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ASTHO*Report*

SECOND EDITION

Public Health Confronts the Mosquito

DEVELOPING SUSTAINABLE STATE AND LOCAL MOSQUITO CONTROL PROGRAMS

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Recommendations of the
Mosquito Control Collaborative

A Project of the
Association of State and Territorial Health Officials

In partnership with
The National Association of County and City Health Officials

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ABOUT THE VECTOR CONTROL WORKGROUP

The Vector Control Workgroup (VCW) included members of state and federal government and non-governmental agencies. Many VCW members also serve in the National Association of Vector-Borne Disease Control Officials (NAVCO), an ASTHO affiliate, or the American Mosquito Control Association (AMCA). VCW's mission is to enhance the capacity of state and territorial health agencies to prevent and control vector-borne disease outbreaks. This document, *Public Health Confronts the Mosquito, 2nd edition*, builds on VCW's contributions to *Before the Swarm* and the Mosquito Control Collaborative's work on the first edition.[1]

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Contents

Acronyms

AMCA:
American Mosquito Control Association

ASTHO:
Association of State and Territorial Health Officials

CASPER:
Community Assessment for Public Health Emergency Response

CDC:
Centers for Disease Control and Prevention

CSTE:
Council of State and Territorial Epidemiologists

DOD:
United States Department of Defense

EEE:
Eastern equine encephalitis

ELC:
Epidemiology and Laboratory Capacity

EPA:
United States Environmental Protection Agency

EOP:
Emergency operations plan

FEMA:
Federal Emergency Management Agency

GIS:
Geographic information system

GMCA:
Georgia Mosquito Control Association

GPCA:
Georgia Pest Control Association

ICS:
Incident command system

IMM:
Integrated mosquito management

IPM:
Incident pest management

LACV:
La Crosse encephalitis

NAVCO:
The National Association of Vector-borne Disease Control Officials

NGO:
Non-governmental organization

NIMS:
National Incident Management System

NPIC:
National Pesticide Information Center

NPS:
National Park Service

PCO:
Pest Control Operator

PHAB:
Public Health Accreditation Board

SLE:
St. Louis encephalitis

S/THA:
State/territorial health agency

S/THO:
State/territorial health official

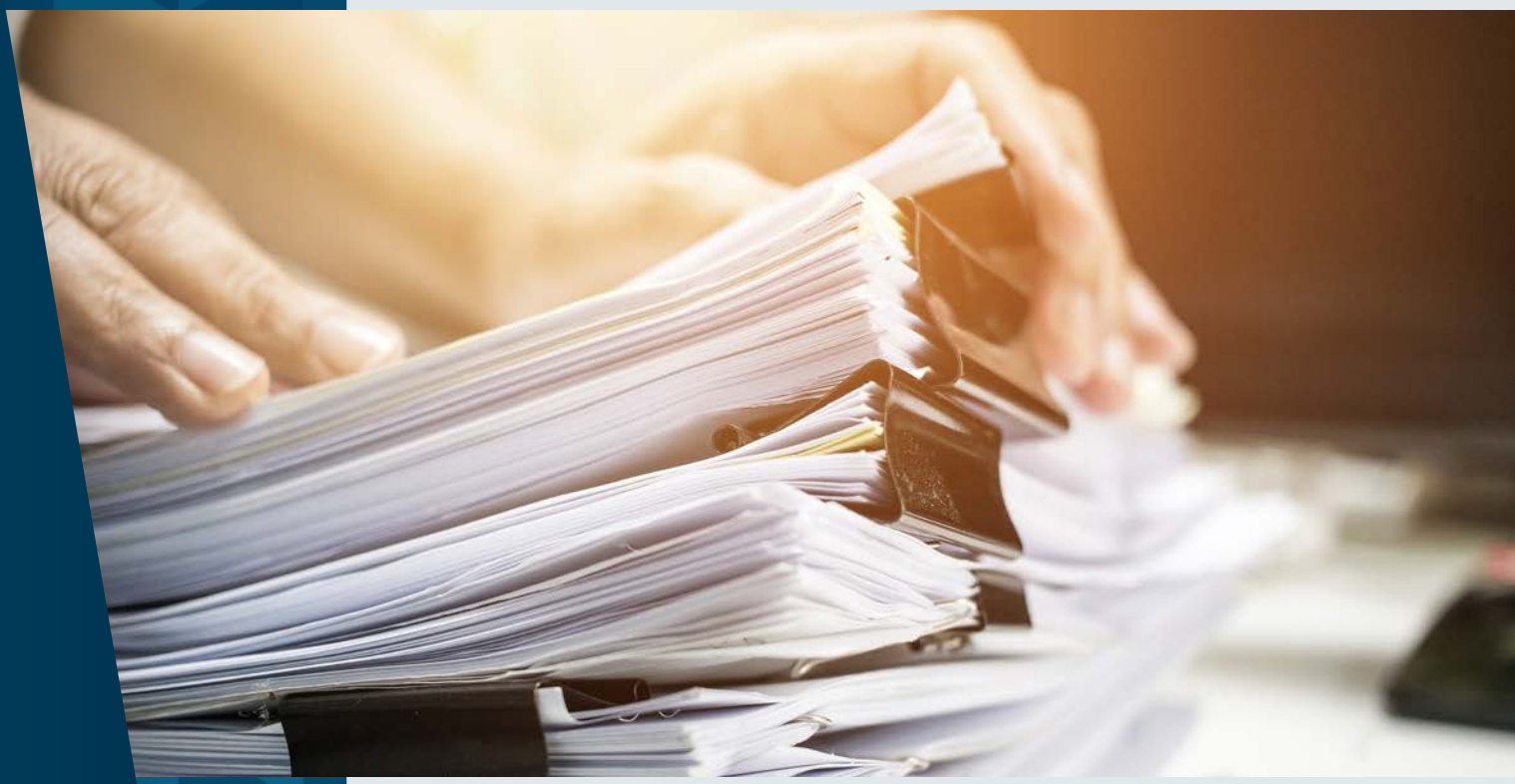
ULV:
Ultra-low volume

USDA:
United States Department of Agriculture

VCW:
Vector Control Workgroup

WEE:
Western equine encephalitis

WNV:
West Nile virus



SECTION 1

Executive Summary

Mosquito control has historically been and remains an important and basic public health function. The rapid spread of West Nile virus (WNV) and the emergence of other viruses such as dengue, chikungunya, and Zika in the United States and its territories demonstrates the continuing need for organized mosquito control activities. States, territories, and local communities are challenged to develop and maintain these essential mosquito control programs, especially when support for mosquito control wanes once immediate mosquito-borne disease threats are no longer perceived to be emergency situations.

GUIDANCE

This document provides guidance to assist local, state, and territorial mosquito control programs in developing and maintaining effective mosquito control programs. Guidance is organized into four sections:

UNDERSTANDING THE ROLES OF GOVERNMENT AND NONGOVERNMENTAL ORGANIZATIONS

- States, localities, and the federal government all have active roles in mosquito control. The exact roles of each will differ among the individual states and localities.
