

# Public Health Mosquito Management Strategy

**Managing mosquitoes and insect-borne diseases with safety in mind**

## Executive summary

The ideal mosquito management strategy emphasizes education, prevention, 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 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.

Spraying should be done responsibly. The decision to use pesticides should only be made after carefully evaluating all of the contributing factors to human epidemics. The public—especially vulnerable populations such as pregnant women—must be notified in advance so they can prevent exposure to potentially dangerous pesticides. Most importantly, pesticide operators should be properly protected and trained on when, where, and how to spray.

The latter half of this strategy 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.<sup>1</sup> Additionally, mosquitoes that survive the spraying may become resistant, longer-lived, more aggressive, and have an increased prevalence of the virus within their bodies.<sup>2</sup>

Further studies are urgently needed to accurately determine the health effects and the efficacy of spraying pesticides, and to help determine whether adulticiding should continue to be used in the battle to control mosquitoes.



## I. Introduction

Mosquito-borne diseases are becoming more prevalent nationwide. With outbreaks of West Nile virus (WNV) in the east and moving west, St. Louis encephalitis in the south, and Dengue fever in the western part of Hawaii, 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.<sup>3,4</sup> Additional risks occur to the growing number of residents living on or near wetlands, which are more likely to be mosquito-breeding habitats.

Many communities around the country are using ineffective and pesticide-intensive mosquito management strategies due to a lack of adequate information. This strategy 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, thus controlling 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.<sup>5</sup>

The guidelines in this strategy are drawn from state and local mosquito management programs that have effective and safe strategies. Connecticut, in particular, has incorporated key elements of a sound approach to prevention and management (see [www.beyondpesticides.org](http://www.beyondpesticides.org) or contact Beyond Pesticides for the state of Connecticut's *Tiered Approach to Mosquito Management*). However, since local and state programs evolve, it is important to follow the guidelines incorporated in this strategy.

Should pesticides be used, and if so, which products are the safest and how should they be applied? This strategy provides information on how to make these difficult choices. Unfortunately, until scientists can provide better evidence on

the effectiveness of spraying, there is no way to know for certain if it is worth the risks of spraying. At the same time, the proven health threats associated with pesticide exposure can no longer be ignored.

## II. Ideal mosquito management strategy

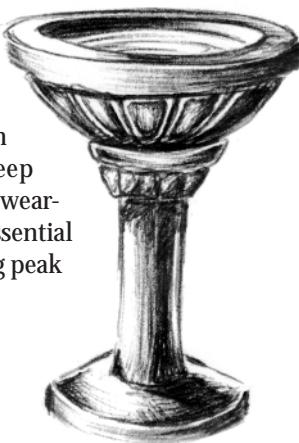
The ideal mosquito management strategy emphasizes public awareness, prevention, and monitoring methods. Adulticides (pesticides intended to kill adult mosquitoes) should be used only as a last resort. A successfully implemented strategy requires the cooperative efforts of individuals, government agencies, and businesses.

### 1. Mosquito prevention: what people can do at home

**Eliminate breeding sites:** Mosquitoes need only a bottle cap of water to breed. Getting rid of mosquito breeding sites gets rid of mosquitoes. Because many types of mosquitoes do not travel far from where they hatch, individuals can have a dramatic impact on local mosquito populations.

**Avoid the bite:** Individuals can take necessary measures to keep mosquitoes from biting them by wearing appropriate clothing, using essential oil-based repellents, and avoiding peak mosquito feeding times.

### 2. Mosquito prevention: what the community can do



**Conduct public awareness campaigns:** Communities must increase the awareness of prevention methods for mosquito-borne illnesses and, should a community decide to spray for pesticide illnesses. Health care providers must also be educated about the symptoms of each and should encourage the use of prevention measures. Communities should utilize 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. Public officials should also communicate mosquito prevention methods.

**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. Managers 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.

**Table 1. *Culex* Mosquito Life Cycle**

In the United States, WNV and St. Louis encephalitis is primarily associated with the *Culex* mosquitoes.<sup>47</sup> 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 80° F, become lethargic at 60° F, and cannot function below 50° degrees F.<sup>48</sup>

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 wigglers, 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 being laid as eggs by their mother. <sup>49</sup>

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 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.<sup>50</sup> *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.<sup>51</sup>

**Mosquito-eating fish:** Aside from traditional larvicides, biological controls, like mosquito-feeding fish of the *Gambusia* genus, have been used nationwide with great success. These hardy freshwater fish can eat their weight in mosquito larvae, according to Wayne Wurtz with the Gloucester County Mosquito Control in Pennsylvania.<sup>6</sup> Predacious fish are also used in the salt-water marshes of Nassau County, New York.<sup>7</sup>

To avoid ecological problems, use indigenous species of mosquito-eating fish, or only introduce them in enclosed bodies of water. They have been known to occasionally trigger algal blooms after consuming algae-eating organisms.

