Policy regarding Wildlife Sanctuary Certification of properties
where broad-spectrum mosquito spraying is used

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Is broadcast spraying for mosquitoes consistent with creating a functioning wildlife sanctuary in one's yard?

Based on the evidence, we believe it is not. For that reason, we will not certify a property as a Wildlife Sanctuary if the owner is or anticipates spraying for mosquitoes. Our reasoning and some answers to questions you may have follow.

To qualify as a wildlife sanctuary, a residential yard should benefit wildlife species living in or visiting it at all stages of their lifecycles, and should also benefit the larger environment. Residential yards significantly affect water quality and aquatic ecosystems via streams that run through or adjacent to them, or stormwater runoff that is transported to streams by storm drains. The effects of mosquito spraying on that larger environment also are a concern, particularly because insects and aquatic invertebrates are highly susceptible to the chemicals the services use. Therefore, property owners who apply for certification are asked to adopt the Healthy Yard Pledge, including pledges to "Reduce pesticide and fertilizer use – No broad-spectrum spraying for mosquitoes" and to "Conserve water and protect water quality."

The mosquito sprays kill pollinators and other insects essential to a functioning wildlife sanctuary.

The active ingredients in the most commonly used mosquito sprays are pyrethroids (including Permethrin, Resmenthrin, Bifenthrin, and Sumithrin) and organophosphates (Malathion, Naled).[1] Organophosphates are toxic to birds and animals.[2] Pyrethroids and pyrethrins are highly toxic to all insects, fish, and aquatic invertebrates.[3] Pyrethroids and pyrethrins, the chemicals that

mosquito services use to kill mosquitoes in residential yards, are a class of broad-spectrum insecticides that target a wide range of pests in both agricultural and non-agricultural settings. Pyrethrins are botanical insecticides derived from chrysanthemum flowers, and pyrethroids are synthetic derivatives of pyrethrins. Pyrethroids are more persistent in the environment than pyrethrins.[4] An applicator's adherence to the guidelines on the chemicals' labels does not eliminate risks to pollinators. More information on why that is follows, but first, let's look at examples of how pollinators are poisoned by mosquito spray services.

Pyrethrins and pyrethroids are acutely toxic to terrestrial invertebrates, including pollinators such as bees, butterflies, and other beneficial insects. These include the caterpillars birds require to feed their nestlings, and on which so much of the food chain that supports native wildlife depends. Pollinators are exposed to the spray itself and to residue on vegetation, in contaminated water, and from contaminated nesting material and nesting areas.[5] Bees are poisoned when they absorb toxic chemicals through their exoskeleton, when they drink contaminated nectar or when they eat contaminated pollen during their larval stage. When leafcutter bees collect contaminated leaf pieces for nest construction, the pesticides covering the leaves concentrate in the nest where they are slowly absorbed by the larvae during development.[6]

Pollinators and other beneficial species are affected by direct contact with pesticides in the application area both while pesticides are being applied and when animals enter the treated area after the treatment. Pollinators that have been exposed in the application area at sublethal concentrations can return to the hive, or, in the case of native bees, to their foraging area or nest, and affect others. They may be exposed after a pesticide application when they visit flowers, walk on treated leaves, or gather contaminated pollen and nectar. This is especially problematic when a pesticide has a long persistence in the field.[7] In general, pyrethroids have long half lives in soil ranging from 5 to 170 days. Bifenthrin has a half-life in soil of 96 days and permethrin has a half-life of 39 days in aerobic soil.[8] Once pyrethroids attach to soil particles, they can get carried across the landscape as dust in dry conditions or enter aquatic environments through runoff.