- A recent survey of state and territorial environmental health directors found that states and territories employ a variety of structures to organize mosquito control activities. Local mosquito programs exhibit similar variability. Common to all programs is the need to establish key federal, state, local, and non-governmental partnerships to effectively implement mosquito control activities.
- Non-governmental organizations and private industry are important adjuncts to government programs.

PLANNING

- Developing an effective mosquito control program takes time, preparation, and planning. Effective planning requires strategies for addressing the needs of both routine mosquito control operations and emergencies caused by weather events or outbreaks of vector-borne disease.
- Mosquito control programs may benefit from participating in larger, comprehensive public health planning initiatives for public health accreditation, setting environmental public health standards, and emergency response planning.

BUILDING RELATIONSHIPS AND PUBLIC SUPPORT

- Effective mosquito control programs require continued broad-based community and stakeholder support.
- To support efforts toward broad stakeholder engagement, it's important to clearly identify which agency leads local and state mosquito control, confirm who can speak for that agency during emergencies, and to include the media in developing strategies for communication with the public.
- Stakeholders can support effective public education efforts by developing communications plans that employ simple messages for personal protection, ensure consistent messaging across levels of government, and make monitoring information publicly available.

USING THE BEST SCIENCE

- Effective mosquito control programs are founded on a solid understanding of:
    - Knowledge of local mosquito biology, temporal and geographic distribution, and relative abundance.
    - Timing and distribution of human and animal mosquito-borne disease cases.
    - Control strategies that are cognizant of mosquito population dynamics and prevent the emergence of adult mosquitoes.
    - Options for controlling adult mosquitoes and strategies for minimizing the impacts on non-target species.
- Mosquito control programs can be minimal (Level I), intermediate (Level II) or comprehensive (Level III) depending on the resources available to address the threat, concerns with nuisance mosquitoes, and other political, legal, environmental, and geographic considerations. This document provides guidance on activities appropriate to each level of program.

INFORMATIONAL APPENDICES

APPENDIX A
provides suggested guidelines for a phased response to WNV and Zika virus surveillance data.

APPENDIX B
lists suggested components for bids or contracts for a mosquito control program.

APPENDIX C
presents the results of ASTHO's 2017 Mosquito Control Management Survey. This national survey of state and territory vector control programs aimed to explore how U.S. mosquito control activities are organized and better understand vector-borne disease preparedness and capacity in state and territorial health agencies (S/THAs).

- The organizational structure of mosquito control management is affected by local nuances, contributing to the wide range of mosquito control management tactics seen across the United States.
- S/THAs depend on partnerships to implement mosquito control activities, such as emergency response, communication, surveillance, worker training, and prevention activities, within their jurisdictions.
- S/THAs most often establish key partnerships with departments of environment, emergency management agencies, and agricultural agencies to implement mosquito control activities. Partnerships with federal agencies are especially important for funding state and local mosquito control efforts.

