PUBLIC HEALTH MOSQUITO MANAGEMENT STRATEGY

For Decision Makers and Communities

Beyond Pesticides

Technical assistance provided by public health officials, environmental health groups, and mosquito control officers

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EXECUTIVE SUMMARY

The ideal mosquito management strategy emphasizes education, prevention such as source reduction and larval control, support for ecological systems, and monitoring for both mosquito-borne illnesses and pesticide related illnesses. This strategy will ensure that the use of pesticides will not add to the health problems already associated with insect-borne diseases. Successful control of mosquito populations requires that local governments along with community leaders teach residents and business owners how to reduce breeding habitats and mosquito bites through strong public awareness campaigns.

Using the prevention and monitoring techniques outlined in this report, many communities will find that they can significantly reduce or even eliminate their reliance on pesticides while calming the public's fears over uncontrolled mosquito populations. Tracking larval and adult mosquito populations, species types, breeding locations and virus outbreaks is an essential part of any mosquito management program. Knowing when and where the virus is likely to strike allows for precise, targeted control techniques.

The decision to use pesticides to kill adult mosquitoes (known as adulticides) should be open for public discussion and made only after carefully evaluating all of the contributing factors to human epidemics. The public—especially vulnerable populations such as pregnant women, the elderly, and people with respiratory or immune deficiencies—must be given the option to opt-out of a spray program as well as notified in advance of a nearby spray so they can prevent their exposure to potentially dangerous pesticides. Pesticide operators should be properly protected, licensed, and trained on when, where, and how to spray. It is also vital to employ consistent monitoring methods to track the effectiveness of the spray program to determine whether risks are being adequately assessed and resources well spent. It should also be noted that spraying pesticides by ground or aerial application contributes to the decline of nontarget organisms, such as bees and other pollinators.[1]

The latter half of this report provides information about the dangers and inefficacy of spraying pesticides. Aside from the adverse health effects posed to humans, adulticiding may actually increase the number of mosquitoes by destroying their natural predators.[2] To date, there is still no proof that using adulticides reduces the incidence of illnesses or deaths from West Nile virus.

Studies have shown that spraying adulticides is not an effective, sustainable strategy, but a risky response to this important nuisance and potential public health concern. However, the frequency of pesticide applications required for aerial/fogging applications to be effective, combined with the public health risk caused as a result of these applications makes mosquito spraying campaigns among the least effective strategies both in terms of cost and public safety.

Overall, the management of mosquitoes should be evaluated in an ecological context since they are a part of aquatic and terrestrial food webs and perform important ecosystem services, including water filtration and algae suppression as larvae. In the context of wetland health, ecological balance is a key consideration to any management plan.

I. INTRODUCTION

Mosquito-borne diseases are becoming more prevalent nationwide. With outbreaks of West Nile virus in almost all states of the U. S., there is an urgent need to develop a national mosquito management strategy. This becomes especially critical as scientists expect the recent changes in climate will increase insect-borne diseases.[3, 4]

Many communities around the country are using ineffective and pesticide-intensive mosquito management strategies due to a lack of adequate information. This report was prepared with the assistance of public health officials, environmental health groups, and mosquito control officers to provide policymakers and community leaders with information on effective strategies that reduce reliance on toxic chemicals and control mosquito populations with a more human-friendly approach.

Most experts agree that an efficient mosquito management strategy emphasizes public awareness, prevention, and monitoring methods. However, if these methods are not used properly, in time, or are ineffective, communities must decide whether or not to use pesticides. They must determine if they should risk exposing vulnerable populations to potentially fatal diseases caused by mosquitoes or to chronic or deadly illnesses caused by pesticides.[5]

The guidelines in this report are drawn from state and local mosquito management programs that utilize safer, more effective strategies. Connecticut, in particular, has incorporated key elements of a sound approach to prevention and management. Their four-tiered approach to mosquito management is discussed in Appendix 5. However, since local and state programs evolve, it is important to follow the guidelines incorporated in this paper.

Should pesticides be used, and if so, which products are the safest, and how should they be applied? This report provides information on how to make these difficult choices. However, until scientists can provide better evidence of the effectiveness of spraying, there is no way to know for certain that it is worth the risks. At the same time, methods that do not rely on adulticides have been proven, as have the health threats associated with pesticide exposure.

II. IDEAL MOSQUITO MANAGEMENT STRATEGY

The ideal mosquito management strategy emphasizes public education, prevention, and monitoring methods. Adulticides should be used only as a last resort. A successfully implemented strategy requires the cooperative efforts of individuals, government agencies, and businesses.

1. Mosquito Prevention: What People Can Do at Home

Eliminate Breeding Sites

Vector mosquitoes such as *Culex Pipiens* need only a bottle cap of water in which to breed. Eliminating mosquito breeding sites is the most efficient way to get rid of mosquitoes, but it cannot be done without community involvement. Because many types of mosquitoes do not travel far from where they hatch, individuals can have a dramatic impact on local mosquito populations by following the prevention measures below.

- Clean up standing water on residential property.
- Apply ecological principles to the management of ponds.
- Eliminate unnecessary debris on residential and commercial property, such as old tires.
- Empty water from toys, buckets, birdbaths, swimming pool covers, and any other areas twice per week where water may be collecting.
- Drill holes in the bottom of recycling bins, swing tires and other outside containers.
- Clean out rain gutters and make sure they drain properly.
- Turn garbage can covers right side up.

Avoid the Bite

- Ensure that window and door screening is properly maintained.
- Wear protective clothing if going outside when mosquitoes are most active, which is often in the early morning and evening. Put on a hat, wear long sleeves, and tuck pants into socks—especially in highly infested areas. Wear light colors, as they are less attractive to mosquitoes.
- Use mosquito repellent, according to directions, when outdoors. Choose products containing geraniol (MosquitoSafe), citronella (Natrapel), a combination of soybean, and coconut oils (Bite Blocker), or other all essential oils (All Terrain) and reapply often. Picaridin, which is derived from pepper, is a repellent that provides comparable protection to DEET products. These are effective mosquito repellents that are safer than DEET. When possible, apply to clothing rather than skin. Always wash off repellents with soap and water once indoors. These products can be purchased at many pharmacies and camping stores.

  Warning: *Avoid products that contain DEET* (N,N-diethyl- meta-toluamide), especially when choosing a product for children or when using it in combination with other chemicals or medications.[6] Several cases of DEET poisonings have been reported by EPA, including three fatalities. In 1995 alone, the National Poison Control Center in Washington received over 6,700 reports of poisonous effects from DEET, including one death. A majority of the reports concerned children. Doctors recommend using products that contain no more than 30 percent DEET for adults.[7] DEET should not be used on infants or children. In 1998, EPA made it illegal for any product containing DEET to make child safety claims.[8] A recent study by Duke University researchers found that combined dermal exposure to DEET and permethrin, which is a mosquito spray, can lead to motor deficits and learning and memory dysfunction.[9] We strongly recommend that people be encouraged to experiment with different non-toxic repellents to find the one that works for them. The label restrictions on DEET capture the exposure concerns: "Do not apply over cuts, wounds, or irritated skin. Do not apply to hands or near eyes and mouth of young children. Do not allow young children to apply this product. Do not use under clothing. Avoid over-application of this product. After returning indoors, wash treated skin with soap and water. Wash treated clothing before wearing it again.[10]
- Set up large fans for home barbeques or other outdoor gatherings.
- Use citronella candles or yellow outdoor light bulbs to repel mosquitoes.
- Fill holes or depressions in trees with sand or mortar, or drain after each rain.
- Stock ornamental ponds with mosquito-eating fish like mosquitofish, fathead minnows, killifish, and bluegill; encourage amphibians like small frogs and toads; protect predatory insects like predaceous beetles, dragonflies, and damselflies.
- Avoid using misting systems as a convenient method for mosquito control. Misters pose

unique dangers to human health due to inhalation and dermal absorption of the fine pesticide mist and the increased probability of chemical drift.

2. Mosquito Prevention: What the Community Can Do

Conduct Public Awareness Campaigns

Public officials should communicate mosquito prevention methods and encourage community- wide efforts to increase the awareness of prevention methods for mosquito-borne illnesses, particularly for the elderly, and to reduce breeding sources. Should a community decide to spray, monitoring for effectiveness of the spray program, as well as for pesticide illnesses is vital.