Pollinators and other beneficial insects can be exposed to applications that may take place far from their hives and nests. Bees can be exposed to pesticides throughout their foraging radius.[9] While some small solitary bees may only travel 50 meters from their nest site to collect pollen and nectar, honeybees and some other large-bodied bees can travel miles for food and thus may be directly exposed to pesticides applied in a much larger area surrounding their hive or nest.[10]

That pollinators and other beneficial species can be killed even if they survive an initial exposure in a treatment or when they are not in the area during an application is clear from tests for residual toxicity. The Environmental Protection Agency (EPA) in 2012 began testing products to identify those with extended residual toxicity, or ERT, to honeybees, with an aim to better reflect the true pesticide hazard to bees. EPA measures residual toxicity by the mortality of 25% of the lab population, or RT25. The ERT is the number of hours after application during which 25 percent of exposed bees die.[11] EPA defines an ERT of concern to honeybees as an RT25 greater than 8 hours, but not all pollinator species are affected to the same extent. Data from Pacific Northwest Extension shows bifenthrin, a common pyrethroid used for mosquito spraying, has an ERT of greater than 24 hours for leafcutter bees. Bumblebee species (Bombus) are more sensitive to pyrethroids than honeybees, for whom the EPA labels are written, and greater precautions are needed.[12] Bumble bee colonies favor small cavities under lodged grass, in abandoned rodent burrows, in trees, or old bird nests which are hard to detect. These unmanaged pollinators are an on-site natural resource, and, unlike honey bees, cannot be moved from the field when pesticides are used.

Pyrethroids used in mosquito sprays contaminate surface waters and kill aquatic organisms.

Spray drift from an application of pyrethrins or pyrethroids can carry the chemicals directly to water or can be carried to a body of water by rainwater or irrigation runoff, including through storm drains. Chemicals applied to impervious surfaces, such as sidewalks and driveways,

increase the concentration of runoff from soil. If an applicator uses ultra-low volume (ULV) spraying, which sprays fine or very fine droplets, the risk of drifting spray is greater, because the droplets remain airborne longer. One set of field studies found that about 90% of insecticide remained airborne 200 yards from the ULV spray source.[13] The chemicals also can migrate to aquatic ecosystems from improper disposal down storm drains, whether in the form of pet shampoo or rinsing spraying equipment. Although sewage treatment plants remove a high proportion of pyrethroids from wastewater, enough remains to pose risks to aquatic organisms in the water bodies where treated wastewater is released. EPA acknowledges that permethrin and bifenthrin pyrethroids have been detected in treated wastewater effluent more than other pesticides.[14]

Pyrethrins and pyrethroids easily become concentrated in the aquatic environment. Pyrethrins and pyrethroids do not volatilize, are not soluble in water, and bind tightly to the soil. Spray drift and runoff deposit pyrethroid residues into the water column in suspended particulates, sediment, and pore water (i.e. the water between sediment particles) of aquatic environments. The pyrethroids and pyrethrins bind with organic carbon in soil, water and sediment, and thus build up in sediments and affect benthic (sediment-dwelling) communities. There is some risk to fish, but the risks are much greater for aquatic invertebrates, because concentrations of pyrethroids are much lower in the water column than the concentrations found in the soil and sediment where they accumulate after multiple applications. Pyrethroids are also toxic to insects in their aquatic nymph stage such as mayflies and stoneflies as well as crustaceans.[15] A 2019 study exposed damselflies to three different concentrations of the pyrethroid cypermethrin. Pyrethroid exposure had a significant negative effect on egg hatching and larval growth of damselfly and increased mortality in larvae.[16]

In aquatic environments, exposure to pyrethroids kills off sensitive species and selects for insecticide-tolerant species, altering the composition of the benthic community. Repeated exposure may make recovery of the community impossible. The local elimination of selected species can have much larger indirect community-level consequences. For example, broad-

spectrum mosquito spraying can eliminate natural predators of other pest insects, leading to outbreaks of them. Pest resurgence is the best documented indirect effect of insecticides. Hardin *et al.* stated that "insecticide-induced resurgence of arthropod pests has long been known to occur in response to a reduction in natural enemy populations, releasing the pest population from regulation." [17] A different effect has been observed when reduced populations of pollinators led to a decline in a rare plant.[18] Indirect effects on wildlife that depend on aquatic organisms as prey also can occur through impact on food chains. This is the province of the field of ecotoxicology, which treats complex effects of chronic, sub-lethal exposure on a community of organisms in a habitat.