APPENDIX D
presents the results of ASTHO's analysis of the express legal authority for mosquito control programs in each state, the District of Columbia, and Puerto Rico. Finding from these results include:

- Mosquito control roles, responsibilities, powers, and authorities at the state, territorial, district, and local levels are often expressly provided by state statute and vary among the jurisdictions.
- Specific funding mechanisms for mosquito control and abatement may be authorized at the various jurisdictional levels.
- State statutes also provide enforcement provisions and mechanisms for ensuring mosquito control and abatement at the various jurisdictional levels.

RECOMMENDATIONS

In addition to this guidance, VCW developed the following recommendations for meeting the challenges of emerging *vector-borne disease*.

1 Maintain a capable mosquito control infrastructure focused on prevention through sustained funding and support.

One-time federal appropriations can help state/territorial and local mosquito control programs respond to immediate threats from emerging mosquito-borne disease, but sustained funding is needed to prevent or rapidly contain future emerging vector-borne disease.

RECOMMENDATION 1.

Local, state/territorial, and federal governments provide reliable and consistent funding and support for mosquito control programs and infrastructure. To be effective, this infrastructure requires that:

1.1 With assistance and support from CDC, each state maintains an entomologist or medical entomologist on staff who has access to current and historic surveillance data, and who can provide the expertise needed for effective mosquito control activities.

1.2 All mosquito control activities are informed by proactive surveillance for native and exotic species, regardless of the immediate threat of disease outbreaks.

1.3 S/THAs incorporate vector-borne disease preparedness and response into their comprehensive planning processes, such as public health accreditation, environmental health standards, and emergency operations plans.

1.3.1 S/THAs support local mosquito control programs to incorporate their plans into comprehensive local accreditation and emergency operations plans.

1.3.2 Those areas with a limited need for sustained local mosquito control programs (e.g., low-population areas with low rates of mosquito-borne disease) need contingency plans for addressing potential threats of emerging mosquito-borne disease, which can include mosquito control services provided through private companies and/or neighboring mosquito control programs with support from state or federal agencies.

2 Commit to mosquito control strategies that rely on integrated mosquito management.

Mosquito control programs are variable in size and scope (categorized as Basic or Level I, Intermediate or Level II, and Comprehensive or Level III). All programs benefit by adopting approaches of integrated mosquito management (IMM), using good science and practice to maximize control effectiveness while minimizing unintended adverse consequences. The existing mosquito control infrastructure has been unable to prevent the rapid spread of mosquito-borne viruses like dengue, chikungunya, WNV, and Zika from impacting the United States and its territories. New approaches are needed. Given current resource and funding limitations, successfully preventing the spread of emerging disease relies on improving existing programs' effectiveness and educating the public about mosquitoes and mosquito-borne disease, how to control breeding sites/larval habitats, and how to employ personal protection measures (e.g., repellents and clothing).

RECOMMENDATION 2.
All local mosquito control programs employ IMM strategies.

2.1 Where needed, state/territorial and federal agencies provide assistance to local programs to ensure that employing IMM is possible.

2.2 Community involvement and changes in individual behavior are a necessary component of IMM, especially for container-breeding mosquitoes found in residential areas (i.e., peridomestic species).

2.2.1 Create an effective public education campaign about the threats of mosquito-borne disease. Following the model of the national campaign to address tobacco smoke exposure, design the campaign to encourage state and local governments, non-governmental agencies, private sector groups, and other public health advocates to adapt the campaign materials for their own uses.

2.2.2 Create consistent messaging promoted by multiple federal and state agencies in order to increase the impacts of media campaigns.

2.2.3 Support S/THA community engagement activities through statewide media and education campaigns.

3 Promote a more effective, robust national mosquito control infrastructure by developing a better-trained and -prepared mosquito control workforce and better-informed public.

Maintaining a competent mosquito control program workforce is a challenge for state, territorial, and local agencies. As with other public health disciplines, mosquito control programs face challenges of retaining adequate staff, providing oversight for regulated individuals and entities, and finding skilled individuals to fill program vacancies. Responsibly applying pesticides for mosquito control requires that all individuals who apply pesticides, as well as many of those who supervise pesticide applicators, have appropriate certification and training. Training must provide a sufficient understanding of the biology of mosquitoes related to their surveillance and control.

RECOMMENDATION 3.
Ensure that mosquito control program staff and contractors have appropriate certification and training.

3.1 Promote training among mosquito control program staff, program contractors, and private sector pesticide management operators.

3.2 Raise awareness of available training, e.g., online training through CDC or trade associations like the American Mosquito Control Association (AMCA).

3.3 Use pesticide applicator certification programs to promote information sharing on pesticide applications relative to pesticide resistance in target mosquito species, unintended consequences for pollinators and other non-target impacts, and IMM best practices.