## **Table 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.<sup>52</sup> WNV can cause a potentially fatal illness known as encephalitis or 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 (CDC) website.<sup>53</sup>

### **What is the likelihood that someone will become ill?**

Most people's immune systems are able to fight the virus. Only a small percentage of the population will get the virus. Some may develop flu-like symptoms. In the United States, people older than 50 years and those with weakened immune systems have the highest risk of severe encephalitis. "Less than one percent of those infected with West Nile virus will develop severe illness," according to the CDC. Birds, horses, and other animals are also at risk. In 1999, there were 62 reported cases of severe disease, including 7 deaths; in 2000, there were 21 reported illnesses and 2 deaths; and in 2001, there were 48 illnesses and 5 deaths. According to the March 5<sup>th</sup> issue of the *Proceedings of the National Academy of Sciences*, there is a new vaccine against WNV that is ready for testing in non-human primates and horses.

### **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 is spreading throughout the United States. In 2001, the virus had been found in 27 states throughout the Northeast, Southeast, and Midwest. 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.

### **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 when, where, and what 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 will 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.

"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."<sup>8</sup> As with most animals, mosquitoes will not travel farther than their habitat necessitates. 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. This is why it is critical to monitor both the vector and the traditional host before determining the most effective strategy for your community.

### **4. Larviciding: what's safe to use**

Because not all breeding sites can be eliminated, it may be necessary to use larvicides, which kill mosquito larvae. It is recommended that products containing the biological pesticide B.t.i. (*Bacillus thuringiensis* var. *israelensis*) be used in such places as storm drains and sewer treatment plants. *Bacillus sphaericus* works best in organically rich water in drains. B.t.i. is proven to be effective and has low levels of toxicity to humans and wildlife.<sup>9</sup> When sprayed into larval pools, B.t.i. is ingested by feeding mosquito larvae and kills them.

A critical component of any successful application is monitoring to ensure that the insect population is at its most susceptible stage for B.t.i. application. B.t.i. is only effective against insects in their larval feeding stages and must be ingested. Experts say it is most efficient to use B.t.i. during the first and second stage of the larvae.

In some cases, when the larvae are in the third and fourth stage of metamorphosis, when B.t.i. is likely to be less than

60 percent effective, Methoprene (Altosid) may be necessary to kill larvae and prevent the use of adulticides.<sup>10</sup> B.t.i. lasts approximately 30 days, and Methoprene lasts about 150 days. However, some studies find that Methoprene causes wildlife deformities by interfering with hormones.<sup>11</sup>

As with any pesticide, larvicides should not be used widely because mosquitoes may become immune to them. It is also important to note that larvicides may pose a risk to vulnerable populations, and proper notification should be made through public awareness campaigns.

## 5. Adulticiding: use only as a last resort and spray responsibly

**How communities can reach a decision to spray:** Spraying should only be done after carefully evaluating the likelihood of pesticide-related illnesses and the contributing factors to a human epidemic of mosquito-borne diseases. Such factors include the ecology of the disease, the prevalence and types of mosquito and host species found in your area, and weather patterns. Specifically, this will involve: 1) identifying species that are vectoring the disease; 2) distinguishing between nuisance mosquitoes and those that vector the disease; 3) find diseased birds; and, 4) use mammals, such as mice, as sentinel species to see if mosquitoes in a given area are at high enough levels to vector the disease.

Often, spraying occurs in response to human illnesses, high numbers of mosquitoes, or dead birds. Research shows this is not only the least effective method for managing mosquitoes, but also dangerous. 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 show up and at least 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.

It is not efficacious to spray around the location of dead birds. Only mosquitoes can transmit the disease; birds cannot. As discussed in Table 1, some of the mosquitoes known to carry WNV usually only travel within a few mile radius of their pool. (This 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.<sup>12</sup> 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, it is critical to have a good understanding of the ecology of each prior to beginning any spray program.

**Nuisance spraying:** 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 when possible. Public awareness should also be used to raise the bar on tolerance levels. At a minimum, citizens must be given the right to have no pesticides sprayed around their house or neighborhood.

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

**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.**

■ Identify and locate the infected mosquito pools or areas.

■ Choose the least dangerous pesticides. In general, synthetic pyrethroids have lower human health and environmental risks than organophosphates.<sup>13</sup> However, both synthetic pyrethroids, such as resmethrin and permethrin, and organophosphates, such as malathion, are neurotoxins that can cause chronic health problems. Do not use Dursban™ and Sevin™; they are highly toxic. While botanical-based chemicals, including synthetic pyrethroids, are linked to breast cancer and endocrine disruptors,<sup>14</sup> pyrethroids are applied in smaller amounts and have shorter residual lives than malathion and other organophosphates.