Health care providers must also be educated about the symptoms of each and should encourage the use of prevention measures. Communities should use all forms of educational tools: the media; websites; posters placed around schools, libraries, post offices, and markets; and pamphlets distributed to doctors' offices and libraries.

Eliminate Breeding Sites on Public Land

As on personal property, public land should be cleared of all standing water that could serve as a potential breeding habitat where ecological management is not possible. (See above.) Businesses should be advised of the hazards of old tires behind gas stations and garages, and asked to recycle the tires or cut them in half. Gutters and ditches in public areas also need regular maintenance to prevent standing water.

Using Natural Predators

While amphibians,[11] birds,[12] and bats[13] consume adult mosquitoes along with other flying insects, natural control of mosquito populations—like human-managed control—is most effective at the larval stage.[14] Biological controls, like mosquito-feeding fish of the *Gambusia* genus, have been used worldwide with great success. Although these hardy freshwater fish can eat their weight in mosquito larvae, according to Wayne Wurtz with the Gloucester County Mosquito Control in Pennsylvania,[15] they have negative impacts on other invertebrates, fish, and amphibians and should not be introduced outside of their natural range.[16] Predators have been known to occasionally trigger algal blooms after consuming algae-eating organisms, and it may take time to establish ecological balance. Many native fish eat mosquito larvae and pupae, including fathead minnows, killifish, and bluegill. Predacious fish are also used in the salt-water marshes of Nassau County, New York.[17]

A number of aquatic invertebrates prey on mosquitoes. They include predaceous mosquitoes, midge larvae, diving beetles, water scavenger beetles, backswimmers, giant water bugs, water scorpions, naiads of dragonflies and damselflies, aquatic and semi-aquatic hunting spiders, mites, tadpole shrimp, leeches, flatworms, and copepods.[18] Protection of these small native predators can provide natural mosquito control.

Louisiana and New Jersey have employed thousands of tiny shrimp-like copepods that eat their way through mosquito larvae in swamps, roadside ditches, and small pools. The crustaceans do not get much bigger than two millimeters and are voracious predators of mosquito larvae. According to a study by the New Orleans Mosquito and Termite Control Board, copepods have proved more effective for practical mosquito control than any other invertebrate predator of mosquito larvae. The most effective copepod species have the capacity to kill more than 40 mosquito larvae/copepod/day, typically reduce mosquito production by 99-100%, and maintain large populations in habitat for as long as there is

water, and can persist in diapause when water dries up. Copepods are particularly useful in controlling mosquitoes breeding in containers. Although native species abound, copepods are easily raised and can be stored at low temperatures to avoid cannibalism. They can be applied with a sprayer. They tolerate exposure to *Bti* and some chemical insecticides.[19]

3. Monitoring Mosquitoes, Host Species, and the Virus

Monitoring is an essential part of an effective mosquito management program, and should be done regularly throughout the season. Tracking larval and adult population numbers, species types, and breeding locations provides invaluable information used to determine what, where, and when control measures might be needed. Identification of potential disease carriers and a gauge on the program's effectiveness are also afforded through population counts. Knowing when and where the virus is likely to strike allows for precise, targeted control techniques.

Monitoring can be labor intensive and costly. However, an accurate index of this information over time assists the program manager in predicting and anticipating control needs. For example, mosquito control officers should know which ponds breed the most mosquitoes, so they can target prevention and control measures. Local weather reports should also be consulted regularly to help prepare the community for possible outbreaks of mosquitoes, which usually occur after droughts followed by heavy rains, when aquatic ecosystems are disturbed.

"Birds serve as important natural hosts for the virus in the disease cycle," states a report from three professors from Texas A&M. "Public health officials often survey migrating bird populations to determine the incidence of virus and the potential for transmission to man and animal by feeding mosquitoes."[20] As with most animals, mosquitoes will not travel farther than they need to. If mosquitoes are not restricted by topography or climate and have an adequate food source, which is typically from birds, they will likely stay in a specific area.

However, some mosquito species can fly much farther in search of a blood meal, especially if it is windy. Thus, it is critical to monitor both the vector and the traditional host before determining the most effective strategy for your community.

The CDC recommends the following research priorities for St. Louis encephalitis: developing a standardized national surveillance program; characterizing overwintering mechanisms and other aspects of enzootic maintenance cycle; evaluating vector control strategies; determining biological basis for increased risk with age; and developing more effective systems for disease prevention.[21] The CDC also recommends the following priorities for Dengue fever: developing improved laboratory-based international surveillance; developing rapid, sensitive and specific diagnostic tests; developing more effective community-based prevention programs; and developing tetravalent dengue vaccine.[22]

4. Larviciding: What's Safe to Use

It is often not possible to eliminate all breeding sites where natural controls are not feasible. Therefore, it may be necessary to use larvicides to kill mosquito larvae. Several municipalities have supplemented tight budgets and/or small staff sizes by enlisting volunteers at critical times to help apply larvicides. Products containing *Bti* (*Bacillus thuringiensis* var. *israelensis*), such as Vectobac, are recommended for

larval control, especially in storm drains and sewer treatment plants. *Bti* is proven effective and has low levels of toxicity to humans, but its use should be minimized due to direct toxicity to non-target organisms such as frogs and harmless and/or beneficial insects, as well as indirect effects, which can impact ecosystem function, from water quality to bird reproductive success.[23,24] When deposited into larval pools, *Bti* is ingested by feeding mosquito larvae and kills them. For waters with high organic content, *Bacillus spharicus* (Vectolex) may be better suited with repeat applications every 4-6 weeks. Mosquitoes are a part of the ecological food web and therefore nurturing ecological balance in aquatic and terrestrial ecosystems is helpful.[25] However, with toxic chemical drift and runoff into the environment, a disruption of this balance raises challenges.

A critical component of any successful application is dip testing before and after application to ensure that the insect population is at its most susceptible stage for *Bti* application. *Bti* must be ingested by the insect and thus is most effective in the first and second stages of the larvae.

When the larvae are in the pupal (non-feeding) or adult stage of metamorphosis, *Bti* is less than 60 percent effective and will not be effective again until the next generation.

As with any pesticide, the use of larvicides should not be excessive as mosquitoes can become resistant to them. *Bti* settles out of the water column, but persists as spores in sediment, retaining toxicity when the sediment is disturbed.[26] Activity of *Bti* in leaf litter persists for months after application.[27] Persistence contributes to the development of resistance in mosquitoes, so monitoring for resistance is another important component of any program that relies on the use of pesticides, including larvicides. It is also important to note that larvicides may pose a risk to some vulnerable populations and should be accompanied by proper notification through public awareness campaigns.

5.

6. Adulticiding: Use Only as a Last Resort and Spray Responsibly

<u>How Communities Can Reach a Decision to Spray</u>

Spraying should only be done after carefully evaluating the likelihood of virus transmission, pesticide-related illnesses, and the contributing factors to a human epidemic of mosquito-borne diseases. Any program that is determined to responsibly respond to threat of WNv should exploit fully all non-chemical and preventive methods (including least-toxic larvicides) before resorting to spraying.

Contributing factors to a decision to use adulticides include: the public tolerance level of mosquito-disease and exposure to pesticides, ecology of the mosquito and disease transmission, the prevalence and types of mosquito and host species found in the area, and weather patterns. Specifically, this will involve:

1. Identifying local species capable of vectoring the disease;
2. Distinguishing between nuisance mosquitoes and vector species;
3. Virus surveillance through testing of dead birds, sentinel species, and mosquito pools to see whether the mosquito population in a given area reaches the threshold to vector the disease; and
4. Various mosquito-trapping methods that indicate densities of females, species, and virus.

Often, spraying occurs in response to a high numbers of mosquitoes or the finding of a “positive”—either a

positive mosquito pool, a positive bird, or a positive human case. Research shows adulticiding at these levels alone is not only the least effective method for managing mosquitoes, but also dangerous (see pages 15-17).