3.4 Explore opportunities to recruit qualified individuals to the mosquito control workforce.

SECTION 2

Introduction and Background

INTRODUCTION

The mosquito is a highly effective and deadly vector for human disease agents. The tiny insect has played a powerful role in spreading communicable diseases such as malaria and viruses that cause disease, including varieties of encephalitis (e.g., eastern equine encephalitis [EEE], western equine encephalitis [WEE], encephalitis from West Nile virus [WNV], St. Louis encephalitis [SLE], La Crosse encephalitis [LACV]), dengue fever, and, most recently, Zika virus.

Mosquito control activities are conducted for many reasons – reducing nuisance levels, economics, agricultural productivity, recreational enjoyment, livestock health and safety, and, most importantly, protecting the human population from death and disability from mosquito-borne disease.

ASTHO's VCW was assembled with a mission to enhance the capacity of state and territorial health agencies to prevent and control vector-borne disease outbreaks. In response to the emerging threat of Zika virus in 2016, the VCW began its charge to update the document, *Public Health Confronts the Mosquito*.[2] This revision builds on both the VCW's earlier work on *Before the Swarm* and the work on the 2004 edition of *Public Health Confronts the Mosquito* by the Mosquito Control Collaborative.[3]

HISTORY OF MOSQUITO-BORNE DISEASE AND MOSQUITO CONTROL PROGRAMS IN THE UNITED STATES

Mosquito-transmitted diseases have likely existed in the Americas since long before European settlement. EEE, WEE, and SLE viruses are examples of such threats.[4] With the coming of the Europeans to the New World, additional diseases, such as malaria, dengue, and yellow fever were added to the mix of vector-borne diseases. Most people today are unaware that malaria extended throughout the United States and into southern Canada in the 1800's.[5] As early as 1831, the impact of viral mosquito-borne diseases on horses has been recognized in the United States, with significant economic impacts of EEE disease and other mosquito-borne diseases continuing to the present.[6,7] The first organized mosquito control programs were established in the early 1900s. In the eastern United States, a mosquito control program was established in South Orange, New Jersey in 1901.[8] In the west, a program in the San Francisco Bay began controlling nuisance mosquitoes in 1904, and California's Mosquito Abatement Act passed a decade later in 1915.[9,10]

The increasing intercontinental movement of goods, animals, and people to the United States has experienced a variety of new and exotic disease problems. Mosquito-borne diseases like West Nile encephalitis are zoonoses, or diseases of animals that can be transmitted to humans. Such diseases have the potential to spread quickly. WNV spread from coast to coast in only five years, primarily through bird migration. Zika virus behaves slightly differently. It can move with people into urban areas, where it is efficiently transmitted from person to person by the *Aedes aegypti* and *Aedes albopictus* mosquitoes. Large numbers of infected people have the potential to quickly spread the virus through movements to other communities where these vectors are present. Given the increasing globalization of travel and commerce, it is likely that other exotic agents will be transported and established in the United States, its territories, or other areas of the Americas.[11,12]

CURRENT STATUS OF MOSQUITO CONTROL PROGRAMS IN THE UNITED STATES

By 1997, a national survey found 345 mosquito control districts or programs in the United States serving a population of approximately 97 million people.[13] Data up to March 2016 are available from the National Pesticide Information Center (NPIC), a cooperative agreement between Oregon State University and the U.S. Environmental Protection Agency (EPA). The NPIC collects and maps information on county/local mosquito control programs.[14] Since the late 1990s, support for mosquito control programs has fluctuated, shrinking in response to budgetary pressures and expanding when the threats of vector-borne disease gain public attention. In their assessments of state and local health department capacity to conduct surveillance, the Council of State and Territorial Epidemiologists (CSTE) observed a significant decrease in capacity in 2013 compared to 2004, corresponding to a 61% decrease in federal surveillance funding during this period.[15]

The variability in coverage by local programs (see Figure 1 or the NPIC **website** for resources by state) reflects many factors, including:

- Adequate population and/or tax base to support a local mosquito control program.
- The extent of mosquito-borne disease threats.
- The presence of nuisance mosquitoes, especially floodwater mosquito species whose populations can periodically explode to disruptive levels.
- The tolerance of the population to nuisance mosquitoes.

