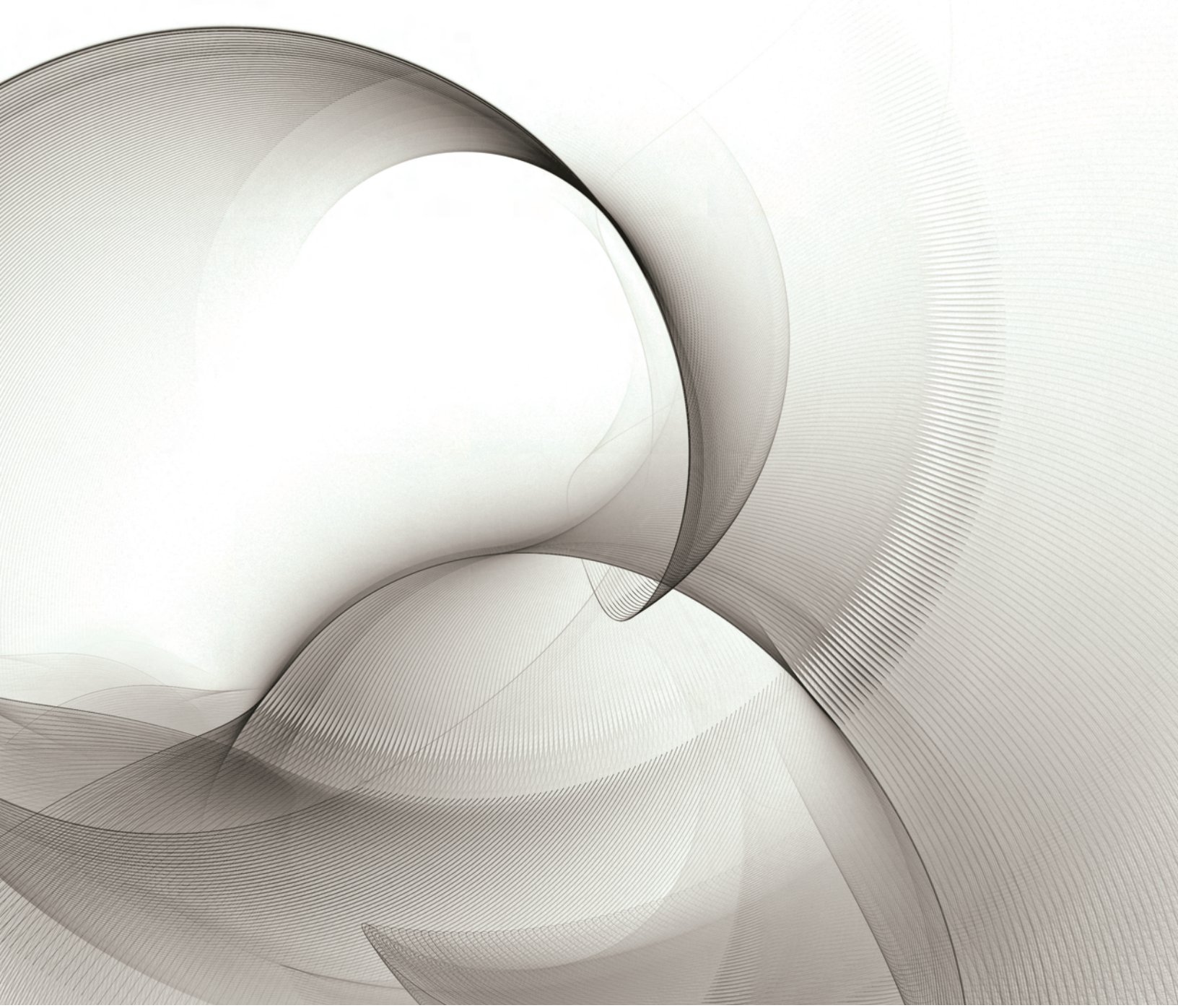

Before The Swarm:

Guidelines for the Emergency Management of Mosquito-Borne Disease Outbreaks

A Project of the Mosquito Control Collaborative

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Executive Summary

Mosquito-borne diseases pose a continual threat to the nation's health. Worldwide, mosquito-borne diseases kill over one million people each year[1] and sicken more than 700 million people annually[2], which is almost six times the combined total of people who attended a professional basketball, football or baseball game in the United States in 2007. Many of these same diseases already exist in the United States and other dangerous pathogens could be just a plane ride away from entering the country. In response to this threat, this document provides straightforward and realistic guidance to help state and local agencies, non-governmental organizations, and private industry groups prepare for the emergency management of mosquito-borne disease outbreaks.

This document addresses three trigger events (existing diseases, natural disasters, and exotic diseases) that could necessitate an emergency response. Building on the solid foundation established by the Association of State and Territorial Health Officials (ASTHO) in the report ***"Public Health Confronts the Mosquito: Developing Sustainable State and Local Mosquito Control Programs"***, this document provides analysis and recommendations for countering the threat of mosquito-borne disease outbreaks in five sections:

- **Plan Ahead**
- **Involve Others**
- **Use the Best Science and Data**
- **Inform the Public**
- **Responding to a Mosquito-Borne Epidemic Emergency**

While emergencies can be extremely challenging, careful planning may avert many difficulties. Mosquito control programs simply cannot respond effectively to exotic diseases, existing pathogens or natural disasters if thorough, deliberate and evidence-based preparation is absent. At the same time, this document provides recommendations for mosquito control in areas with limited resources or a reduced response capacity.

A summary of this document's recommendations is available in a checklist format on the following page. These recommendations are not designed to be all-encompassing, nor will they necessarily apply to every stakeholder involved in the fight against mosquito-borne diseases and nuisance mosquitoes. Rather, this document's analysis and recommendations will assist policymakers to make informed decisions on how best to prepare their respective jurisdictions for the dangerous threat that mosquitoes pose to human and animal health, economic prosperity, and overall quality of life.