The widespread use of pyrethrins and pyrethroids has already had a significant, adverse effect on aquatic organisms. Based on numerous monitoring studies, EPA reports that pyrethroid detections are widespread in surface waters across the United States, including effluent from sewage treatment plants, urban streams, and downstream of agricultural areas. In a study of urban streams in northeast Unites States, pyrethroids were detected in 79% of 49 streams sampled.[19] According to EPA, "the pyrethroid concentrations in effluent monitoring data exceeded toxicity endpoints for the most sensitive aquatic invertebrate species. Because pyrethroids are so toxic to aquatic invertebrates, even a substantially reduced amount of pyrethroids in surface water is expected to result in toxic effects to aquatic invertebrates." [20] As would be expected, insecticide contamination is greater after storm events, and near sites where the chemicals have been applied.

Why don't application guidelines prevent the harm to non-target species and the larger environment?

The focus of much of the toxicity testing by regulatory agencies has been on domesticated honeybees because their pollination services are critically important for our agriculture system and food production. Researchers have documented widespread contamination of honeybee hives with toxic pyrethroids.[21] Much less is known about the impacts of these sprays on wild

insects and other native wildlife, but mosquito-control insecticides have been linked with declines of native pollinators. It's clear that wild native bees and other pollinators also are at risk from mosquito pesticides.[22]

When EPA approves use of a pesticide, it balances its environmental risks against its benefits. For example, pesticide use may control disease-carrying insects that pose a public health threat, or control insects that threaten crops or structures, such as termites. In striking that balance, EPA attempts to impose limits on use and application that reduce the harm the chemical can cause. The limits EPA imposes appear on the product label and have the force of law.

When a pesticide is registered by the EPA for use in agriculture or horticulture, that does not mean that it is safe for all pollinators and beneficial insects, even when applied according to the label. It means that there is an economic benefit to using it even though there are also known risks.[23]

So, what restrictions are there on the pyrethroids the mosquito spray services use? They include application limits (application only within a specific vertical and horizontal footprint, no application to impervious surfaces, no application during rain or within 24 hours of expected rain, no application within 25 feet of a body of water, no application when wind speed is greater than 15 mph) and disposal limits (no leftover product or rinsewater from cleaning equipment down any drain).[24] Although EPA restricts application within 25 feet of a water body, the width of this buffer does not appear to be evidence-based. Field studies find that ultra-low volume (ULV) sprays deposit material much farther away.[25] According to Schleir *et al.*, there is no validated model that can accurately predict deposition of insecticides applied using ULV technology for adult mosquito management.[26] The restrictions reduce the harm, but commonly used pyrethroids are toxic to non-target organisms even when applied at the labelled rate and much less frequently than is done in residential mosquito applications.

The protocol used by the Pyrethroid Working Group (an industry group) to collect the data that informed EPA's 2016 ecological risk assessment of nine common pyrethroids provides some indication of the problem. "The outdoor non-agricultural section assessed urban residential, institutional and commercial uses of the pyrethroids that occur outdoors, as well as turf, ornamental plant, and nursey uses. For residential and commercial uses, the maximum labeled rate was one application per year occurring on the same day in a 10-hectare watershed with 58 residential (or commercial) lots." (emphasis added)[27] The ecological risk of residential mosquito fogging applications, with treatment normally occurring every three weeks during summer, not once a year, was not assessed, and is clearly much higher. But, even with only a yearly application, harm was evident: "The assessment found that there were acute and chronic listed and non-listed LOC (Levels of Concern) exceedances for freshwater and estuarine/marine invertebrates from the residential, commercial, turf and nursery uses for bifenthrin, cyfluthrin, lambda-cyhalothrin, cypermethrin, esfenvalerate, and permethrin. Benthic (sediment-dwelling) invertebrates tend to be more sensitive to the pyrethroids and pyrethrins than water column dwelling invertebrates. The assessed active ingredients with the most risk concerns for fish were permethrin and bifenthrin. For bifenthrin, there were chronic listed and non-listed exceedances for freshwater fish for turf, residential, and nursery scenarios. Bifenthrin also had acute listed-only LOC exceedances for all uses for freshwater fish."[28] These pesticides harm insects, fish and macrobenthic organisms--all organisms not specifically targeted by the applicators.