■ 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 when spraying. For example, *Culex* mosquitoes take refuge in grass and brush during the day, so spray *Culex* at dusk when they are active and most vulnerable.

■ Look at your 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 three mph or less. This air movement helps to disperse the pesticide effectively, but does not move it to unwanted areas.”<sup>15</sup> In general, mosquitoes are most active at 80° F, become lethargic at 60° F, and cannot function below 50° degrees F.<sup>16</sup>

■ Ensure that the person spraying is properly trained and certified to use these pesticides. They should use protective clothing and equipment.

- **Monitor application procedures.** Verify strict compliance with all label 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. In most cases, spraying should be done from vehicles or by professional certified applicators on foot.
- **Monitor pesticide equipment calibration.** Comply with requirements for storage, disposal, and equipment cleaning.
- **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 hit less of the target area.
- **Continue implementing source reduction and other prevention strategies!**

**Public officials must warn the public about pesticide dangers:**

City or town officials have the duty, experience, and resources to warn the public about the dangers of pesticides and provide information on ways to minimize exposure. Pesticides are extremely toxic to public health and the environment. While the following is an understatement, the EPA warns, “[N]o pesticide is 100 percent safe and care must be used in the exercise of any pesticide.”<sup>17</sup>

New York State Attorney General Elliot Spitzer recommends that local governments establish Pest Management Advisory Boards to provide public input into mosquito response plans and create more public accountability. He suggests these boards review an agency’s vector control practices throughout the mosquito season to monitor effectiveness.

Public officials should embrace and utilize the following guidelines:

- **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 harmful. The mechanisms described below can be used to help notify the public.

- Install a mosquito hotline. Update it each day with information about where spraying will occur and how to protect yourself from pesticides. Residents



can call into a multiple-line message service that is available 24/7.<sup>18</sup>

- Issue Public Notices to organized groups, such as school superintendents, hospital associations, chambers of commerce, police and fire departments, and village associations. This is another efficient means of notifying the public, as those organizations will be responsible for and better able to forward the notices to the right places in a timely manner.
- Inform public drinking water agencies to prevent drinking water contamination.
- Utilize the media to warn the public about spraying and to publicize the mosquito hotline.

• Place paid public service announcements with local media.

• Use county/local websites to provide information about protection measures against the disease and pesticides. This should also be updated daily with information about where spraying will occur.

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

- **Ensure the public still follows prevention guidelines.** As the Centers for Disease Control (CDC) states that adult spraying is the least efficient mosquito control technique, it is critical that prevention education coincide with spray announcements.

- **Monitor the public for adverse health effects of pesticide exposure.** Set up a hotline for receiving reports, collecting hospital records, and requiring physician reporting of incidents.

- **Monitor pesticide levels in the environment.** Use wipe tests of outdoor and indoor surfaces, check air conditioner filters, evaluate water samples, and conduct soil and food residue tests from gardens and farms.

- **Advise hospitals and schools.** Also notify other buildings with especially vulnerable populations to take extra precautionary measures to prevent pesticides from entering buildings.

**How individuals can protect themselves from exposure to dangerous pesticides:**

- **Leave the area.\***

\* Infants, children, pregnant women, the elderly, and individuals with compromised 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.

- 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 just been sprayed.
- Wipe paws off pets with a wet cloth before they re-enter your home.

### **III. Pesticides are dangerous to public health and the environment**

The two types of pesticides used in spraying adult mosquitoes include synthetic pyrethroids and organophosphates. Scientific studies show that both types are dangerous, especially to vulnerable populations. Ironically, the same population that is most susceptible to severe encephalitis is 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.<sup>19</sup>

According to the New York State Department of Health, more people were reported to have gotten sick from pesticide spraying than from exposure to WNV in 2000.<sup>20</sup> 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.<sup>21</sup> Additionally, almost all synthetic pyrethroid mosquito products are combined with synergists, such as piperonyl butoxide (PBO), which increase potency and compromise the human body's ability to detoxify the pesticide.