It is not efficacious to spray around the location of dead birds. Only mosquitoes can transmit the disease; birds cannot. As discussed in Appendix 1, some of the mosquitoes known to carry WNv usually travel only within a radius of few miles of their pool. (The distance can vary depending on habitat, geography, and mosquito species.) Since most birds can travel much farther than this, spraying around dead birds does not get rid of the source problem and may never hit a vector mosquito. Some experts use sentinel species, such as chickens or ducks, to first detect infected mosquito populations. However, as mosquito species and vectors can vary in different areas, and as larval control is considerably more efficacious, it is critical to have a good understanding of the ecology and the stage of mosquito development prior to beginning any spraying program. (Adulticides will not affect mosquito larvae and therefore cannot get at the largest source of the problem.)

Most experts agree that by the time a human illness is detected, it is already a month too late to start spraying pesticides in the same area where that person was exposed. It takes approximately two to ten days for symptoms to appear and up to two to three weeks for blood tests to confirm a positive link to the virus. The efficacy of spraying will be much greater if earlier detection of infected mosquito pools and other factors mentioned above are used as spray indicators, rather than humans. Additionally, as most urban and suburban mosquito vectors are weak fliers (such as *Cx. Pipiens* – the "backyard mosquito") they will not travel far from where they breed. Spraying along residential streets will have limited effectiveness on mosquito populations not in the area (or in the backyard) and are known to rebound to pre-spray levels within days.

Therefore, any spray activity must be augmented with strong public education campaigns, source reduction, and larval control.

Spraying of Nuisance Mosquitoes

A number of mosquito control programs respond to biting or sighting complaints by spraying to kill adult mosquitoes. Given the potential health risks and environmental impacts of adulticiding, monitoring and prevention techniques must be heavily emphasized, and spraying purely to control nuisance mosquitoes should be avoided. Public awareness should also be used to raise the bar on tolerance levels and to educate on the most effective means of mosquito control. At a minimum, citizens must be given the right to have no pesticides sprayed around their house or neighborhood and to be notified well before spraying takes place.

<u>Responsible Spraying</u>

Responsible spraying for mosquito-borne diseases should adhere to the guidelines provided above and below.

- *Identify and monitor the infected mosquito pools or areas. Set publicly acceptable threshold levels.*
- *Use the least dangerous pesticides.* The two main categories of available adulticides, synthetic pyrethroids and organophosphates, each have their problems. In general, synthetic pyrethroids, such as resmethrin, sumithrin, and permethrin, have lower acute human health and environmental risks than organophosphates, but may be problems for vulnerable populations.[28] Organophosphates, such as malathion and naled, are associated with high acute poisoning rates. Both synthetic pyrethroids and organophosphates are neurotoxins that can

cause chronic health problems. Do not use Dursban™, which contains chloropyrifos, a chemical already banned for residential use due to high toxicity, particularly to children. Naled is particularly toxic and should not be considered a likely candidate for mosquito control. Although synthetic pyrethroids are applied in smaller amounts and have shorter residual lives than malathion and other organophosphates, they should be used only with great hesitation and extreme caution.

Pyrethroids usually contain a carcinogen (science has not determined a "safe level of exposure" to carcinogens or at what level a carcinogen will trigger cancer cell development), are linked to endocrine or hormonal disruption (a health risk not currently evaluated by the U.S. EPA.) and breast cancer,[29] and may aggravate asthma or other respiratory conditions. In other words, the risk of using chemical adulticides must be assessed alongside the actual risk of the virus.

- *Spray when mosquitoes are most active.* After determining which mosquitoes carry the disease, research the biology and behavior of the vector to find out when they are most likely to be exposed to spray. The spray must hit the mosquito while in flight in order to be lethal. For example, *Culex m*osquitoes take refuge in grass and brush during the day, so spray *Culex* at dusk when they are active and most vulnerable. Avoid spraying areas with human populations and take extreme caution not to spray people.

- *Check local weather forecasts to gauge temperature and wind.* According to an article in Common Sense Pest Control, "The best condition is during a slight breeze of 3 mph or less. This air movement helps to disperse the pesticide effectively, but does not move it to unwanted areas."[30] EPA advises not to spray in winds over 10 mph. In general, mosquitoes are most active at 80º F, become lethargic at 60º F, and cannot function below 50º degrees F.[31]

- *Notify the public at least 72 hours in advance.* Inform every household, school, hospital, and business in the community about when the spraying will occur so they will have ample time to protect themselves. Alert the public that pesticides are not safe and to take precautions. The mechanisms of notifying the public are described below.

- *Ensure that the person spraying is properly trained, certified, protected, and monitored.* Verify strict compliance with all label and manufacturer instructions, including prohibitions on spraying and drifting of certain pesticides over bodies of water. Mist blower and aerial application of these materials to populated areas will result in human exposure. Spraying should be done in the most targeted manner possible such as from vehicles or on foot by professional certified applicators, rather than from aircraft.
- *Ensure pesticide equipment calibration.* Comply with requirements for proper calibration, storage, disposal, and equipment cleaning. Never allow pesticides to be diluted to save cost, as sub-lethal doses may result in pesticide resistance.

- *Do not conduct aerial spraying.* This is the least efficient method of spraying. Most small planes are restricted from flying during the evening, when many mosquito species are most active, and pesticides sprayed from planes hits less of the target area.

- *Continue implementing source reduction, larval control and other prevention strategies!*

Public Officials Must Warn the Public about Virus AND Pesticide Dangers

City or town officials have the duty, experience, and resources to warn the public about both mosquito-borne viruses and the dangers of pesticides and should provide information on ways to minimize exposure to both. As discussed on pages 15-17 of this document, pesticides are hazardous to public health and the environment and are even more so for vulnerable populations such as children, the elderly, people with respiratory or compromised immune systems or with chemical sensitivities. Regardless of intentions, government officials should never tell the public that pesticides are safe. EPA prevents manufacturers from making such claims in pesticide advertising and warns, "[N]o pesticide is 100 percent safe, and care must be used in the exercise of any pesticide."[32] The U.S. General Accounting Office has told Congress on several occasions that the public is misled on pesticide safety by statements characterizing pesticides as "safe" or "harmless."[33]

The danger of pesticides should never be trivialized. State officials have a responsibility to inform residents of the city about the hazards of all pesticides used. They also have a responsibility to cooperate with all neighboring jurisdictions in the region to develop preventive strategies that focus on control of larvae and utilize least toxic approaches.

Public officials should embrace and utilize the following guidelines:

- *Establish a Community Pest Management Advisory Board.*
  - It is recommended by CDC[34]and Beyond Pesticides that Health Departments create a Citizen Advisory Committee or West Nile Task Force as a beneficial mechanism to increase public input, education, and buy-in from the community on the department's program to protect the public both from disease and poisoning. A community task force should include representatives from government, local university, business, health, and environmental sectors in order to achieve optimal consensus-building on the appropriate threat response.[35]

- *Notify the public at least 72 hours in advance of application.*
  - Install a mosquito hotline. Update it regularly with information about where spraying will occur, when, and how to protect from pesticide exposure. Provide a multiple-line message service that is available 24/7.[36]
  - Issue public notices to organized groups including public and private school superintendents, hospital associations, chambers of commerce, police and fire departments, hospitals, libraries, and village associations. Utilizing community groups is an efficient means of notifying as well as involving the public as those organizations are often better able to circulate the notices to the right places in a timely manner.
  - Include notice to water management, environmental quality, and fish and wildlife agencies in order to ensure proper monitoring of pesticide residues and prevent contamination.
  - Use the media to inform the public about spraying and to publicize the mosquito hotline. Place paid public service announcements.
  - Use county/local websites to provide information about protection measures against the disease and pesticides. Include information about the municipality's

methods of mosquito management, including any plans to spray with locations, times, and dates, and keep the information regularly updated.

- *Provide members of the public with the opportunity to opt-out their residences from spraying.* Certain populations are more at risk of pesticide poisoning than the general public and have a right to protect themselves from pesticide exposure. This service should be an integral part of any spray program and should include buffer zones (usually 150 ft – 300 ft) to counteract pesticide drift. Residents should also be pre-notified (usually 72 hours prior) before any spraying occurs in their area so they may make important preparations.

- *Provide the public with precautionary measures.* Everyone should receive guidelines on how to reduce exposure to pesticides. (See tips below.)