Planning and Action Checklist

(These recommendations are included in the beginning of the document for ease of use and are explained in detail later in the document)

Plan Ahead

- ☐ Begin now to devise plans for potential emergencies
- ☐ Hold on-site training sessions with state epidemiologist and/or entomologist
- ☐ Send mosquito control and public health personnel to attend training sessions from specialized providers, if applicable
- ☐ Take advantage of online and printed training manuals and pesticide applicator certification materials
- ☐ Ensure that all persons with a direct role in emergency management activities receive the appropriate training in the National Incident Management System (NIMS) and Incident Command System (ICS)
- ☐ Ensure that all persons with a direct role in emergency management activities have a firm grasp of resource typing for the request for assistance agreements between jurisdictions

Involve Others

- ☐ Ensure continuity of communication between health agencies, private industry, academic, and other public sector response partners
- ☐ Designate one leader who can coordinate emergency mosquito control operations
- ☐ Involve entities such as schools, faith-based organizations and churches, community groups, and businesses as distribution pathways for relevant health information
- ☐ Coordinate with both elected and non-elected community leaders in the release of important public information
- ☐ Maintain a good working relationship with academic partners that permit the sharing of viral surveillance data and technical expertise

Use the Best Science and Data

- ☐ Ensure the continuity of surveillance efforts and data collection from a variety of immature mosquito, adult mosquito, equine, human, wild bird, and sentinel vertebrate sources
- ☐ Prepare cooperative, resource-sharing agreements with other jurisdictions for use in future emergencies
- ☐ Ensure that appropriate emergency management, mosquito control, and public health personnel have a complete understanding of the Emergency Management Assistance Compact (EMAC) protocol
- ☐ Access agricultural extension agents and subject matter experts
- ☐ Contract private companies to conduct surveillance, if necessary
- ☐ Work with state agriculture and public health agencies to facilitate access to important surveillance data from veterinarian associations, zoos, and equine, falconry, and raptor rehabilitation organizations
- ☐ Analyze geographic distribution of telephone complaint calls and train volunteers, college interns, and employees to track landing rates as a last resort for a basic source of surveillance data

Inform the Public

- ☐ Organize risk communication campaigns that have accurate, clear and timely information to reduce public anxiety and give people practical and concrete steps to protect themselves
- ☐ Summarize important messages with phrases that are easy to remember-such as the "Five D's of Prevention"
- ☐ Repeat important mosquito control and public health messages on a routine basis even before an emergency starts
- ☐ Adapt routine messages with new information that explains any enhanced risk during an emergency
- ☐ Translate brochures, public service announcements, and other forms of communication into other languages to reach minority communities
- ☐ Visit the CDC's "Fight the Bite" campaign for helpful information on risk communication campaigns (more information available in Appendix A)
- ☐ Develop and practice plans to ensure the distribution of important public information
- ☐ Route all public messages through the agency Public Information Officer (PIO) for a consistent message
- ☐ Maintain regular contact with media outlets by periodically passing along relevant stories through the PIO
- ☐ Designate an Incident Command PIO in emergencies where more than one PIO or agency is involved
- ☐ Release important public information quickly as time can be of the essence in emergencies
- ☐ Work with the PIO to hold a town hall or participatory community meeting about the risks and benefits of using pesticides
- ☐ Hold the above public dialogue session(s) even before a disease outbreak occurs

Responding to a Mosquito-Borne Epidemic Emergency

- ☐ Collaborate with a variety of organizations that may conduct mosquito control operations, such as community groups, public works departments, and transportation agencies
- ☐ Establish shared service agreements, equipment pools, regional districts, and standard contracts for services with other, nearby jurisdictions before an emergency occurs
- ☐ Coordinate with public health laboratories for testing and surveillance services during an emergency
- ☐ Sign preemptive contingency agreements with private contractors for mosquito control services that stipulate that the businesses will respond within a given time period (i.e. 72 hours)
- ☐ Public health and mosquito control agencies should help prepare and regularly update county Pre-Disaster Mitigation Plans together with other emergency management offices
- ☐ Participate in regional mosquito control teams that could supply technical expertise in the event of an emergency
- ☐ Become familiar with federal response partners and their protocols for requesting assistance
- ☐ Make informed, evidence-based decisions regarding pesticide applications in the areas where the risk for mosquito-borne disease is highest
- ☐ Work with the public to eliminate possible larval habitats, if applicable
- ☐ Consider the costs and benefits when implementing 'pay for service' mosquito control initiatives
- ☐ Take advantage of GIS tools to track the status of pesticide applications, source reduction efforts and public education message coverage

Monday, August 23, 1999 - New York City

Occasionally, he still became disoriented on his way around town. An observant passerby could easily tell Denis Nash was new to the Big Apple by the way he briefly paused to study the subway map before boarding a train. Indeed, Dr. Nash had just come to New York a few weeks ago.

Dr. Nash was still getting used to the subway and his new job as an Epidemic Intelligence Service (EIS) Officer. Dr. Nash, fresh from the Johns Hopkins PhD Epidemiology program and on loan to New York City from the Centers for Disease Control and Prevention (CDC), looked forward to a summer full of learning experiences. He had a million questions for his fellow senior EIS counterpart in New York, but they would have to wait until Dr. Farzad Mostashari got back from vacation.

Dr. Nash was deep in an investigation of a minor salmonella outbreak when, suddenly, the telephone rang. Dr. Nash's boss, Marci Layton, needed his help. An infectious disease physician from Flushing Hospital in Queens had just called with an unusual report. Four elderly patients. Advanced swelling of the brain. Was it an outbreak of Saint Louis encephalitis? Or something else entirely? It had all just begun…

While most areas in the United States do not confront exotic diseases on a frequent basis, the lessons learned from the first West Nile (WN) virus disease outbreak of 1999 in New York City remain important today. Mosquito-borne disease outbreaks can occur suddenly, with little or no warning. It is impossible to predict if such an outbreak will occur after a drought in Texas, in the form of a previously unseen disease agent in California, or as a resurgence of an existing pathogen in Nebraska. The unpredictable nature of these outbreaks demonstrates the urgent need for careful preparation and the incorporation of mosquito control emergency management activities into overall public health preparedness efforts.

The fact that the United States is home to competent hosts and vectors for many of the world's most serious vector-borne diseases underscores the fundamental importance of creating and sustaining mosquito control programs.[3] One key component of these programs is the ability to identify and mitigate mosquito-borne diseases that pose a substantial health threat to the public. This document discusses three trigger events that could necessitate an emergency response and require extraordinary measures and resources to protect the public:

- *Existing Diseases* - For the purpose of this document, existing diseases are defined as mosquito-borne diseases that appear regularly at varying levels of activity within the United States. Examples of existing mosquito-borne diseases in the U.S. include West Nile fever and neuroinvasive disease, St. Louis encephalitis, eastern equine encephalitis, western equine encephalitis, and La Crosse encephalitis. Although these diseases do not routinely appear in every part of the U.S., they often occur in sporadic, focal outbreaks or are consistently present at low to moderate levels in certain geographic areas. While new diseases receive greater media attention, existing diseases have the potential to be just as destructive. While already problematic in many regions, these existing diseases could become more prevalent as human activity continues to expand into previously underdeveloped areas.