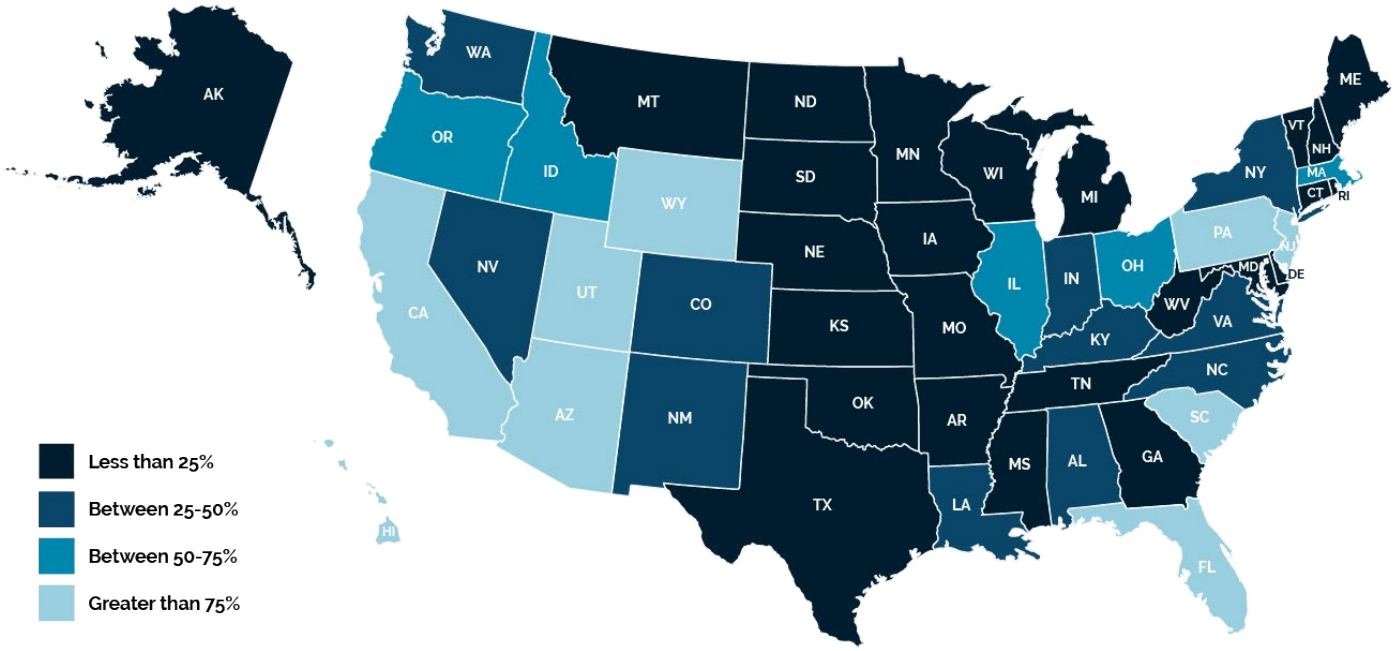


FIGURE 1:
Counties with reported vector control districts.
(This data is accurate as of March 2016. For more information, visit NPIC).

A 2017 ASTHO survey of its member state and territorial health officials found that the organizational structure of mosquito control management is affected by local nuances that contribute to a wide range of mosquito control tactics seen across the United States (see **Appendix C**). State and territorial health agencies depend on organizational partnerships to implement mosquito control activities—such as emergency response, communication, surveillance, worker training, and prevention activities—within their jurisdictions. Key organizational partners often include federal agencies, departments of environment, emergency management agencies, and agricultural agencies.

COSTS OF MOSQUITO-BORNE DISEASE

Mosquito control programs can offer cost-effective vector-borne disease prevention. Data for mosquito control programs in FY2017 indicate that mosquito control remains cost effective. For example, Miami Dade County's mosquito control program costs $16.7 million annually and served 2.7 million residents (a rate of $6.18/person) and supported a $25 billion tourism industry.[16,17] The Central Massachusetts Mosquito Control Program, representing a more rural area that includes 42 towns, has an annual budget of $2.3 million and serves approximately 1 million residents, for a rate of $2.30/person.[18]

The relatively low costs of maintaining effective prevention programs contrast with the much higher costs of taking emergency measures after an outbreak occurs and treating cases of mosquito-borne illness. For example, the total cost of the 2002 WNV epidemic in Louisiana was estimated at $20.1 million.[19] In addition, it's estimated that between 1999 and 2012, the cumulative medical cost for hospitalized WNV patients in the United States was $778 million.[20] During the 2016 Zika virus outbreak, researchers used models to estimate the economic burden of Zika across the six states that are at greatest risk of its emergence, forecasting a $1.2 billion impact in medical costs and productivity losses at an attack rate of 1 percent.[21]

The costs associated with newborns suffering from Zika-related birth defects are even higher, with lifetime care costs for a Zika-affected newborn estimated to average $3.2 million (up to a potential $5.5 million) per child.[22] These cost estimates fail to address the additional emotional costs to these patients and their families.