- *Ensure that the public still follows prevention guidelines.* It is critical that spray announcements are accompanied by continued prevention education and calls for personal protection.

- *Monitor the public for adverse health and environmental effects.* Set up a hotline for receiving pesticide incident reports from the public and the medical community to ensure that the method of mosquito control is not causing additional public health or environmental problems. Physicians should be briefed on identifying pesticide poisoning and required to report incidents.

- *Monitor pesticide levels in the environment.* Pesticide sprays also affect non-target beneficial species and can drift long distances. Several federal, state, and local laws require the protection of federally listed endangered or threatened species and their habitat, quality drinking water sources from the effects of pesticide drift. Include pesticide residues in all water and soil tests.

<u>How Individuals Can Protect Themselves from Exposure to Dangerous Pesticides</u>

- Leave the area.*
- Close the windows.
- Turn off air intake on window unit air conditioners.
- Take toys and lawn furniture inside.
- Remove shoes before entering homes to avoid tracking in residues.
- Cover swimming pools.
- Don't let children play near or behind truck-mounted applicators or enter an area that has been sprayed within several days (depending on material sprayed).
- Wipe pet paws off with a wet cloth before they re-enter your home.

**Infants, children, pregnant women, the elderly, and individuals with compromised respiratory or immune systems are the most vulnerable populations and should take extra care to avoid pesticide exposure. People with multiple chemical sensitivities or other pesticide illnesses are also more vulnerable to pesticide exposure.*

III. PESTICIDES ARE DANGEROUS TO PUBLIC HEALTH AND THE ENVIRONMENT

The two types of pesticides used in spraying adult mosquitoes are synthetic pyrethroids and organophosphates (OP). Scientific studies show that both types are dangerous, especially to vulnerable populations. Ironically, the same populations that are most susceptible to severe encephalitis are also at risk of getting sick from pesticides—the elderly and people with compromised immune systems. A study conducted by the National Research Council found that pregnant women, infants, and children also have a greater risk of getting sick from pesticides.[37]

According to the New York State Department of Health, more people were reported to have gotten sick from pesticide spraying than from illness caused by the virus in 2000.[38] In 2001, 37 young ball players and spectators at a softball game in upstate New York were hospitalized after being poisoned. According to Moreau Emergency Squad Captain Andre Delvaux, the organophosphate malathion was being sprayed to control potential WNv carrying mosquitoes near the baseball field while a game was in progress.

The most recent CDC review of acute pesticide poisonings that resulted from mosquito sprays found 265, with almost half from work-related incidents. Of the non-work-related poisonings, the majority of cases were respiratory (66%) and neurological (61%) and almost 75% were due to OP poisonings (mostly malathion). Since only few states have pesticide poisoning surveillance systems, (which even still may miss the majority of cases as pesticide poisonings are known to be often misdiagnosed or remain unreported), CDC was forced to gather over a quarter of the reports from the news media.[39]

Pesticide spraying may also leave the public with a false sense of security, and they may not take personal precautions. Worse, communities may feel it is no longer necessary to follow the prevention guidelines that will eliminate breeding sites.

1. Health Effects of Pyrethroids

Synthetic pyrethroids, which include resmethrin (Scourge) and sumithrin (Anvil), are adulticides patterned after pyrethrum, an extract from the chrysanthemum flower. While similar to pyrethrum, synthetic pyrethroids have been chemically engineered to have greater toxicity and longer breakdown times.[40] Additionally, almost all synthetic pyrethroid mosquito products are combined with synergists, which increase potency and compromise the human body's ability to detoxify the pesticide.

According to the 2017 Annual Report of the American Association of Poison Control Centers, pyrethroids were the class of pesticides most often reported to poison control centers.[41] Over 23,000 exposures, including 5,487 children less than five years old, were reported.[42] Over 4,000 of these cases required medical attention.[43]

Symptoms of pyrethroid exposure include dermatitis and asthma-like reactions, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations.[44] Synthetic pyrethroids are endocrine disruptors and have been linked to breast cancer.[45] Deaths have resulted from respiratory failure due to exposure to these chemicals. *People with asthma and pollen allergies should be especially cautious.* Breakdown times range from a few hours in

direct sunlight, to several months in damp, dark environments (such as indoors, where they have been shown to end up). However, synthetic pyrethroids pose lower levels of human health risks than organophosphates.[46]

2. Health Effects of Organophosphates

Organophosphates are a highly toxic class of pesticides that affect the central nervous, cardiovascular and respiratory systems. They include malathion (Fyfanon), naled (Dibrom) and chlorpyrifos (Mosquitomist), which are extremely hazardous to public health and the environment.

According to the American Association of Poison Control Centers, over 2,300 exposures to organophosphates, including 623 children under five years old, were reported.[47] Almost 600 of these cases required medical attention.[48]

Initial, short-term symptoms of exposure include numbness, tingling sensations, headache, dizziness, tremors, nausea, abdominal cramps, and sweating, lack of coordination, blurred vision, difficulty breathing, and slow heartbeat.[49] More severe exposures can cause unconsciousness, incontinence, and convulsions, which may lead to death.[50] Some organophosphates have been linked to birth defects and cancer. Breakdown times range from a few days in direct sunlight, to several months in damp, dark environments.

3. Combining Chemicals Is Dangerous

Another concern is that the EPA does not adequately review the synergistic effects of active and inert ingredients within the same product or those of different products before registering a pesticide. Furthermore, combinations of pesticides have not been tested to rule out their health effects on vulnerable populations.

For example, two chemicals commonly used to control bites from mosquitoes may produce a dangerous combination. A study by Duke University researchers found that combined exposure to DEET and permethrin, which is a mosquito spray, could lead to motor deficits and learning and memory dysfunction.[51] Dr. Mohammed Abou-Donia, a Duke University pharmacologist and co-author of this study, recommends that DEET should not be used with other chemicals or by people who are taking medication.

Dr. Abou-Donia is concerned that these chemicals are used not only in areas where there are healthy people, but where there are vulnerable populations, such as infants, children, and pregnant women. These and other vulnerable populations have a higher risk of becoming ill due to pesticide and DEET exposure. Additionally, several cases of DEET poisonings have been reported by EPA, including three fatalities.

4. Pesticide Spraying Is Harmful to the Environment

Pesticide spraying is also harmful to ecosystems and wildlife.[52] Adulticides pose well- documented threats to wildlife, birds, fish, shellfish, and beneficial insects such as bees, butterflies, and dragonflies, which prey on mosquitoes. All adulticides are noted as being toxic to fish. In 1999, malathion spraying was found responsible for the death of over 2,000 fish on Staten Island.[53]

As discussed below, pesticide spraying often kills other types of mosquito predators, too. Furthermore, wildlife and ecosystems depend on mosquitoes for their survival. It is important to note

that, similar to human health risks, synthetic pyrethroids generally pose lower environmental risks than organophosphates.[54]

5. Legal Concerns of Improperly Trained Pesticide Applicators

New York and Maine faced hefty pesticide-related lawsuits as a result of spray activities. Five spray operators who worked for a New York City contractor in 2000 filed a complaint with the Occupational Safety and Health Administration. They said they became sick because of improper training and prolonged exposure to the chemicals.[55] Another lawsuit, for $125 million, came from commercial fisherman who claimed there was a dramatic decrease in their lobster harvest because of pesticides used against mosquitoes believed to carry the WNv.[56]

IV. PESTICIDE SPRAYING IS NOT PROVEN HIGHLY EFFECTIVE AND IS INEFFICIENT

The CDC states that adulticiding should only be used as a last resort, when all preventive methods have failed. According to the CDC's website, "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."[57]

While many report that lower mosquito counts occur immediately after spraying pesticides, it is not certain what percentage of the population is actually reduced.[53] Most studies of the efficacy of adulticides are conducted with caged mosquito traps under controlled conditions, which is not a realistic representation of mosquitoes in their natural environment. Furthermore, mosquito counts are rarely measured a week or more after a spray to see whether the mosquito population has returned to pre-spray levels. In Florida, state officials took bite counts before and after widespread aerial spraying and found that mosquito populations surged back to pre-spray levels within three days of the treatment.[58]