- *Natural Disaster* - Natural disasters such as floods, severe storms, or hurricanes often cause great public concern about mosquito-borne disease outbreaks. Members of the public often assume that water-related natural disasters produce more pools of standing water, which lead to

more mosquitoes and more cases of mosquito-borne disease. In reality, mosquito-borne disease outbreaks after natural disasters in the United States are fairly uncommon.[4 5 6]

Despite the overall low risk of immediate disease outbreaks after natural disasters, the case of West Nile virus and Hurricane Katrina in 2005 illustrates the importance of up-to-date surveillance data. Hurricane Katrina apparently did not significantly increase mosquito-related human disease risk, and it is possible that the storm's destruction of mosquito habitat and the dispersal or killing of birds and mosquitoes likely decreased the risk of West Nile virus transmission.[7] However, West Nile virus is still relatively new to many parts of the country, and its full disease profile remains uncertain. Thus, only the sustainable dedication of resources for mosquito control, surveillance, and personnel can help advance both our understanding of West Nile virus, and our capacity to respond in a timely and effective fashion.

- *Exotic Diseases* - As globalization increasingly becomes an aspect of daily life, so too will new, exotic and-re-emerging pathogens from around the world. Exotic mosquito-borne diseases such as Rift Valley fever, dengue, chikungunya fever, Japanese encephalitis, and Venezuelan equine encephalitis could enter the United States through a variety of avenues. Realistically, public health and mosquito control programs cannot expect that the plan for any one exotic disease can provide a reliable one-size-fits-all response model. Exotic disease agents could target several different hosts. The dead bird reporting system designed to track West Nile virus cases may work for exotic pathogens like Japanese encephalitis but would not be useful when confronting other diseases such as Rift Valley fever. For example, whereas Rift Valley fever can affect mammals and humans, Japanese encephalitis mostly targets birds, pigs, horses, and humans.[8] The success of a mosquito control program depends on its ability to use multiple surveillance species and methods to provide data on disease threats.

CDC Public Health Image Library

This document discusses the above trigger events and response recommendations for the emergency management of mosquito-borne disease outbreaks. These recommendations are based on the solid foundation established in the initial ASTHO report, **Public Health Confronts the Mosquito: Developing Sustainable State and Local Mosquito Control Programs**, and employ the same easy-to-use format in four sections:

- **Plan Ahead**
- **Involve Others**
- **Use the Best Science and Data**
- **Inform the Public**

An additional segment, **Responding to a Mosquito-borne Epidemic Emergency**, discusses specific emergency mosquito control measures.

Plan Ahead

Emergency response measures alone cannot begin to provide the same level of response as an organized, established mosquito control program. Any emergency can strain an agency's staffing, equipment, and budget resources. State and local mosquito control programs cannot rely on federal agencies to supply timely financial aid or comprehensive emergency assistance when a disaster strikes. Rather, the ability of state and local actors to provide an effective emergency response depends on independent, well-prepared programs with integrated emergency functions in place. The efficient emergency management of mosquito-borne disease outbreaks, as is the case with any crisis response, requires thorough planning, practice and implementation.

In addition to improving efficiency, sustainable mosquito control programs can also save valuable local emergency response resources. Sustainable mosquito control programs are relatively inexpensive, costing approximately a national average of about $2.40 in 1999 dollars per person served per year.[9] This small figure pales in comparison to the costs associated with the emergency use of expensive contractors, equipment, and pesticides. For example, the cost associated with a West Nile virus outbreak in Louisiana during an eight month period from 2002-3 was $20.1 million and included $9.2 million for public health response, $4.4 million for medical and $6.5 million for nonmedical costs.[10] Emergency costs can quickly drain an organization's budget.

Thorough planning also necessitates ongoing professional development for mosquito control staff. Some examples of professional enhancement activities include:

- *Training sessions* - Many local mosquito control staff report that they find on-site training sessions with the state entomologist or epidemiologist to be extremely beneficial experiences. These training sessions can be mutually beneficial. State experts learn what is happening on the ground level, while local mosquito control authorities gain a better understanding about statewide patterns and best practices. Many mosquito control programs have also sent employees to attend training sessions from private firms. Information on training resources is available in Appendix A.

- *Training Manuals and Pesticide Applicator Certification* - In addition to these training sessions, several states have produced excellent printed materials and training manuals on safe and effective methods to apply pesticides. Links to specific sites that offer these materials and opportunities is available in Appendix A.

- *National Incident Management System* - All persons with a direct role in emergency response measures must complete the relevant National Incident Management System (NIMS) training courses in order to be eligible to receive federal preparedness funding assistance[11]. This training prepares public health and other response partners for the structured cooperation between public and private sector organizations during any major event. Moreover, a firm grasp of "resource typing" is critical to streamlining the assistance request process. Typing provides a common definition of resources that is standardized between jurisdictions and commensurate with the threat level. For example, a Type 1

response team provides a more robust response capability than a Type 4 unit. While not required for most mosquito control officials, an in-depth knowledge and familiarity with the Incident Command System (ICS) and NIMS will allow state and local programs to integrate themselves into general preparedness efforts. More information regarding NIMS, ICS, and resourcing typing is available in Appendix A.

Involve Others

The emergency management of mosquito-borne disease outbreaks can quickly become an extremely complicated activity. A gap in communication often develops between the people with technical expertise in government/academia and the control agencies with logistical training and experience on the ground. Left unchecked, this gap can extend to responding health agencies as well. Only proactive preparation and continuous interagency communication can ensure that all of these groups benefit from working together. Mosquito control agencies must foster this interagency cooperation well before a mosquito-borne disease occurs. In addition, while interagency cooperation is extremely important, mosquito control programs need a knowledgeable leader who can sit at the top of the chain of command and efficiently direct activities during an emergency. Mosquito control programs that wait until an emergency occurs to start forming cooperative interagency relationships or designating leadership roles will find it difficult to conduct an efficient emergency management operation.

Mosquito control programs benefit from taking a broad view of important stakeholders in public education efforts. Organizations such as schools, faith-based organizations and churches, community groups, and businesses can serve as valuable distribution pathways for relevant health information. Mosquito control program staff can work with both elected and non-elected community leaders to coordinate the release of important public information. The maintenance of a good working relationship with academic partners and access to viral surveillance data at these institutions can help guide an appropriate response. The response partners listed in Appendix A are also helpful sources of information and cooperation.