According to the American Association of Poison Control Centers, pyrethrins and pyrethroids are ranked number two among the classes of pesticides most often implicated in symptomatic illnesses.<sup>22</sup> A total of 3,950 illnesses, including 1,100 children less than six years old, were reported in 1996.<sup>23</sup> Most of these illnesses likely required medical attention.<sup>24</sup>

Symptoms of pyrethroid exposure include: dermati-

### **Table 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.<sup>54</sup> 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.<sup>55</sup>

#### **What is the likelihood that someone will become ill?**

According to the CDC, there have been no outbreaks of St. Louis encephalitis since 1999. 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?**

In 1999, there were 20 reported cases of St. Louis encephalitis in New Orleans, Louisiana. However, 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.

tis and asthma-like reactions, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations.<sup>25</sup> Synthetic pyrethroids are endocrine disruptors and have been linked to breast cancer.<sup>26</sup> 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. However, synthetic pyrethroids pose lower levels of human health risks than organophosphates.<sup>27</sup>

## **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, organophosphates are ranked the number one pesticide most often implicated in symptomatic illnesses.<sup>28</sup> A total of 4,002 illnesses, including 700 children less than six years old, were reported in 1996.<sup>29</sup> Most of these illnesses likely required medical attention.<sup>30</sup>

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, slow heartbeat.<sup>31</sup> More severe exposures can cause unconsciousness, incontinence, and convulsions, which may lead to death.<sup>32</sup> 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. Mixing chemicals is dangerous**

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 adult mosquitoes may be a dangerous combination. A recent 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.<sup>33</sup> Mohammed Abou-Donia, Ph.D., 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.



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## **4. Pesticide spraying is harmful to the environment**

Pesticide spraying is also harmful to ecosystems and wildlife.<sup>34</sup> Adulticides pose well-documented threats to wildlife, birds, fish, shellfish, and beneficial insects such as bees, butterflies, and dragonflies, which prey on mosquitoes. 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.<sup>35</sup>

## **5. Legal concerns of improperly trained pesticide applicators**

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.<sup>36</sup> Another lawsuit, for \$125 million, was filed by commercial fisherman who link a dramatic decrease in their lobster harvest to pesticides used against mosquitoes believed to carry WNv.<sup>37</sup>

# **IV. Pesticide spraying is not proven highly effective and is inefficient**

## **1. Pesticide spraying is not proven highly effective**

The CDC also states that adulticiding should only be used as a last resort, when all prevention 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."<sup>38</sup>

While many report that lower mosquito counts occur immediately after spraying pesticides, it is not certain what percentage of the population is reduced. Most studies of the efficacy of adulticides are conducted with caged mosquito monitoring traps, which of course is not a realistic representation of mosquitoes in their natural environment.

For example, Ray E. Parsons, Ph.D., a medical entomologist and the assistant director for the Mosquito Control Division in Houston, Texas, says it is difficult to determine the effectiveness of pesticide spraying because there are currently no accurate means of measuring *Culex* mosquito populations.<sup>39</sup> (As discussed in Table 1, *Culex* is the most common type of mosquito that carries West Nile virus.) Therefore, scientists cannot accurately determine what percentage of the population has decreased after spraying.

**Pesticide spraying may increase mosquitoes:** 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.<sup>40</sup> Furthermore, mosquitoes that survive the spraying may become resistant, longer-lived, more aggressive, and have an increased prevalence of the virus within their bodies.<sup>41</sup>

## 2. Pesticide spraying is inefficient

The CDC states that spraying pesticides intended to kill adult mosquitoes is usually the least efficient mosquito control technique.<sup>42</sup> Preventive measures such as removing breeding areas are much more efficient in eliminating mosquito threats.

David Pimentel, Ph.D., a professor of entomology at Cornell University, estimates that pesticides sprayed from trucks hits less than 10 percent of the targeted spray area. "And you have to put out a lot of material to get that one-tenth of a percent on to the mosquito," Dr. Pimentel added.<sup>43</sup> In a study he wrote for the *Journal of Agricultural and Environmental Ethics*, he estimated that less than 0.0001 percent of ultra low volume (ULV) pesticide sprays reach target insects.<sup>44</sup> The rest of the pesticides is sprayed on unintended areas. It is also difficult for trucks to reach over and in between tall buildings or other structures.

## V. Recommendations

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

**Table 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 table is primarily based on information from the Centers for Disease Control and Prevention (CDC) website.<sup>56</sup>



### 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?

Last year, residents living in the western part of Hawaii had dengue fever. 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."<sup>57</sup> 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.

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 more accurate measurements of its efficacy. It is simply not worth the risks. Existing studies demonstrate 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.

Monitoring systems should also be established to study the diseases associated with mosquitoes.

The CDC recommends the following research priorities for St. Louis encephalitis: develop a standardized national surveillance program; characterize over-wintering mechanisms and other aspects of enzootic maintenance cycle; evaluate vector control strategies; determine biological basis for increased risk with age; and, develop more effective systems for disease prevention.<sup>45</sup> The CDC also recommends the following priorities for Dengue fever: develop improved laboratory-based international surveillance; develop rapid, sensitive and specific diagnostic tests; develop more effective community-based prevention programs; and, develop tetravalent dengue vaccine.<sup>46</sup>

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.

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## Endnotes

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