What guidance do other organizations provide?

Other organizations concerned about environmental impacts uniformly recommend against broadcast spraying. In a joint statement on mosquito control in the United States, EPA and CDC state "the underlying philosophy of mosquito control is based on the fact that the greatest control impact on mosquito populations will occur when they are concentrated, immobile and accessible. This emphasis focuses on habitat management and controlling the immature stages before the mosquitoes emerge as adults. This policy reduces the need for widespread pesticide application in urban areas."[29] The U.S. Fish and Wildlife Service *Handbook for Mosquito Management on*

National Wildlife Refuges considers native mosquitoes a part of the natural ecosystem and allows them to exist unimpeded unless they pose a specific human or wildlife health risk. It recommends practices to minimize the emergence of adults, such as using larvicides and pupacides. Fogging is considered only when a public health agency or an authorized representative determines and states in writing there is risk to public health from mosquitoes in the refuge.

Agricultural services also discourage broadcast spraying broad spectrum insecticides like pyrethrins. The U.S. Department of Agriculture's Natural Resources Conservation Service recommends employing integrated pest management (IPM), a decision-making framework that selects for the least hazardous pest management options, and only when there is a demonstrated need.[30] The framework, which can help protect onsite pollinators (e.g., butterflies, flies, and moths) and other beneficial insects, such as predators and parasitoids of crop pests, uses a four-phase strategy: (1) Reduce conditions that favor pest populations, (2) Establish an economic threshold of how much damage can be tolerated before pest control must occur, (3) Monitor pest populations, and (4) Control pests with the most specific pest control option when the preestablished damage threshold is reached. An IPM approach would not approve using a broad spectrum adulticide spray that targets all flying insects and has documented, residual toxic effects on bees.

Area Land Grant Extension Service websites consistently recommend IPM and several (UMD Extension, Virginia Cooperative Extension, Cornell Extension, Pacific Northwest Extension, NC Extension, PSU Extension) specifically recommend against mosquito spraying with broad spectrum general insect adulticides because they are the least effective against the target species and most harmful to beneficial species and native pollinators. Cornell Cooperative Extension's website is very specific. It states:

> Avoid fogging or spraying for mosquitoes or biting flies. Fogging or spraying for mosquitoes or biting flies around the yard and garden with an insecticide can be

> very harmful to pollinators. *Even if flowering plants are avoided and applications are made after sunset, insecticides applied as a fog or mist can drift onto flowering plants within 100 meters or more depending on the wind speed and direction. The insecticide drift could contaminate pollen and nectar collected by bees for several days or weeks after it is applied, and the residue on leaves can be toxic to caterpillars for weeks or months.* Caterpillars of some species of butterflies are extremely sensitive to insecticide residue on leaves.[31]

Public health organizations also recommend restraint. Locally, the Fairfax County Health Department has a robust mosquito management program that includes monitoring, source reduction (elimination of standing water), use of larvicide to kill mosquito larvae, and community education and outreach. The County sets traps weekly during mosquito season to collect adult mosquitoes and test them for West Nile virus and Zika virus. If that routine monitoring indicates a high risk of disease transmission to humans, the County coordinates larval and/or adult mosquito control measures in public areas as necessary.[32]