Use the Best Science and Data

Effective surveillance is key to any effective response, as it allows mosquito control programs to rapidly assess the scale of the emergency and determine the type and extent of proper response measures. In addition, the Federal Emergency Management Agency (FEMA) requires surveillance data to approve disaster assistance requests.[12] Comprehensive mosquito control programs have access to surveillance data from a combination of immature mosquito, adult mosquito, equine, human, wild bird, and sentinel vertebrae sources (please see Table 1 for a schematic representation). Conversely, mosquito control programs with limited surveillance capability will be hard-pressed to respond effectively.

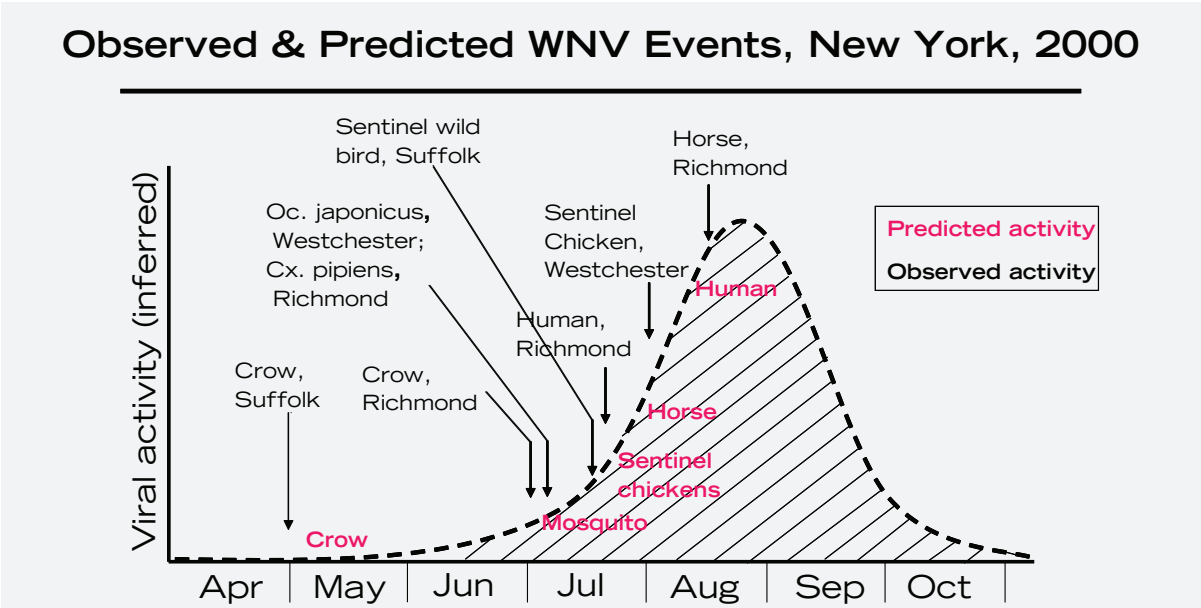


Figure 1 - A good surveillance program can provide early evidence of an impending epidemic, giving agencies a better chance of preventing human cases.[13]

Temporary solutions to the problem of a lack of surveillance resources can never substitute for in-house knowledge and human resources. However, in an emergency situation, mosquito control programs with limited or no funding still have options. In the past, these programs have successfully pursued cooperative relationships and information sharing with neighboring jurisdictions. While the requesting state still must pay for the use of borrowed resources, the Emergency Management Assistance Compact (EMAC) helps facilitate the process by which member states share equipment and human resources during emergencies. Successful examples in New York (West Nile virus, 1999) and Kansas (flooding, 2007) have helped to establish precedents for the sharing of resources for surveillance and/or mosquito control under EMAC. Such agreements between states are most effective when written before an emergency event occurs. State and local mosquito control programs may sign other agreements with neighboring jurisdictions for the sharing of data and information. While these agreements are valuable tools, however, they will be of limited assistance if neighboring areas are facing the same outbreak as the requesting agency.

Mosquito control programs with limited or no funding can work with universities or colleges to access experts and agricultural extension services provided through such institutions. Additionally, mosquito control programs may contract private companies to conduct surveillance (see Appendix A). State agriculture and public health departments can facilitate access to surveillance data from veterinarian associations, zoos, and equine, falconry, and raptor rehabilitation organizations. As a last resort, areas with very limited or no funding have analyzed geographic distributions of telephone complaint calls and trained volunteers, college interns, and employees to track landing rates as basic forms of surveillance data. Table 2 showcases the importance of having at least some sort of surveillance data in a mosquito-borne disease outbreak.

Figure 2[14]

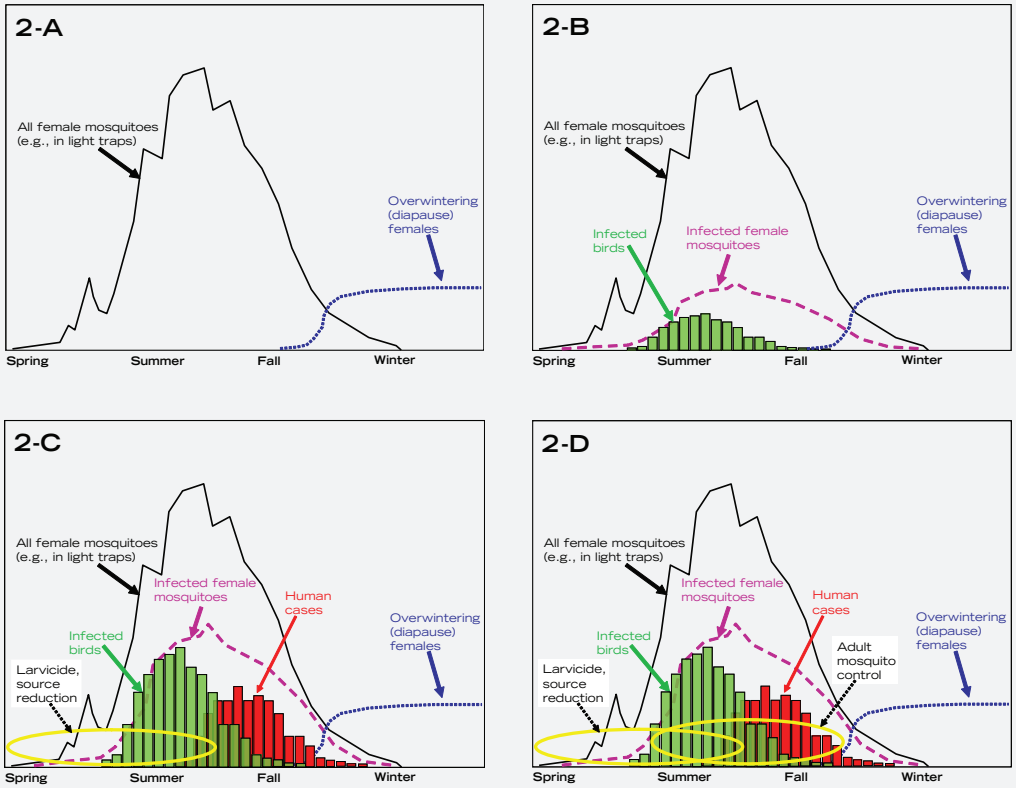


Figure 2 shows the sequence of events in the annual transmission cycle of an arbovirus such as West Nile virus.