In addition to the impact on human and veterinary health, mosquito-borne diseases frequently have a major impact on wildlife, including threatened and endangered species. In 1984, 7 of 39 captive, endangered whooping cranes died from EEE virus infection in Patuxent, Maryland.[23] During its spread across the United States at that time, WNV was responsible for the deaths of millions of birds and continues to kill millions of birds each year. An analysis of data from the more than 500 bird banding stations in the United States showed that 23 of 49 bird species studied suffered declines in populations after the appearance of WNV. About half of these adversely-impacted species experienced some recovery, but for twelve species, populations continue to decline.[24]

SECTION 3

Roles of Governmental and Non-Governmental Organizations for Mosquito Control in the United States

INTRODUCTION

Mosquito control programs across the nation display an extraordinary diversity in their size, the activities they perform, their organizational structure, and how they are funded. Mosquito control is primarily a local responsibility: No federal mandates define how state or local mosquito control programs must operate.

Some areas have established independent mosquito districts. Similarly, local programs are funded by a range of mechanisms, including: a dedicated mill levy, usually through a voter-approved special taxing district; fixed charges added to each household water meter account; local sales tax; or the general revenue fund. (See Appendices **C** and **D**).

This section describes the roles of local, state, and federal government in controlling mosquitoes and mosquito-borne illness. In addition to providing local programs with technical and financial support, state and federal government agencies have roles critical to controlling vectors. Integrating local, state, and federal efforts is especially important when emerging vector-borne disease threatens public health, as occurred with WNV in 2002 and Zika in 2016.

OPTIONS FOR MOSQUITO CONTROL INCLUDE:

- Local public health departments or boards of health.
- Independent mosquito control districts.
- Decentralized and non-specialized agencies, such as public works.
- Private companies, such as mosquito control contractors and pest control operators.
- Federal agencies overseeing federal land, such as military installations.

CORE PUBLIC HEALTH FUNCTIONS	VECTOR CONTROL FUNCTIONS	LOCAL, STATE AND TERRITORIAL, AND FEDERAL MOSQUITO CONTROL ACTIVITIES
Assessment 	Monitor and investigate mosquitoes	Local programs collect mosquito and virus data (needed for IMM) with support from states. States compile these data and submit them to federal data systems.
	Perform disease surveillance	Initial investigation of cases is performed at the local level, with state support for both investigation and response. Federal CDC experts support activities related to outbreaks and emergencies.
Policy Development 	Inform and mobilize communities	Federal agencies develop nationally-consistent messaging and web-based materials from which states can develop their own materials. Local programs meet with and inform communities.
	Develop policies	Federal programs work with state and local mosquito control programs to develop policies to prevent the global spread of mosquito-borne disease.
Assurance 	Enforce pesticide laws	Federal agencies delegate enforcement authority to state programs. State certification sets standards for pesticide applicators whose compliance is monitored by local officials.
	Assure access to medical care	Federal experts provide guidance on mosquito-borne disease diagnosis and treatment. States assure access to laboratory and medical services, which are delivered at the local level.
Systems Management of Cross-Cutting Issues	Establish planning, especially related to emergencies	Local planning is critical to effective mosquito control and requires coordination with stakeholders at all levels. State plans include strategies for surveillance and coordination with federal agencies, which provide emergency/outbreak response oversight.

TABLE 1:
Vector control roles of federal, state and territorial, and local government with respect to core public health services (see Figure 2: The 10 essential public health services).

THE ROLES OF NON-GOVERNMENTAL ORGANIZATIONS

Non-governmental organizations (NGOs), including nonprofit groups and private companies, have been important partners for mosquito control programs. The National Association of Vector-borne Disease Control Officials (NAVCO, formerly SPHVCC) and AMCA and its regional groups promote mosquito control programs' efforts, technical and applied knowledge exchange, mosquito control official peer network development, mosquito control legislation, and vector control program expansion.[25,26]

CASE STUDY:

Collaboration Between Mosquito Control Programs and Pest Control Operators in Georgia

The Georgia Mosquito Control Association (GMCA) actively recruited pest control operators (PCOs) to their association to foster better communication and cooperation between commercial and municipal mosquito control programs and promote information sharing between PCOs and public mosquito control officials. As a first step, several GMCA Board of Directors members became involved with the Georgia Pest Control Association (GPCA) and held talks and trainings for GPCA members. Next, GMCA gained a better understanding of GPCA's perspective by recruiting a pesticide company owner to the GMCA Board of Directors. In addition, by creating a commercial membership category, GMCA enabled pesticide companies to pay one membership fee for all of their employees and have their company name on GMCA's website. This collaboration resulted in increased PCO attendance at the GMCA annual meeting, where PCOs can get mosquito control continuing education credits; GPCA requests for talks and assistance with continuing education training from GMCA; increased PCO attendance at annual mosquito ID classes put on by the Georgia Department of Public Health, and occasional requests for assistance with mosquito IDs; and an established foundation for future cooperation between community-based mosquito control and commercial programs.

FEDERAL ROLES

Federal roles in mosquito control become most apparent when vector-borne disease threatens the public health of the nation. Federal funding and support to coordinate the work of multiple state and local mosquito control programs is essential to controlling the spread of vector-borne diseases to and within the United States. Improving upon the current patchwork of state and local mosquito control requires an increase in federal funding and support for establishing a comprehensive mosquito control infrastructure.