Mosquito spray treatments target adult mosquitoes that are already biting. Adulticide pesticides do not restrict mosquito breeding. Adulticides have minimal and short-term effectiveness. Given their rapid lifecycle, mosquitoes will repopulate quickly, requiring repeated (and expensive) treatments that simply don't solve the problem. These services are often applied on a calendar service basis and mosquitoes develop resistance to chemical pesticides over time. EPA requires resistance management labeling (guidelines on maximum number of applications per season) on pyrethroids because mosquitoes have already shown resistance to pyrethroids on a local basis.[33] Adulticides kill beneficial insects, including mosquito predators, and are expensive. A Cornell University study determined that nearly 99.9% of these sprayed chemicals go off into the environment posing risk to public health and ecosystems and only 0.1% of the pesticides on average reached the target pests. Further, when the Cornell study looked specifically at flying insects, like mosquitos, it found that on average less than 0.0001% (one millionth) of the spray reached a target insect. The droplet size of a mosquito spray must be so small that the chemicals

must float in the air, but they also easily drift out of the target area, diminishing the probability the spray comes into contact with their target insects in the target area.[34]

How to control exposure to mosquitoes without spraying

The most effective mosquito control strategy with the least harm to the environment relies on habitat management and controlling the immature stages before the mosquitoes emerge as adults. This practice reduces the need for widespread pesticide application in urban areas. Only under exceptional circumstances will the Fairfax County Health Department spray insecticides to control adult mosquitoes, and, in these rare cases, the spray will target only those mosquitoes which transmit disease to humans.[35]

Prevention, by minimizing standing water as much as possible, is the first course of action and a Best Management Practice. Some of the most common mosquito larval habitats in our yards are corrugated extension pipes coming off downspouts, rain barrels and landscape features such as ponds without fish, containers, bird baths, toys, garden and sports equipment, folds on tarps—anything that will hold even a small amount of water for at least 7 days. This standing water removal strategy works best if consistently done on a weekly basis once temperatures reach 50 degrees Fahrenheit through the mosquito breeding season, May through November.

Homeowners should

- replace water in birdbaths twice a week
- remove/eliminate discarded tires and any other objects or debris that can hold water
- check for and empty trapped water in children's toys, garden equipment, kiddie pools – anywhere that even a tablespoon of water stands for 7 days becomes a breeding site for mosquitoes. Do this every 7 days.
- clear rain gutters to allow rainwater to flow freely
- clean out drains at the end of downspouts
- Cover corrugated downspout extensions with pantyhose or mosquito netting and secure with rubber band.

- turn over containers that can hold water when stored outside
- check for trapped water in tarps and arrange covers to drain water
- pump out boat bilges
- fix outside water faucets that are dripping
- use screens on rain barrels and water cisterns.
- Some sites may not be conducive to emptying water, such as tree holes, ditches., standing drains. These hard-to-reach water sources can be treated with *Bacillus thuringiensis israelensis* (BTI) dunks, which kill mosquito larvae without harming birds, beneficial insects, or other wildlife.
- Place a bubbler in small ponds and birdbaths. Mosquitoes will not lay eggs in moving water.

Larvicides

It is important to understand that all insecticides used to target adult mosquitoes are indiscriminate and will kill all insects that contact the chemicals. Contact occurs during spraying, encounter with aerosolized drift, and contact with residue on plants and other surfaces. To manage mosquitoes effectively, they must be killed before they become adults. Larviciding in combination with diligent water removal allows control measures to be used in targeted areas, while mosquito larvae are concentrated in breeding pools. *Bacillus thuringiensis israelensis* (BTI) is an effective and the least toxic biological control. It is a bacterial strain that can be applied as a spray or solid BTI dunks into larval pools, is ingested by feeding larvae and kills them. BTI is widely available in a product called Mosquito Dunks™ at local lawn and garden, hardware, and home improvement stores. The dunks are safe for birdbaths, rain barrels, ponds, ditches, tree holes, roof gutters and anywhere water collects. One of the best ways to manage mosquitoes is to entice them to breed in a bucket filled with water, some straw, and a BTI dunk. The females are attracted to the scent of the straw and water, lay their eggs on the surface, and when they hatch, the larvae are killed by the BTI.