Figure 2-A shows the annual abundance pattern of mosquitoes in most of the U.S. Female mosquitoes start to appear in early to mid-spring (black line), the population peaks in mid-summer for most species, then drops off in the fall. At some point in late summer or early fall, newly-emerged female mosquitoes no longer seek a blood meal, but instead feed on plant nectars in preparation for winter survival (called diapause).

Figure 2-B shows what happens in a year with minimal virus activity. Transmission between mosquitoes and wild bird hosts occurs, but virus activity does not "spill over" into urban or suburban settings, and there are few or no human cases. Female mosquitoes start to appear in early to mid-spring (black line) as before. Small numbers of infected mosquitoes (purple dashed line) and infected birds (green bars) start to show up at different points in time over the summer, depending largely on ambient temperature and other environmental factors. The risk of virus transmission to humans is fairly low.

Figure 2-C shows what happens in a year when virus activity is more intense and human cases begin to appear. Virus activity "spills over" into urban or suburban settings, and there are cases in humans (red bars) and domestic animals. Infections in mosquitoes (purple line) and wild birds (green bars) normally appear before cases in humans (red bars). By monitoring activity in mosquitoes and birds, vector control programs can anticipate increased virus activity and take appropriate action. Early-season (time period marked by the yellow ellipse) source reduction (that is, larval habitat elimination) and the application of larvicides, if properly carried out, can greatly reduce the likelihood of an epidemic.

Unfortunately, once emergence of new adult mosquitoes has peaked and large numbers of infected mosquitoes are on the wing (**Figure 2-D**), larviciding and source reduction are much more limited in their impact on virus transmission. At this point, adult mosquito control (period marked by the second yellow ellipse) becomes the primary resource for interrupting virus transmission.

Inform the Public

Informing the public is a key state and local public health agency function during an emergency response situation. Effective risk communication campaigns are successful because they provide accurate, clear, and timely information, which can reduce public anxiety and give people concrete steps to protect themselves.

- *Repetition* - An emergency risk communication program should complement concepts that are already familiar to the population from previous, routine messaging campaigns For example, many mosquito programs summarize mosquito avoidance efforts by educating the public about the "5 D's of Prevention" (Dress, Drain, DEET**, Dusk, Dawn) in response to endemic disease prevention efforts. Repetition of core messages during an emergency can reduce anxiety, although the risk communication program should explain any enhanced risk during an emergency response to help people make informed risk calculations. Brochures, public service announcements, and other forms of communication in several languages can assist in efforts to reach minority communities. The CDC's recent "Fight the Bite" campaign offers simple, effective materials for use during both emergency and non-emergency public education programs (More information available in Appendix A).

- *Regularity* - As natural disasters may interfere with normal media operations, mosquito control programs should develop and practice a plan to ensure the distribution of important public information. Where applicable, agencies should also routinely discuss important matters with the Public Information Officer (PIO) to ensure a consistent message. For the sake of consistency, all public messages should go through the PIO to prevent the mixing of messages and a decline in public confidence. Through the PIO, mosquito control programs should maintain regular contact with media outlets by periodically passing along relevant stories. When more than one responding agency is involved, the PIOs at the different institutions should communicate with one another and designate an Incident Command PIO to ensure a cohesive message. This continued contact will be of great value during emergencies when important public information requires timely distribution.

- *Rapidity* - Water-related disasters underscore the importance of enacting a rapid risk communication strategy. Effective risk communication can decrease the danger of a potential mosquito-borne disease outbreak. Depending on the species, new mosquitoes may appear 5-10 days after a water-related natural disaster and increased mosquito activity may continue for several weeks thereafter[15]. Even without the presence of disease-carrying mosquitoes, large numbers of biting nuisance mosquitoes can seriously hamper power restoration activities, impede recovery efforts, and pose significant public health hazards. For example, after Hurricane Katrina in 2005, researchers recorded landing rates (defined as "a count of the number of mosquitoes that land on a person in a given amount of time"[16]) of up to 200 per minute or more[17], which made life unbearable for recovery workers and regular citizens alike. Damage and destruction of homes, power outages, hot temperatures, and recovery work increase the amount of time people spend

** Note: DEET is currently one of several repellent products recommended by CDC.*

outdoors. Even mild damage to doors, windows, and screens can allow mosquitoes to enter homes. This increased exposure to mosquitoes emphasizes the importance of disseminating protection messages and providing appropriate materials. Quick and effective risk communication regarding risk and advised courses of action can protect these vulnerable populations.

The mere implementation of risk communication messages does not mean that the public will immediately accept the program's advice. The target audience must also see the recommended actions as practical and feasible. The public must also believe that the risk is substantial enough to take action. Several West Nile virus studies suggest that many people who ignore advice to wear repellent or adopt other preventive measures do so because they do not perceive the risk of contracting mosquito-borne disease to be high enough to warrant such actions. People most often report they believe their time of exposure is too short for them to be bitten or that repellents are inconvenient as reasons for non-use of repellent.

Some people have negative attitudes regarding mosquito repellent. These surveys indicate that some people do not like the way traditional mosquito repellents smell or feel on the skin. Other respondents have questions about safety. Recent public information campaigns have sought to address safety concerns and highlighted the newest generation of mosquito repellents, which may counter some of these concerns.

Effective risk communication is also crucial in engaging groups opposed to pesticide application. Wide-area pesticide use is controversial in some communities. As the Environmental Protection Agency indicates, "no pesticide is 100% safe and care must be exercised in the use of any pesticide."[18] Opponents of pesticides have used legal suits and other mechanisms to limit or even prevent mosquito control spraying efforts from taking place. This opposition can seriously affect an unprepared program's ability to respond quickly to mosquito-borne disease during emergencies.