The federal roles in mosquito control are distributed between Congress, the federal legal system, and the executive branch. Federal support for mosquito control starts with funding appropriated by Congress. Federal agencies use these funds to either provide direct funding support to state and local programs or to support their own agency activities. Federal agencies provide technical assistance to state and local governments, participate in disaster response, and support vector and vector-borne disease surveillance and response. CDC, FEMA, USDA, EPA, and the U.S. Department of Defense (DOD) have the largest roles in mosquito control (see Table 2 for more information).

FEDERAL ROLES INCLUDE:

- Allocating available mosquito control resources to state and local governments.
- Developing global partnerships for identifying and controlling emerging mosquito-borne diseases.
- Analyzing trends in mosquito populations, researching emerging issues, and developing diagnostic tests for mosquito-borne disease.
- Weather forecasting.
- Developing public information strategies and campaigns.
- Providing technical assistance to state and local programs.
- Supporting state activities (e.g., certifying vector control training courses).

AGENCY	PRIMARY MOSQUITO CONTROL-RELATED RESPONSIBILITY	MOSQUITO CONTROL ACTIVITIES	ROLES AND RESPONSIBILITIES
CDC	Human Disease	Mosquito management, surveillance, and response, including laboratory services for speciation and disease detection.	Has multiple roles related to vector management, surveillance, and response
FEMA	Disaster preparedness and response	Resources for mosquito control following floods or other disasters.[27]	May provide support in the event of a disaster declaration. The requirements for accessing emergency resources are stringent, and require thorough record keeping
USDA	Livestock health	Zoonosis prevention and surveillance and research on management of human and animal pests.	Is concerned with mosquitoes because they are livestock pests and transmit livestock diseases. Some of these diseases—like those caused by certain encephalitis viruses and WNV—are zoonoses, diseases that also affect humans
EPA	Pesticide impacts on human health and the environment	Pesticide registration and review, along with Clean Water Act permits for discharge of pesticides into U.S. waters.[28]	Has authority to review the health and environmental effects associated with pesticide use. Pesticides registered for use in mosquito control have already undergone extensive EPA review, but may still require permits for application
DOD	Vector impacts on military personnel	Mosquito control at military installations and technical assistance to adjacent communities.	Provides mosquito control for its military bases and can provide technical assistance to surrounding communities

TABLE 2:
Federal agencies with the largest roles in mosquito control.

CDC has forged partnerships with other federal agencies and national organizations concerned with mosquito control and mosquito-borne illness. It has also conducted studies to determine mosquito adulticide exposure levels to humans during actual aerial and truck application in communities.[29,30] Conferences on emerging infectious diseases like WNV, chikungunya, and Zika have provided opportunities to disseminate scientific information and train state and local officials and stakeholders. Furthermore, national public information campaign materials, websites, and group email lists have increased community awareness of mosquito control issues by providing timely, credible information to state and local governments and the public.

STATE AND TERRITORIAL ROLES

States and territories have a responsibility for overall mosquito control planning (discussed in more detail in the Planning section), guidance, and leadership, especially during public health emergency situations. States and territories are strategic political, technical, and legal resources for local governments, just as the federal government is a strategic resource to states and territories. While only some states and territories provide direct mosquito control services to communities, most assume mosquito control responsibilities in response to emergencies that compromise or overwhelm local resources.

State and territorial agencies work with the media to assure that consistent messages are communicated to physicians, veterinarians, and the public, and provide educational materials to the clinical community and the general public. State public health laboratories also play important roles in mosquito-borne disease control efforts by testing human, animal, and mosquito samples. State agricultural and environmental agencies may require training, certification, and licensing for agencies intending to use pesticides as a part of their overall control program. In border areas with other states or nations or areas adjacent to DOD facilities, states and territories have a role in coordinating mosquito control efforts.

Mosquito control policy continues to evolve as new issues emerge. State-level responses are influenced by their organizational structure and their statutory authority. States and territories employ a variety of structures to organize mosquito control activities, which require successful partnerships with key federal, state, local, and non-governmental agencies (see **Appendix C**). Mosquito control roles, responsibilities, powers, and authorities at the state, territorial, district, and local levels are often expressly provided by state statute and vary among the jurisdictions. State statutes may also authorize specific mosquito control funding mechanisms and enforcement authorities (see **Appendix D**).

STATE AND TERRITORIAL MOSQUITO CONTROL ROLES INCLUDE:

- Developing, collecting, and analyzing state-specific mosquito surveillance data, including data on mosquito-borne illness.
- Developing state policy recommendations.
- Implementing laws and regulations regarding mosquito control, disease surveillance, and reporting.
- Coordinating with federal agencies and neighboring states.
- Developing state plans to address mosquito control.
- Allocating available resources to assist local mosquito control programs.
- Maintaining state information hotlines and websites.
- Developing statewide public information campaigns.
- Providing technical assistance to local jurisdictions.
- Evaluating statewide efforts to control mosquito-borne illness.
- Providing public health laboratory services.
- Training and certifying pesticide applicators.