1. Pesticide Spraying May Increase Mosquito Populations

An article in the *Journal of the American Mosquito Control Association* showed that long-range effects of pesticide spraying can actually increase the number of mosquitoes by destroying their natural predators.[59] Furthermore, mosquitoes surviving the spraying may pass on genes for resistance to the pesticide—which has already occurred in several areas around the country. A 2003 study finds that mosquitoes carrying West Nile virus and malaria developed resistance to organophosphate and carbamate insecticides as a result of a single genetic mutation.[60]

Efforts to control the transmission of malaria are encountering a big, though predictable, problem—the mosquitoes that transmit malaria are developing resistance to at least five of the insecticides that have been central to limiting transmission of the disease. A 2020 study reveals a dramatic increase in resistance to pyrethroid insecticides and DDT across sub-Saharan Africa.[61]

2. Pesticide Spraying Is Inefficient

The CDC states that spraying pesticides intended to kill adult mosquitoes, known as adulticiding, is usually the least efficient mosquito control technique.[62] Preventive measures such as removing breeding areas are much more efficient in eliminating mosquito threats. One study from the Harvard

School of Public Health[63] found that aerosol plumes fail to contact the target mosquitoes, and concludes that such insecticidal aerosols may not effectively reduce mosquito populations and the potential for disease transmission. This means that the vast majority of the chemical is allowed to enter the air and environment.

Dr. David Pimentel, a professor of entomology at Cornell University, estimates that pesticides sprayed from trucks hit less than .01 percent of the targeted spray area.[64] In a later article he wrote, "Based on the estimate that target mosquitoes only receive about 0.0000001% of the aerial spray (Pimentel 1995), 1 million insecticide droplets must be

produced to hit one target mosquito. Suppose a city spent $500,000 for mosquito control and only 1 insecticide droplet in a million hits a mosquito. This means that the 50¢ of the tax money resulted in killing 1 mosquito."[65] The rest of the pesticide remains in the environment where it can have detrimental effects on public health and ecosystems. To date, Pimentel's calculations have never been challenged. For the spray to be effective, it must hit the mosquito while it is in flight. Yet, it is nearly impossible for the truck- based sprays to reach over and in between foliage, buildings, or other structures where most mosquitoes may reside. The high potential for sprays to miss their target makes the actual cost of the chemicals even higher than the tag might indicate.

V. RECOMMENDATIONS

1. Implement strong public education campaigns (especially targeted to the populations most vulnerable to serious illness from WNV) to educate people on what they can do to minimize their exposure to mosquitoes and mosquito-borne diseases like WNV.
2. Conduct good surveillance to monitor populations of mosquitoes, host species and the virus.
3. Implement source reduction techniques on public lands, including maintaining healthy ecosystems.
4. Conduct least-toxic larval control to kill mosquitoes before they become biting adults.
5. Use biological controls such as mosquito-eating fish for hard-to-reach pools.
6. Use adulticides only as a last resort, meaning when the threshold of mosquitoes has reached epidemic proportions, and when the community is not more adverse to the pesticides than they are the threat of the virus.
7. Ensure any use of adulticides is done responsibly:
   - *Identify and monitor the infected mosquito pools or areas. Set publicly acceptable threshold levels.*
   - *Choose the least dangerous pesticides.*
   - *Spray when mosquitoes are most active.*
   - *Check local weather forecasts to gauge temperature and wind.*
   - *Notify the public at least 48 hours in advance.*
   - *Ensure that the person spraying is properly trained, certified, protected and monitored.*
   - *Ensure pesticide equipment calibration.*
   - *Do not conduct aerial spraying.*
   - *Continue implementing source reduction, larval control and other prevention strategies!*
   - *Notify the public at least 72 hours in advance of application.*
   - *Provide members of the public with the opportunity to opt-out their residences from spraying. Certain populations are more at risk of pesticide poisoning than the general public.*
   - *Provide the public with precautionary measures to avoid pesticide exposure.*
   - *Ensure the public still follows prevention guidelines.*
   - *Monitor the public and environment for adverse health effects.*
   - *Monitor pesticide levels in the environment.*

In order to conduct adequate risk/benefit analyses of spraying adult mosquitoes when there is a disease outbreak, several key monitoring systems are needed. First, scientists must develop better ways of measuring mosquito populations in a given area. Pesticides should not be sprayed on such a widespread basis until there can be accurate measurements of its efficacy. It is simply not worth the risks. Existing studies indicate that by spraying pesticides, we are compounding the low risks of acquiring this disease with another public health threat.

Secondly, pesticide monitoring systems must be developed that accurately measure and record the location of spraying, and the types and amounts of pesticides used for each given area. This will enable pesticide illness tracking programs to more accurately determine the number of illnesses caused by using pesticides. In order to successfully implement this system, public health officials must educate doctors and nurses, and community leaders must educate the public about symptoms of pesticide poisoning.

Finally, pesticide applicators and mosquito control teams should receive better training to achieve higher levels of safety and efficacy. They should be properly trained to decide when and if they should spray, choose the least-toxic pesticide, use the best methods, and spray at the right time.

VI. ACKNOWLEDGMENTS

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Appendix 1
Culex Mosquito Life Cycle

In the United States, WNv and St. Louis encephalitis is primarily associated with the *Culex* mosquitoes.[66] Within this genus, three species, namely *C. pipiens*, *C. restuans*, and *C. salinarius*, make up the majority of those mosquitoes found to be infected with WNv. Only female mosquitoes take blood meals.

Adult females may live 2-4 weeks or more, depending on climate, species, predation, and a host of other factors. Like other insects, mosquitoes are cold-blooded. They are most active at 80º F, become lethargic at 60º F, and cannot function below 50º degrees F.[67]

All mosquitoes go through a complicated life cycle called "complete metamorphosis." Complete metamorphosis involves four distinct stages – egg, larva, pupa, and adult. The length of time that each stage lasts depends on a number of variables with temperature having the greatest impact.

Eggs are laid in "rafts" on standing bodies of water. The eggs require one to two days in water before hatching into larvae.
Larvae, or wrigglers, molt three times during ten to twelve days before pupating.
Pupae, or tumblers, metamorphose over one to two days into adults.
Adults emerge from their pupal cases approximately twelve to sixteen days after egg laying.[68]

After mating, the female requires a blood meal in order to produce over 250 eggs. It takes her three to four days to digest the blood and produce the eggs. Females can transmit diseases when they live long enough to spread infection from the first blood meal victim to the second blood meal victim. Only a very small percentage of females live this long.[69] *Culex* mosquitoes are generally weak fliers and do not move far from their larval habitat, although they have been known to fly up to two miles.[70]

Appendix 2
The Facts about West Nile Virus

What is West Nile virus?

West Nile virus (WNv) is a mosquito-borne disease that was first detected in the United States in 1999.[71] Birds act as hosts for the virus, and mosquitoes spread it through their bites. Current evidence shows that only mosquitoes can spread the disease; humans or other animals cannot.

The information in this section is primarily based on information from the Centers for Disease Control and Prevention (CDC) website.[72]

What is the likelihood that someone will become ill?

The vast majority of people (about 80%) who become infected with WNv will show no symptoms and never become sick. Some 20% may experience mild flu-like symptoms within 3 - 15 days. Less than one percent of those infected with WNv will develop severe illness, according to the CDC. The serious illness can cause a potentially fatal condition known as encephalitis or inflammation of the brain. In the United States, people older than 50 years and those with weakened immune systems have the highest risk of severe encephalitis. Birds, horses, and other animals are also at risk. Not all cases are reported or able to be tracked. In 2018, CDC received 2,647 reports of WNv cases and 167 fatalities. From 1999 through 2018, CDC received 50,830 reports of WNv cases and 2,330 fatalities.

What are the symptoms?

Most people who become infected will have mild symptoms that include fever, head and body aches, skin rash, and swollen lymph glands. However, a health care provider should be contacted immediately if there is high fever, confusion, muscle weakness, and severe headaches. It may take 3 to 15 days for any of these symptoms to show.

Where is WNv found?

WNv has spread throughout the United States. In 2003, the virus had been found in birds or humans in every state besides Washington and Oregon. By 2012, every state in the continental U.S. had reported cases of WNv. The disease is also found throughout the world, including Africa, West Asia, Eastern Europe, and the Middle East. In areas where mosquitoes carry the virus, less than one percent of the mosquitoes are infected.