Studies by the EPA, Karpati, et al.; Currier, M, et al.; and Peterson, et al. support the idea that the benefits of controlling the spread of vectors with pesticides, when conducted according to the directions on the label, outweigh the risks of potential harmful health effects from pesticide spraying.[19] [20] [21] To ensure that the public fully understands and embraces this risk/benefit consensus, mosquito control programs and PIOs are most successful when they initiate an ongoing dialogue with community members before a disease or a natural disaster occurs. Town hall and participatory community meetings have allowed members of the public and mosquito control programs to openly discuss the most current understanding of the health risks of pesticides. Mosquito control programs can use these meetings to discuss how the relative health risk of pesticide spraying is considerably lower than the risks posed by many mosquito-borne diseases such as West Nile virus. An guide to holding productive dialogue sessions with communities is available in Appendix A.

Responding to a Mosquito-borne Epidemic Emergency

Emergencies affect multiple agencies within the community and demand timely, effective, and well-coordinated response measures. A detailed response matrix published by CDC is found in Appendix B. Many organizations, from community groups to public works departments to transportation agencies, conduct mosquito control operations and all are valuable partners during emergencies. Mosquito control programs should use this matrix to help coordinate response measures. Several other key components are listed below:

- *Resource Sharing and Ability to Acquire Resources Quickly* - Rapid procurement of mosquito control resources can make a great difference in emergencies. During the 1999 experience with West Nile virus, New York City quickly purchased or borrowed (from Suffolk County) the necessary equipment, human resources, or pesticides. The establishment of shared services agreements, equipment pools, regional districts, and standard contracts for services can be extremely helpful to mosquito control programs with limited or no funding. Public health laboratories in other areas may assist with testing and surveillance during an emergency.

  Contractors can provide immediate help, but may be already committed elsewhere or prohibitively expensive for many communities. To ensure a timely response, mosquito control programs can preemptively sign contingency agreements that stipulate that contractors will respond in a given period (e.g. 48-72 hours). For an innovative and successful example of resource sharing and cooperation between the public and private sectors, please see the case study on the following page.

- *County Pre-Disaster Mitigation Plan* – Each county in every state should prepare and regularly update their county Pre-disaster Mitigation Plan. Public health and mosquito control officials should contact their county Emergency Management or Disaster and Emergency Services office and collaborate in the development of this important planning document. This accomplishes three things:

  1) begins a communication relationship with the local emergency planner
  2) helps gain visibility for the issue so it is remembered during general county emergency planning
  3) qualifies your department for future pre-disaster mitigation funding from federal agencies.

- *Regional and Federal Response Partners* - Interested mosquito control programs can take the idea of cooperation one step further. Regional mosquito control teams of veteran experts could make themselves available for technical assistance in the event of a disease outbreak. Such teams would be able to complement the outbreak investigation work often conducted by CDC, but would be able to remain available on a long-term basis.

  For presidentially declared emergencies, the Federal Emergency Management Agency may be able to provide reimbursement for mosquito control costs. However, this process can be time-consuming and FEMA will only reimburse mosquito control programs for

eligible costs. More information about FEMA's reimbursement policy for mosquito control costs is available in Appendix A.

US Air Force Reserve

The military may provide aerial applications of insecticides for approved, presidentially-declared emergencies. The US Air Force Spray Flight has historically participated as part of FEMA-funded emergency response initiatives. Several aircraft are available for large area rapid mosquito control where such measures are warranted.

- *Rapid Informed Deployment of Chemical Measures* - While biological controls, sanitation programs, and wetlands management are critical components of sustainable mosquito control programs, they are slow to take effect. Chemical measures have become a cornerstone of many mosquito control programs, but they also have some significant drawbacks in emergencies. If a natural disaster has created many potential habitats for mosquitoes, it will be difficult (both economically and logistically) to apply larvicide to huge areas of land. Larviciding after a natural disaster may also prove unnecessary if dry conditions prevent larvae from developing.

  Adulticides also have significant drawbacks. Adulticiding is expensive and its efficacy is dependent on a large variety of factors, such as temperature, rainfall, humidity, wind patterns, geographic distribution of the application, altitude above the ground (in aerial applications), and expertise of the applicators. Since adulticides only kill those mosquitoes that are exposed to pesticide droplets, spraying is not a "one-and-done" solution. Instead, adulticiding requires multiple applications separated by anywhere from 2-4 days. Finally, if mosquito control activities begin too late, then no amount of larviciding, adulticiding or source reduction can prevent an outbreak or significantly reduce large numbers of nuisance mosquitoes.

  Still, given these considerations, the use of larvicides and the targeted application of adulticides are important aspects of emergency management operations. Larvicides will help lessen the threat of a future outbreak. The use of adulticides can protect recovery workers, large public gatherings, and other exposed groups. As each species of mosquito has different activity patterns, control programs are most successful when they use surveillance data to determine the correct time, place, and frequency of pesticide application. In order to be most effective, mosquito control programs should prioritize pesticide application according to risk. Locations with high population densities, mosquito-borne disease activity, popular outdoor events (sports events, fairs, concerts, etc.), large numbers of recovery workers, homes without power, the elderly, and displaced individuals living in temporary housing or compromised shelters should receive priority attention. Control programs must also consider the geographic area of the outbreak and its corresponding weather and climate conditions.

Case Study - Georgia's Emergency Mosquito Surveillance Trailer[22 23 24 25 26]

From April to June 2007, wildfires blazed through Ware County, Georgia. The fires eventually burned close to 600,000 acres in south Georgia and north Florida. After weeks of intense fighting, the massive fires were finally extinguished. Just when the community thought it could finally catch its breath, an unforeseen problem surfaced. Mosquitoes breeding in the equipment tracks and water left behind after the fire fighting efforts created the increased potential for mosquito-borne diseases. Adding to the problem were the facts that the fires burned much of the vegetation that would normally soak up water.

Although the fires had been declared an emergency and their response was funded through the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA), no one had thought to include fighting the outbreak of mosquitoes into the request for assistance. Luckily, Ware County was able to request the assistance of the Georgia Emergency Mosquito Surveillance Trailer.

Georgia Division of Public Health

The Georgia Emergency Mosquito Surveillance Trailer is a 16-foot trailer with equipment to support surveillance of vector and nuisance mosquito species. This trailer is designed for use during any emergency or disaster where mosquitoes constitute a public health problem either by virtue of disease transmission or by nuisance factor. The trailer has desk space for five people, storage, an air conditioner and a generator. Equipment in the trailer includes microscopes, mosquito traps, cryolizers, larvae collection kits, a backpack aspirator and a backpack sprayer. Any geo-politically recognized level of government within Georgia or in a neighboring state with a mutual aid agreement can request to use the trailer and equipment, along with the assistance of the state medical entomologist from the Georgia Department of Human Resources' Division of Public Health (DPH).