Lethal adult mosquito traps

Research has shown that once these larval habitats are no longer available--containers are emptied, removed, or treated with dunks, and corrugated drainpipe ends are covered with netting--using a trap that mimics a good oviposition site (larval habitat) such as the Gravid Aedes Trap (GAT) can significantly reduce populations. A before and after experimental study of the effectiveness of trapping interventions by the Center for Disease Control and Prevention (CDC) in Puerto Rico found that densities of *Aedes aegypti* mosquitoes were reduced over 80% after traps were introduced.[36] Lethal oviposition traps that attract and kill egg-laying female *Aedes albopictus* (Asian tiger) mosquitoes and larvae are especially effective when used community- or neighborhood-wide. This was demonstrated by a Citizen Action through Science initiative pilot in University Park Maryland in 2016 to reduce populations and biting by Asian Tiger Mosquitoes (Aedes albopictus). In blocks where 80% or more residents placed traps in their yards, Asian Tiger mosquito densities were vastly reduced compared to blocks with less complete coverage.[37]

Note that it is important to continue to dump all sources of water weekly to ensure maximum draw of egg-laying female mosquitoes to the traps. An inexpensive homemade GAT trap design is available from MyGreenMontgomery.[38]

Both the homemade larvicide traps and the commercial GAT traps can be even more effective in reducing bite pressure if they are also used by members of your neighborhood. Rutgers University research found that a mass trapping program in University Park, Maryland that mobilized neighbors across a community to use these traps resulted in significant reduction of mosquitoes biting.[39] If you want to mobilize your neighborhood, you could start by distributing some of our publications. See our articles in the Potomac Flier on mosquito spray services , setting up a mosquito larva trap, and non-toxic mosquito control.

Personal protection

People can protect themselves from mosquitoes by wearing long sleeves and long pants, and applying insect repellent (such as DEET or picaridin or OLE) to exposed skin. The federal

Centers for Disease Control (CDC) recommends a combination of insect repellents and permethrin-treated clothing as a way to maximize protection against blood-feeding insects.[40]

Cornell University College of Agriculture and Life Sciences Integrated Pest Management recommends the following personal protection regime:[41]

- Cover up with loose-fitting, lightweight clothing from dusk to dawn.
- Use insect repellents properly. Read the label and follow precautions.
- Use clothing treatments (per label instructions) such as permethrin to kill mosquitoes (and ticks) on contact.
- Keep household screens in good repair and do not prop open windows or doors.
- Keep topical treatments on hand to reduce the itching and possibility of skin irritation if you or someone in your family has reactions to bites.
- Use fans on outdoor patios and decks to keep mosquitoes away from people. Mosquitoes are weak fliers.

In summary, pesticides released to the environment can directly affect non-target species in ways that are often contrary to their intended use. Insecticide spraying programs to control mosquitoes harm pollinators and other beneficial insects even when applied according to the EPA label guidelines. While mosquito spraying does kill mosquitoes that are present in the immediate area during the time of spraying (and all other insects present as well), it does not prevent repopulating of the area by mosquitoes from elsewhere, does not kill larvae, does not prevent breeding, and the residue lasts at least several weeks, continuing to harm pollinators and other beneficial insects. Substantial research has confirmed these findings. Spraying is ineffective in controlling mosquitoes because it is a temporary measure and requires repeated treatments approximately every three weeks. Mosquitoes can fly a half to two miles, depending on the species, and quickly repopulate sprayed areas unless breeding sources are eliminated. Sprays have minimum impact in controlling *Culex spp.* mosquitoes that spend most of the time in the tree canopy. Mosquitos are most active at dawn and dusk, but mosquito spray companies often come during the day when most pollinators are active. Treatments that target standing water also

kill beneficial insects that eat mosquitos, such as dragonfly larvae. If the spray is focused on wet areas, such as piles of wet leaves, it kills insects sheltering there such as fireflies and butterfly larva. The best mosquito management program in the home garden is one that incorporates integrated pest management (IPM) methods that include regular checking and removal of all potential breeding habitats and standing water, using appropriate personal protection, and deploying larval traps. This IPM strategy protects pollinators and the beneficial insects (including insects that eat mosquitoes) that support a healthy habitat.

Notes

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