When is it most common?

In most parts of the United States, WNv is most common in late summer and early fall. In southern Florida and other warmer regions of the world, this disease can occur year-round. In the northeast, residents are advised to take precautions until there are two hard frosts.

Appendix 3
The Facts about St. Louis Encephalitis

What is St. Louis encephalitis?

St. Louis encephalitis is a mosquito-borne disease that was most recently detected in Louisiana in 1999.[73] St. Louis encephalitis is a potentially fatal illness that causes inflammation of the brain. Birds act as hosts for the virus, and mosquitoes spread it through their bites. Current evidence shows that only mosquitoes can spread the disease; humans or other animals cannot. The information in this section is primarily based on information from the Centers for Disease Control and Prevention (CDC) website.[74]

What is the likelihood that someone will become ill?

From 2009 through 2018, an average of 7 cases were reported annually (range 1–19). The elderly and people who work outdoors are most at risk. Mortality rates range from 3 to 30 percent, and are higher with the elderly.

What are the symptoms?

People with mild infections will usually have a fever and a headache. More severe infection is marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, occasional convulsions (especially in infants) and spastic paralysis.

Where is St. Louis encephalitis found?

Outbreaks of the disease can occur throughout the United States. During 1974-1977, there was an outbreak in the Midwest with over 2,500 reported cases.

When is it most common?

In temperate regions, people are most at risk during the late summer or early fall. In milder climates, such as southern U.S. states, St. Louis encephalitis can occur year round.

Appendix 4
The Facts about Dengue

What is dengue?

Dengue is a disease caused by one of the four viruses: DEN-1, DEN-2, DEN-3, or DEN-4. It is transmitted to humans through the bite of an infected mosquito. In 2001, an outbreak in Hawaii was transmitted by the *Aedes albopictus* mosquito. However, in most parts of the western hemisphere, the *Aedes aegypti* mosquito is the most common vector of this disease. The information in this section is primarily based on information from the Centers for Disease Control and Prevention (CDC) website.[75]

What is the likelihood that someone will become ill?

Generally, younger children have a milder illness than older children and adults. Dengue hemorrhagic fever is a more severe form of the disease, and is caused by the same infection as dengue. Worldwide, over 100 million cases of dengue fever occur each year.

What are the symptoms?

People who become infected will have a high fever, severe headache, backache, joint pains, nausea and vomiting, eye pain, and rash. A person with dengue hemorrhagic fever will have a fever that lasts from 2 to 7 days, and general signs and symptoms that could occur with many other illnesses (e.g., nausea, vomiting, abdominal pain, and headache). This stage is followed by the tendency to bruise easily or other types of skin hemorrhages, bleeding nose or gums, and possibly internal bleeding. The smallest blood vessels become "leaky," allowing the fluid component to escape from the blood vessels. This may lead to failure of the circulatory system and shock, followed by death, if circulatory failure is not corrected.

Where is Dengue found?

Dengue fever has been reported throughout the U.S., mostly resulting from travel. This disease can also be found in Puerto Rico. According to the CDC, "There is a small, but significant, risk for dengue outbreaks in the continental United States."[76] Dengue is common in areas of the Caribbean (including Puerto Rico), Central and South America, Southeast Asia, and the Pacific Islands. In the United States, local cases and limited spread of dengue occurs periodically in some states with hot, humid climates and *Aedes* mosquitoes. The areas most at risk for dengue transmission and sporadic outbreaks are Southern Texas and southeastern U.S, which is where the *Aedes aegypti* is found. Outbreaks generally occur in tropical urban areas, where the *Aedes* mosquito lives.

Appendix 5
Case Study: Connecticut's Tiered Approach to Mosquito Management

Today, successful mosquito management programs generally use the same guidelines we recommend in this report: 1) public awareness; 2) prevention, which includes source reduction and personal protection against mosquito bites; 3) monitoring/surveillance; and 4) spray adulticides only when absolutely necessary, after careful evaluation of the contributing factors to a human epidemic of mosquito-borne diseases.

The State of Connecticut's Mosquito Management Program is hailed by Audubon, which said, "[N]o state program is more effective than Connecticut's, which didn't buy into the regional hysteria… [It] sprayed only those areas where infected mosquitoes were found; focusing its efforts on reducing mosquito breeding areas through wetland restoration rather than spraying."

Connecticut uses a tiered approach of response levels to WNv. The Connecticut Department of Public Health (DPH) will work with other state and local agencies to evaluate the potential threat to human health. After evaluating data obtained from public health surveillance activities, the DPH will recommend which control measures to be implemented in proportion to the human threat of WNv. In their 2001 Draft Response Plan, the four-tiered approach described below is recommended.

Level	Status of WNv	Actions to be Taken
1. Public Health Notification	WNv is first confirmed in a Connecticut town through bird, mosquito, or domestic animal surveillance	a) Evaluate need to expand mosquito trapping and enhance human and bird surveillance b) Expand educational efforts on prevention and control to local health directors, elected government officials, and the public—especially older persons c) Evaluate need for additional larviciding in the affected area and recommend additional applications as necessary

2. Public Health Alert	a) WNv is confirmed in multiple horses or domestic animals; or b) Dead crow sightings of two or more per square miles in a week in a town; or c) Two or more human-biting mosquito pools collected at one or more trap locations; or d) Combinations of the above surveillance events; or e) A person was likely infected in a specific area	A Public Health Alert will be announced and the following actions will be taken: a) Information on adulticide applications will be disseminated, and additional emphasis on personal protective measures will be made. b) The State Mosquito Management Team will conduct an evaluation of surveillance data from all sources, the ability to thoroughly cover the area of risk by ground spraying, and an evaluation of weather conditions. c) Based on this evaluation, the Commissioners of Environmental Protection and Public Health, in consultation with local town officials, will consider and may recommend the ground application of adulticides in areas where WNv poses the highest human risk.
Level	**Status of WNv**	**Actions to be Taken**
		4) The application of adulticides by the State will only be done with the approval of municipal officials in the affected towns.
3. Public Health Warning	A Public Health Warning will be announced when WNv is confirmed in a Connecticut or contiguous town: a) In a person with characteristic severe neurological disease; and b) When in the judgment of the Commissioners of Environmental Protection and Public Health, evidence of the virus presents a serious human health risk based upon high levels of WNv activity (e.g., two or more human-biting mosquito species in the area of concern test positive for WNv).	The following actions will be taken: a) All actions in a Level 2. response will be continued or initiated. b) The Commissioners of Environmental Protection and Public Health will recommend ground application of adulticide in the affected area when the Commissioner has determined it is necessary to control mosquito vectors of human disease. The recommendation will be conditional and will be based on the evaluation conducted by the State Mosquito Management Team. c) The Commissioners of Environmental Protection and Public Health will review the potential need for aerial application of adulticides after evaluating surveillance data, the time of year, current level of mosquito activity, the size of the affected area, and the practicality of ground spraying of the same area

		and weather conditions. d) The application of adulticides by the State will be done only with the approval of the municipal officials in the affected towns.
4 Public Health Emergency	WNv is confirmed in a Connecticut or contiguous town: a) In multiple persons with characteristic severe neurological disease; and b) When conditions exist that favor the continued transmission of WNv to people.	The following actions will be taken: a) All actions in a Level 3. response will be continued or initiated. b) The Governor will evaluate the need for declaring a civil preparedness emergency. c) After consultation with the Commissioner of Public Health, the Commissioner of Environmental Protection has the responsibility and authority to act unilaterally if the application of chemical pesticides from the air or ground is necessary to control mosquito vectors of human disease. Officials from the Mosquito Management Program will concurrently meet with local officials in the affected communities to inform them of the situation and to discuss the logistics of spraying. 4) The application of adulticides by the State at this action level does not require the approval of the municipal officials in the towns affected.

Source: The State of Connecticut West Nile Virus Surveillance and Response Plan, 2001. Website address: http://dep.state.ct.us/mosquito/index.asp. Accessed March 2002.