Since Ware County, like many Georgia counties, had limited resources for mosquito surveillance they contacted Trey English who is a mosquito control specialist for ADAPCO, a provider of products, technology and services to the mosquito control industry. English used the trailer and equipment to collect mosquitoes in the area and documented copious numbers of Ps. columbiae, Ps. ciliata and Ae. vexans. With this surveillance data in hand, the county was able to justify the need for emergency mosquito control and the Governor was able to commit discretionary funds to assist with this effort.

English worked with the Georgia DPH, using the data collected, to develop a plan to deal with the mosquito problem. Soon spray block maps were created and, just as an additional wave of mosquitoes was hatching, airplanes were treating the area. Further surveillance showed the efforts were successful, leading to a major reduction in mosquito populations.

With the availability of the Georgia Emergency Mosquito Surveillance Trailer, Ware County was able to acquire data, to document the need for emergency mosquito response, to obtain financial support and to use the data to make good mosquito control decisions in a timely manner.

- *Timely Source Reduction* - The effective emergency management of mosquito-borne disease outbreaks and nuisance mosquitoes often requires that response partners enlist the public in source reduction efforts. For areas with limited or no funding, public service announcements and educational campaigns can be an inexpensive and effective way to get people to eliminate standing water.

  At the same time, large-scale elimination of standing water may not be feasible, especially in the wake of natural disasters. While members of the public can turn over empty pots or clean birdbaths, they cannot drain primary sources of mosquitoes such as rice fields, drainage areas, or ponds. In addition, only timely, informed surveillance data can spur effective source reduction efforts, as these activities depend greatly on the type of mosquito species present in the affected area(s).

- *Pay for Service* - Several counties and communities have used "pay for service" models with some success in the past. Such systems charge communities for pesticide applications to control adult mosquitoes. While such initiatives may provide service for those areas willing to pay the fees, the environmental justice implications of such

a model raise concerns that low-income areas would not receive the same treatment as wealthier communities. Furthermore, "pay for service" models do not take into account the short-lived nature of pesticide application or the fact that mosquitoes may migrate from non-paying areas.

- *Real Time Use of GIS Tools* - Computer-based Geographic Information Systems (GIS) can provide mosquito-control programs with instantaneous mapping of target areas. Whenever possible, spray maps are most useful when prepared and updated regularly in advance of the trigger event. GIS can greatly increase the efficiency of control measures, as it can supply a real-time map of the status of pesticide application, source reduction efforts, and public education messaging coverage. While some advanced GIS programs may be too expensive for many mosquito control programs, free Web-based services such as Google Earth can still be helpful.[27]

Conclusion

Mosquito control, public health, and emergency response programs face constant challenges. Increased global travel, natural disasters, changing climates, and the movement of vectors and pathogens are just a few of the issues that contribute to the complicated threat of mosquito-borne disease outbreaks.

While the exact location, scope, and severity of the next mosquito-borne disease outbreak remains unclear, one thing is certain. Jurisdictions that begin to prepare and practice now for future mosquito-borne disease threats will find themselves in the best position to protect public health when an outbreak occurs.

Appendix A

Annotated Mosquito Control Resources Alphabetically by Topic

Associations

Please note that a comprehensive list of state mosquito control associations is available at http://www.mosquito.org/resources/links.aspx.

American Mosquito Control Association (AMCA) (http://www.mosquito.org/)
A national organization that combines work on mosquito control issues and related health policy with excellent general information and further resources. AMCA also publishes the quarterly Journal of the American Mosquito Control Association.

American Public Works Association (APWA) (http://www.apwa.net/)
The national and international professional and educational association of public works agencies. While mosquito control resources on this website are limited, APWA does have many active members who work on relevant mosquito control issues.

Association of Public Health Laboratories (APHL) (http://www.aphl.org/Pages/default.aspx)
A national organization that provides support to the nation's public health laboratories through the promotion of effective programs and public policy.

Association of State and Territorial Health Officials (ASTHO) (http://www.astho.org/)
The national nonprofit organization representing the state and territorial public health agencies of the United States, the U.S. Territories, and the District of Columbia. The ASTHO vector control page is available at http://www.astho.org/index.php?template=mosquito_control.html.

Mid-Atlantic Mosquito Control Association (http://www.mamca.org/)
A regional network of mosquito control actors from eight Mid-Atlantic states.

National Association of County and City Health Officials (NACCHO) (http://naccho.org/)
The national nonprofit organization representing the local health departments of the United States. The NACCHO mosquito control page is available at http://www.naccho.org/topics/environmental/mosquitocontrol.cfm.

National Emergency Management Association (http://www.nemaweb.org/)
The professional association of state emergency management directors.

Northeastern Mosquito Control Association (http://www.nmca.org/)
A regional association of several Northeastern states.

Northwest Mosquito and Vector Control Association (http://www.nwmvca.org/)
A regional organization of five Northwestern states and three Canadian provinces.

Society for Vector Ecology (SOVE) (http://www.sove.org/Home.html)
The professional organization of vector biology and control experts. SOVE also publishes the Journal of Vector Ecology.

West Central Mosquito and Vector Control Association
(http://www.westcentralmosquitoandvector.org/)
A regional network of eight Great Plains and Rocky Mountain states.

Federal Agencies

Centers for Disease Control and Prevention (CDC) Division of Vector Borne Infectious Diseases (DVBID) (http://www.cdc.gov/ncidod/dvbid/index.htm)
A federal and international reference center for mosquito-borne and vector-borne diseases.

Federal Emergency Management Agency (FEMA) (www.fema.gov)
A federal agency which has the ability to reimburse jurisdictions for mosquito control costs during a presidentially-mandated emergency. FEMA's guidelines for the funds disbursement is available at http://www.fema.gov/government/grant/pa/9523_10.shtm.

U.S. Air Force Medical Entomology
(http://www.afpmb.org/military_entomology/usafento/af.htm)
The network of medical entomologists responsible for the protection of Air Force personnel from vector-borne and other disease threats.

U.S. Air Force Reserve Aerial Spray Flight
(http://www.youngstown.afrc.af.mil/units/aerialspraysquadron/index.asp)
A wing of the Air Force Reserve which has limited capacity to conduct pesticide application during emergencies.

