitigation efforts, habitat restoration and management for pollinators, and applications to roadsides.

Xerces and ICF International also conducted interviews with state departments of transportation and the roadside restoration experts who work with them. The interviews provided documentation of existing roadside vegetation management practices and feedback about the feasibility of implementing strategies that can benefit pollinators. The best management practices will be available early in 2016.

You can find the FHWA literature review at http://1.usa.gov/1P2KLBT.

The Xerces Society is taking on a leading role in a nationwide effort to develop best management practices for roadside habitat. Photograph © dlewis33, iStock.com.

Pollinator Program Launches New Short Course

This past summer was the first for the Xerces Society's new short course on conservation biological control. Our book *Farming with Native Beneficial Insects* was released by Storey Publishing in 2014 in response to a growing interest on farms in promoting beneficial insects and their pest-control services. This course builds on that momentum.

Intended to educate farmers, agriculture employees, natural resource specialists, land managers, and conservation organization staff, the course is a full-day training that provides attendees with the latest science-based methods for integrating beneficial insects back into cropping systems. Ultimately, this approach reduces—indeed, in some cases eliminates—the need for insecticides. Participants leave with the tools necessary to identify and attract beneficial insects, assess and restore habitat, and implement farm practices to support beneficial insects.

So far, Xerces Society staff have offered the course in four locations: Madison, Wisconsin; Boone, Iowa; Farmington, Minnesota; and Kingston, Rhode Island. More than a hundred people have attended. Future efforts will be even bigger, with a plan to provide the course in at least twenty states over the next three years. Our eventual goal is to provide it in all fifty states, and beyond.

Xerces Staff Gather in Portland for Annual Retreat

Fall is special for the Xerces Society staff. This is when we have our annual strategic planning retreat, the one time of the year when all of our regional staff members converge in Portland to share ideas and learn about the great work that everyone is doing. Since we don't often get together, we thought we'd share a photograph of (almost) all thirty-eight of our current staff members (not pictured are Jim Eckberg, Celeste A. Searles Mazzacano, and Hillary Sardiñas). We are grateful for your support—we wouldn't be here without it!

Donor Survey 2015

We want to say a big thank-you to everyone who participated in our donor survey this year. We heard back from more than nine hundred of you, and it was wonderful to learn more about your conservation interests, how you think we are doing, and what you think we can improve. Based upon your feedback, we've already begun making changes for the better. You can find a complete summary of the survey results at www.xerces.org/donorsurvey.

We asked why you donate to the Xerces Society, and here are a few of our favorite responses:

You are taking the lead on pollinator conservation! Thank you!

I love insects. More people should be aware of these wonderful animals and their role in ecosystems.

You seem to get a lot of mileage out of not much money.

No one else speaks up for invertebrates!

I believe in preserving and restoring our habitats.

You support science-based advocacy that helps me to stay current and that I can trust to inform my work.

We also asked what you thought of *Wings*. An overwhelming majority said that you loved it and nearly half of you read it from cover to cover. Regarding the content, some people would like it to be less scientific, some more scientific, but the most frequent response was to keep it as it is. We found that most of you rely on *Wings* for updates on our work, with around a third of you reading our e-newsletter or using our website.

All in all, the survey responses were extremely helpful. Although we have wrapped up this donor survey, your feedback is always welcome, so please do keep in touch. Many thanks!

WINGS, Fall 2015 **Volume 38, Number 2**

Wings is published twice a year by the Xerces Society, an international, nonprofit organization dedicated to protecting the diversity of life through the conservation of invertebrates and their habitat. A Xerces Society membership costs $35 per year (tax-deductible) and includes a subscription to *Wings*.

 Xerces Society Executive Director: Scott Hoffman Black; *Editors*: Scott Hoffman Black, Margo Conner, John Laursen, and Matthew Shepherd; *Design and Production*: John Laursen. Printed on recycled paper.

For information about membership and our conservation programs for native pollinators, endangered species, and aquatic invertebrates, contact us:

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

628 Northeast Broadway, Suite 200, Portland, OR 97232

toll-free 855-232-6639 fax 503-233-6794 info@xerces.org www.xerces.org

The jagged ambush bug (genus *Phymata*) is a master of camouflage, typically difficult to see on a flower head. A sit-and-wait predator, it will grab insects visiting the flower with its mantis-like, raptorial front legs. Photograph by Bryan E. Reynolds.

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

628 Northeast Broadway, Suite 200, Portland, OR 97232

A $35 per year Xerces Society membership includes a subscription to *Wings*.

On the cover: A bee assassin (genus *Apiomerus*) hunts for prey on a blanket flower (genus *Gaillardia*). As its name suggests, this predatory bug will eat bees, as well as yellowjackets, wasps, and any other insects it can catch. It impales its prey with its rostrum (needle-like mouthparts) and then injects digestive fluids. Photograph by Bryan E. Reynolds.