Beyond Pesticides (formerly National Coalition Against the Misuse of Pesticides), headquartered in Washington, D.C., works with allies in protecting public health and the environment to lead the transition to a world free of toxic pesticides. The founders, who established Beyond Pesticides as a nonprofit membership organization in 1981, felt that without the existence of such an organized, national network, local, state and national pesticide policy would become, under chemical industry pressure, increasingly unresponsive to public health and environmental concerns.

Beyond Pesticides seeks to protect healthy air, water, land and food for ourselves and future generations. By forging ties with local and state governments, nonprofits and people who rely on these natural resources, we reduce the need for unnecessary pesticide use and protect public health and the environment. Beyond Pesticides provides hands-on services to the public and supports local action by: identifying and interpreting hazards; and, designing safe pest management programs.

With the information provided by Beyond Pesticides, people may not only be able to make informed choices and adopt practices that protect themselves and their families from unnecessary exposure to pesticides, but they will be able to effect changes on community-wide pest management decisions and policies that govern pesticide use, such as pesticide uses in parks, schools, for community insect control and along roadsides. Beyond Pesticides believes that people must have a voice in decisions which affect them directly.

Beyond Pesticides' primary goal is to effect change through local action, assisting individuals, community-based groups and regional organizations to stimulate discussion on the hazards of toxic pesticides to human health and the environment. Beyond Pesticides provides important information on toxic pesticides and non-toxic alternatives, organizing and policy change. Education and outreach is accomplished through hands-on support, our website, coalitions, and our journal ***Pesticides and You***.

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ENDNOTES

[1] Harriott, N. "Mosquito Control and Pollinator Health." Pesticides and You. Beyond Pesticides. 2016. 36:2.

[2] Howard, John J. and Joanne Oliver. 1997. "Impact of Naled (Dibrom 14) on the Mosquito Vectors of Eastern Equine Encephalitis Virus," *Journal of the American Mosquito Control Association*. Vol. 13, No. 4, pgs. 315-325.

[3] Epstein, Paul R. and C. Defilippo (2001). "West Nile Virus and Drought." Global Change & Human Health. 2: 105-107.

[4] Epstein, Paul (2000). "Is Global Warming Harmful to Health." Scientific American, Inc.

[5] People older than 50 years and those with compromised immune systems have a greater risk of developing a serious illness from West Nile virus. This same population, plus infants, children, pregnant women and those with compromised immune systems have a greater risk of getting seriously ill from pesticide exposure.

[6] Abou-Donia, Mohammed Ph.D. (1999). Quoted on Duke Newsline in August, 1999. http://www.dukenews.duke.edu/Radio/mm0820.htm.

[7] Garrettson LK (1997). Commentary-DEET: Caution for children still needed. *J Toxicol Clin Toxicol*. 35:443-5.

[8] U.S. EPA (1998). "Reregistration of the Insect Repellent DEET." Website address: http://www.epa.gov/opp00001/citizens/deet.htm#4. Accessed March 2002.

[9] Abdel-Rahman, Ali, Ashok K. Shetty, and Mohamed B. Abou-Donia (2001). "Subchronic Dermal Application of *N,N*-Diethyl *m*-Toluamide (DEET) and Permethrin to Adult Rats, Alone or in Combination, Causes Diffuse Neuronal Cell Death and Cytoskeletal Abnormalities in the Cerebral Cortex and the Hippocampus, and Purkinje Neuron Loss in the Cerebellum." Experimental Neurology, Volume 172.

[10] U.S. EPA. DEET. 2020. https://www.epa.gov/insect-repellents/deet.

[11] Sarwar, M., 2015. Controlling dengue spreading Aedes mosquitoes (Diptera: Culicidae) using ecological services by frogs, toads and tadpoles (Anura) as predators. *American Journal of Clinical Neurology and Neurosurgery*, *1*(1), pp.18-24.

[12] Sarwar, M., 2015. Reducing dengue fever through biological control of disease carrier Aedes Mosquitoes (Diptera: Culicidae). *International Journal of Preventive Medicine Research*, *1*(3), pp.161-166.

[13] Gonsalves, L., Law, B., Webb, C. and Monamy, V., 2013. Foraging ranges of insectivorous bats shift relative to changes in mosquito abundance. *PloS one*, *8*(5), p.e64081.

[14] Knight, R.L., Walton, W.E., O'Meara, G.F., Reisen, W.K. and Wass, R., 2003. Strategies for effective mosquito control in constructed treatment wetlands. *Ecological Engineering*, *21*(4-5), pp.211-232.

[15] Mancuso, Sara Isadora (2001). "NJ Uses Weapon in Fight Against Mosquitoes: Fish." Philadelphia Inquirer, September 8, 2001.

[16] Pyke, G.H., 2008. Plague minnow or mosquito fish? A review of the biology and impacts of introduced Gambusia species. *Annual review of ecology, evolution, and systematics*, *39*, pp.171-191.

[17] Turrillion, Greg (2002). Director of Mosquito Control Program in Nassau County, NY. Personal communication in March 2002.

[18] Mogi, M., 2007. Insects and other invertebrate predators. *Journal of the American Mosquito Control Association*, *23*(sp2), pp.93-109.

[19] Marten GG, and Reid JW (2007). Cyclopoid copepods. *J Am Mosq Control Assoc*. 23(2 Suppl):65-92.

[20] McWhorter, G. Michael and J.K. Olson (1997). "Mosquito Pests of Man and Animals." Texas A&M

University website: http://insects.tamu.edu/extension/bulletins/l-1744.html.
[21] Centers for Disease Prevention and Control (2001). "Fact Sheet: St. Louis Encephalitis." Located on website at www.cdc.gov/ncidod/dvbid/arbor/slefact.htm.
[22] Centers for Disease Prevention and Control (2001). "Fact Sheet: Dengue and Dengue Hemorrhagic Fever." Located on website at www.cdc.gov/ncidod/dvbid/dengue/facts.htm.
[23] Hicks, Lebelle (2001). *Human Health and Environmental Relative Risks of WNV Mosquito Control Products*.
Maine Board of Pesticides Control.
[24] Research demonstrating impacts of *Bti* is reviewed in Attachment A to City of Boulder, CO Memo Updating the City's Mosquito Management Plan (2018). https://www-static.bouldercolorado.gov/docs/BoulderCCMemo_Update_to_Mosquito_Management_Program_8Nov2018-1-201906051539.pdf?_ga=2.29944247.900285061.1595012023-931808414.1595012023.
[25] City of Boulder, Colorado. Memorandum. April 12, 2018. *"Mosquitoes are native species with a critical ecological niche in wetlands and terrestrial systems, including water filtration and algae suppression as larvae. Some species act as pollinators as adults. All life stages of mosquitoes are at the base of the food chain in both aquatic and terrestrial food webs. A thorough understanding of the ecology and the role and interrelationships of the members of these ecosystems can lead to the most effective ways of improving wetland natural regulation of mosquitoes."*
[26] Ohana, B., Margalit, J. and Barak, Z.E., 1987. Fate of Bacillus thuringiensis subsp. israelensis under simulated field conditions. *Applied and Environmental Microbiology*, *53*(4), pp.828-831.
[27] Tetreau, G., Alessi, M., Veyrenc, S., Périgon, S., David, J.P., Reynaud, S. and Després, L., 2012. Fate of Bacillus thuringiensis subsp. israelensis in the field: evidence for spore recycling and differential persistence of toxins in leaf litter. *Applied and environmental microbiology*, *78*(23), pp.8362-8367.
[28] Hicks, Lebelle (2001). *Human Health and Environmental Relative Risks of WNV Mosquito Control Products*.
Maine Board of Pesticides Control.
[29] Vera Go, Joan Garey, Mary S. Wolff, and Beatriz G.T. Pogo (October 19, 1988). "Estrogenic Potential of Certain Pyrethroid Compounds in the MCF-7 Human Breast Carcinoma Cell Line." Environmental Health Perspectives, Volume 107, Number 3, March 1999.
[30] Quarles, William. (Spring, 2001). "Sprays for Adult Mosquitoes—A Failed Technology?" Common Sense Pest Control XVII(2). Berkeley, CA.
[31] Rutgers Entomology Website (2001). "FAQ's on Mosquitoes." www.rci.rugers.edu/~insects/mosfaq.htm.
[32] EPA (2000). *Questions and Answers: Pesticides and Mosquito Control.* Department of Prevention, Pesticides and Toxic Substances. May 2000. Website address: http://www.epa.gov/pesticides/citizens/pmcfs.pdf.
[33] U.S. General Accounting Office. "Nonagricultural Pesticides: Risks and Regulations," 1986.
[34] Centers for Disease Control and Prevention. 2003. Epidemic/Epizootic West Nile Virus in the United States:
Revised Guidelines for Surveillance, Prevention, and Control. Atlanta, GA.
[35] New York State Attorney General Elliot Spitzer recommended that local governments establish Pest Management Advisory Boards to provide public input into mosquito response plans, review an agency's vector control practices throughout the mosquito season to monitor effectiveness and create public accountability.
[36] Nassau County in New York installed a 24-line message service, which cost only $15,000 to serve 1.3 million people. This helped alleviate the burden and resources needed to answer up to 12,000 calls per day. Onondaga Health Department in upstate New York responded to public demand for pre-notification of mosquito spraying by
utilizing a reverse 911 phone system. The system was originally used, successfully, to help track missing children.