U.S. Army Medical Entomology
(http://www.afpmb.org/military_entomology/usarmyento/army.htm)
The network of medical entomologists responsible for the protection of Army personnel from vector-borne and other disease threats.

U.S. Army Medical Zoology Branch (http://139.161.100.20/dphs/MedZoo/mission.htm)
Provides training on vector-borne disease control to Army personnel.

U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS)
(http://www.aphis.usda.gov/)
A branch of the U.S. Department of Agriculture which specializes in the protection of agricultural resources, plants, and animals (including vector-borne diseases).

U.S. Environmental Protection Agency (EPA) Mosquito Control
(http://www.epa.gov/pesticides/health/mosquitoes/index.htm)
Provides information on mosquito control strategies and pesticides.

Grants

Epi and Lab Capacity Program Grant Information
(http://www.cdc.gov/ncidod/osr/site/epi_lab/)
Offers a primer on the CDC's ELC grant program.

Risk Communication

Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/)
A guide to holding productive dialogue sessions with the community is available at http://www.atsdr.cdc.gov/risk/riskprimer/index.html.

Centers for Disease Control and Prevention (CDC) (www.cdc.gov)
Information on the "Fight the Bite" risk communication campaign is available at http://www.cdc.gov/ncidod/dvbid/westnile/prevention_info.htm.

Training Materials

American Association of Pesticide Safety Educators (AAPSE) (http://www.aapse.org/)
A national organization providing pesticide education and applicator certification information for each state. Specific information for each state is available under the 'Pesticide Safety Programs' link at http://pep.wsu.edu/psp/.

Association of American Pesticide Control Officials (AAPCO) (www.aapco.org)
A national organization which offers pesticide regulation information.

American Mosquito Control Association (AMCA)
(http://www.mosquito.org/resources/links.aspx)
Provides links to training websites and information.

Centers for Disease Control and Prevention (CDC)
(http://www.cdc.gov/ncidod/dvbid/westnile/education.htm#training).
Provides taxonomic guides for mosquito identification and training materials.

Federal Emergency Management Agency (FEMA) (www.fema.gov)
Information on the National Incident Management System (NIMS) and the Incident Command System (ICS) is available at http://www.fema.gov/emergency/nims/nims_training.shtm. More information on resource typing is available at http://www.fema.gov/pdf/emergency/nims/resource_typing_qadoc.pdf.

Appendix B

Arboviral Disease Outbreak Risk Categories[28]

Definitions and stepwise response for risk categories for mosquito-borne arboviral disease outbreaks in the United States. Risk categories are tentative and approximate. Local and regional characteristics may alter the risk level at which specific actions must be taken.

Category	Probability of outbreak	Definition	Recommended response
0	Negligible or none	Off-season; adult vectors inactive; climate unsuitable	None required; may pursue source reduction and public education activities
1	Remote	Spring, summer, or fall; adult vectors active but not abundant; ambient temperature not satisfactory for viral development in vectors	Source reduction; use larvicides at specific sources identified by entomologic survey; maintain vector and virus surveillance
2	Possible	Focal abundance of adult vectors; temperature adequate for extrinsic incubation; seroconversion in sentinel hosts	Response from category 1 plus: Increase larvicide use in/near urban areas; initiate selective adulticide use; increase vector and virus surveillance
3	Probable	Abundant adult vectors in most areas; multiple virus isolations from enzootic hosts or a confirmed human or equine case; optimal conditions for extrinsic incubation and vector survival; these phenomena occur early in the 'normal' season for viral activity	Implement emergency control contingency plan: Response in category 2 plus: Adulticiding in high risk areas; expand public information programs (use of repellents, personal protection, avoidance of high vector contact areas); initiate hospital surveillance for human cases
4	Outbreak in progress	Multiple confirmed cases in humans	Continue with emergency control contingency plan: Concentrate available resources on strong adulticiding efforts over areas at risk; hold daily public information briefings on status of epidemic; continue emphasis on personal protection measures; maintain surveillance of vector/virus activity, human cases

Appendix C

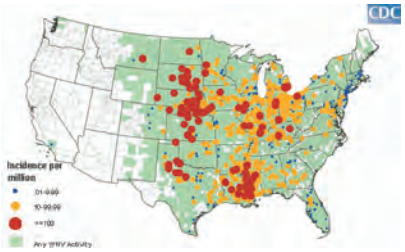
West Nile Virus Human Neuroinvasive Disease Incidence in the U.S., 1999-2007[29]

The following disease maps show how the initial outbreak of West Nile virus in New York City in 1999 spreads to every state in the continental United States by 2006. This rapid spread foreshadows the ease by which an even more destructive virus could spread throughout the United States.

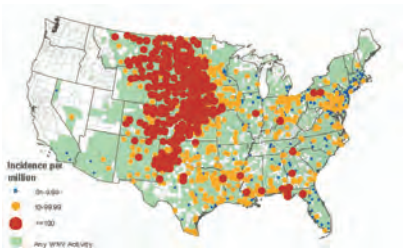
1999

2000

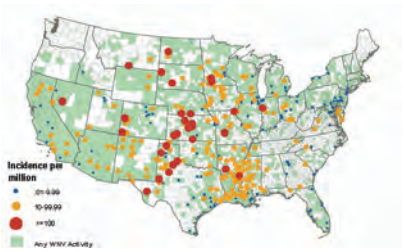
2001



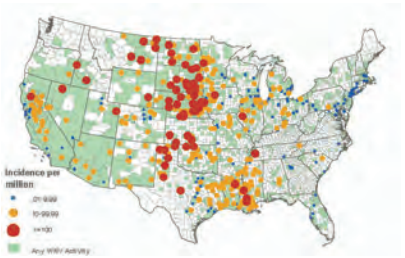
2002



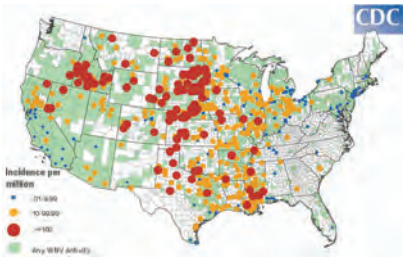
2003



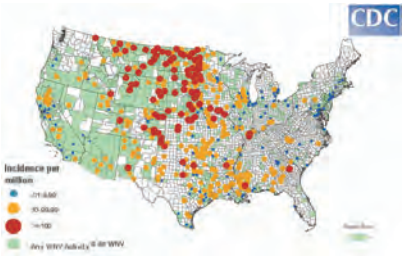
2004



2005



2006



2007

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