[37] National Research Council (1993). "Pesticides in the Diets of Infants and Children." National Academy Press, Washington, D.C. 1993.
[38] City Health Information (2001) *West Nile Virus Surveillance and Control: An Update for Health Care Providers in New York City.* New York City Department of Health. May 2001, Vol. 20, No. 2. Website address: http://www.nyc.gov/html/doh/pdf/chi/chi20-2.pdf.
[39] "Surveillance For Acute Insecticide-Related Illness Associated With Mosquito-Control Efforts -- Nine States, 1999-2002." July 11, 2003 edition of CDC *Morbidity and Mortality Weekly Report*. Vol.52(27).
[40] Gosselin, R.E. 1984. *Clinical Toxicology of Commercial Products*. Williams and Wilkins. Baltimore, MD.
[41] Gummin DD, Mowry JB, Spyker DA, Brooks DE, Osterthaler KM, et al. 2017 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 35th Annual Report. Clin Toxicol (Phila). 2018 Dec 21;:1-203. PubMed PMID: 30576252.
[42] Ibid.
[43] Ibid.
[44] Extension Toxicology Network. 1994. "Pyrethroids." *Pesticide Information Profiles*. http://ace.orst.edu/cgi- bin/mfs/01/pips/pyrethri.htm.
[45] Brander, S.M., Gabler, M.K., Fowler, N.L., Connon, R.E. and Schlenk, D., 2016. Pyrethroid pesticides as endocrine disruptors: molecular mechanisms in vertebrates with a focus on fishes. *Environmental science & technology*, *50*(17), pp.8977-8992.
[46] Hicks, Lebelle (2001). *Human Health and Environmental Relative Risks of WNV Mosquito Control Products*. Maine Board of Pesticides Control.
[47] Gummin DD, Mowry JB, Spyker DA, Brooks DE, Osterthaler KM, et al. 2017 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 35th Annual Report. Clin Toxicol (Phila). 2018 Dec 21;:1-203. PubMed PMID: 30576252.
[48] Ibid.
[49] Extension Toxicology Network. 1994. "Malathion." *Pesticide Information Profiles*. http://ace.orst.edu/cgi- bin/mfs/01/pips/malathio.htm.
[50] U.S. EPA (1999). "Recognition and Management of Pesticide Poisonings." Fifth Edition. Office of Prevention, Pesticides, and Toxic Substances.
[51] Abdel-Rahman, Ali, Ashok K. Shetty, and Mohamed B. Abou-Donia (2001). "Subchronic Dermal Application of *N,N*-Diethyl *m*-Toluamide (DEET) and Permethrin to Adult Rats, Alone or in Combination, Causes Diffuse Neuronal Cell Death and Cytoskeletal Abnormalities in the Cerebral Cortex and the Hippocampus, and Purkinje Neuron Loss in the Cerebellum." Experimental Neurology, Volume 172.
[52] For example: The label on a permethrin product says, "This product is extremely toxic to fish and other aquatic organisms. Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark." Malathion label states that it can adversely affect non-target species.
[53] Beyond Pesticides. 2000. Chemical Watch Factsheet: Malathion. Undated. https://beyondpesticides.org/assets/media/documents/pesticides/factsheets/Malathion.pdf.
[54] Hicks, Lebelle (2001). *Human Health and Environmental Relative Risks of WNV Mosquito Control Products*.
Maine Board of Pesticides Control.
[55] Parker and Waichman, Attorneys at Law (2001). "Workers Say Chemicals Used in Mosquito Spraying Made Them Ill."
[56] Southampton Press. 2000. "Lobstermen Suing Pesticide Makers," September 7.
[57] CDC. www.cdc.gov. Website accessed September, 2001.
[58] News and Observer. 1996. State alters mosquito plans. 9/21/96.
[59] Howard, John J. and Joanne Oliver. 1997. "Impact of Naled (Dibrom 14) on the Mosquito Vectors of Eastern Equine Encephalitis Virus," *Journal of the American Mosquito Control Association*. Vol. 13, No. 4, pp. 315-325.

[60] Weill, M., et al. 2003. "Insecticide Resistance in Mosquito Vectors." *Nature* 423(6936): 136-137.
[61] Hancock, P.A., Hendriks, C.J., Tangena, J.A., Gibson, H., Hemingway, J., Coleman, M., Gething, P.W., Cameron, E., Bhatt, S. and Moyes, C.L., 2020. Mapping trends in insecticide resistance phenotypes in African malaria vectors. *PLoS Biology*, *18*(6), p.e3000633.
[62] Centers for Disease Control and Prevention (2001). Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance, Prevention, and Control. Atlanta, GA. http://www.cdc.gov/ncidod/dvbid/westnile/resources/wnv-guidelines-apr-2001.pdf.
[63] Reddy, M, Spielman, A, et al. (2006) Efficacy of Resmethrin Aerosols Applied from the Road for Suppressing *Culex* Vectors of West Nile Virus. *Vector-Borne and Zoonotic Diseases*. Summer 6(2): 117-127.
[64] Pimentel, David, 1995. "Amounts of Pesticides Reaching Target Pests: Environmental Impacts and Ethics." Journal Of Agricultural And Environmental Ethics Vol. 8, No. 1, pgs. 17-29.
[65] Pimentel, D. and Burgess, M., 2012. Small amounts of pesticides reaching target insects. *Environ Dev Sustain* **14,** 1–2. https://doi.org/10.1007/s10668-011-9325-5.
[66] Centers for Disease Control and Prevention, Division of Vector-Borne Infectious Diseases. West Nile Virus: Entomology. http://www.cdc.gov/ncidod/dvbid/westnile/insects.htm; and CDC Answers Your Questions About St. Louis Encephalitis. http://www.cdc.gov/ncidod/dvbid/arbor/SLE_QA.htm.
[67] Rutgers Entomology Website (2001). "FAQ's on Mosquitoes." www.rci.rugers.edu/~insects/mosfaq.htm.
[68] The Pasco County Mosquito Control District. Mosquito Life History. http://www.pasco-mosquito.org/life_history.htm.
[69] Ibid.
[70] Floore, T. 2000. Mosquito Information. The American Mosquito Control Association. http://www.mosquito.org/mosquito.html.
[71] West Nile Virus is closely related to the St. Louis encephalitis virus that is also found in the United States.
[72] Centers for Disease Control and Prevention, Office of Vector-Borne Infectious Diseases. West Nile Virus Background. Website accessed July, 2020. .http://www.cdc.gov/ncidod/dvbid/westnile/index.htm.
[73] St. Louis encephalitis is closely related to the West Nile virus that is also found in the United States.
[74] Centers for Disease Control and Prevention, Office of Vector-Borne Infectious Diseases. CDC Answers Your Questions About St. Louis Encephalitis. https://www.cdc.gov/sle/. Website Accessed. July, 2020.
[75] Centers for Disease Control and Prevention, Office of Vector-Borne Infectious Diseases. Dengue and Dengue Hemorrhagic Fever: Questions and Answers. Website accessed July 2020. https://www.cdc.gov/dengue/.
[76] Ibid.