LOCAL ROLES AND ROLES OF SPECIAL DISTRICTS

In contrast to the data and surveillance activities typically performed by S/THAs, the application of pesticides and other activities associated with control of mosquito populations generally occurs at the local level. Cities, counties, special districts, and multi-jurisdictional districts have historically performed mosquito control activities, either for nuisance control or to protect the public's health. Financial, scientific, legal, and legislative support for these efforts may come from the state or territory, but local taxes and fees are more common sources for funding these programs.

County commissioners, city council members, and other local elected or appointed officials usually make decisions regarding mosquito control programs, but the agencies selected to see to mosquito control programs vary from public works to public health. In addition, government-appointed boards, especially local boards of health, participate in mosquito control as part of their responsibility to support and encourage efforts that protect the public. Finally, because land use control is generally a local issue, involving local planning boards in a community mosquito control program can help prevent problems (such those that occur when stormwater management areas—which can serve as mosquito breeding grounds—are sited near communities, schools, and businesses).

Local government often works with the state or territory and, occasionally, the federal government for comprehensive mosquito control programs. In some instances, they work together to provide services for state- and federally-owned properties and land. Some of the challenges in mosquito control can come from disagreements on how to perform effective mosquito control on federal land, state land, and local parks and natural areas. Developing strategies to shape action well in advance of a mosquito control response can help avoid conflict. Mosquito control partnerships are necessary because no single agency can effectively respond to an environmental public health emergency of the magnitude of mosquito-borne illness.

Although effective mosquito control programs can be organized in diverse ways at the state and local levels, special mosquito control districts have proved to be a practical and effective option to handle mosquito-borne public health threats with greater consistency over multiple seasons. These districts carry governmental authority to make decisions and conduct mosquito control activities within district boundaries.

Many states have enabling statutes that allow mosquito control districts to be established by voter approval. These districts establish an infrastructure for monitoring and control actions and fund these activities. Districts can cover one town, multiple counties, or even an entire state. Boundaries between districts and local governments may overlap, so communities often use intergovernmental agreements to assign responsibility, accountability, and clarity to programs that occur within multiple jurisdictions. To maximize economies of scale, multiple local communities can participate in cooperative agreements.

LOCAL ROLES INCLUDE:

- Designating a lead agency and authority within a jurisdiction.
- Developing a mosquito control program with available resources, including developing contracts for mosquito control services from the private sector, if needed.
- Coordinating activities with local agencies and among public health, medical, and veterinary communities.
- Coordinating activities with neighboring jurisdictions.
- Surveilling, monitoring, and reporting virus activity and mosquito-borne illness.
- Coordinating activities with the state lead agency.
- Educating local officials.
- If needed, issuing or recommending emergency orders and declaring states of emergency.
- Developing mosquito control information campaigns to educate the public (especially for high risk groups).
- Evaluating mosquito control efforts.

A nationwide **survey** of local mosquito control programs provided the foundation for recommendations for:
1) local mosquito control competencies
2) strategies for expanding mosquito control capacity, and
3) methods for overcoming barriers to developing competent programs.
Stakeholders can also access resources for improving mosquito surveillance and control capacity, including disease-specific toolkits like **CDC's guidance related to Zika virus** as well as more general but **comprehensive guidance from AMCA**.

STRUCTURES AND ROLES-PLANNING AND ACTION CHECKLIST

States, territories, and local jurisdictions can use the checklist below to establish or improve their mosquito control programs:

- [ ] Determine if the state has legal authority for mosquito control planning and action at the state level.
  - Are current statutes and regulations adequate to support necessary mosquito control decisions?
  - Which agency will have mosquito control authority at the state level? (If not identified in statute, the governor may designate a lead agency for mosquito control, or legislators may need to enact laws to designate the lead agency and its responsibilities.)
- [ ] Determine if the locality has the necessary legal authorities to conduct mosquito control activities. Which agency will have the authority at the local level?
- [ ] Consider how best to structure mosquito control activities and programs. Are special districts a good option for the community?
- [ ] Identify a collaborative format for elected officials and their appointees to address mosquito control.
- [ ] Determine a method among governments to assign mosquito control responsibility based on the level of expertise and capacity of the agencies involved.
- [ ] Clearly identify and understand the roles and responsibilities of the lead state and local agencies.
- [ ] Determine how to structure and sustain mosquito control funding.
- [ ] Identify how existing environmental public health programs, such as air quality, food safety, and water quality services, will be maintained if resources are overwhelmed by an emerging threat, such as WNV. Identify a plan to keep other important programs functioning at various levels depending on the threat.
- [ ] Evaluate agency capability to fit into a response system that can "grow" as the event becomes larger and "shrink" as it decreases. Determine how to create such a system and how it will be activated.
- [ ] Determine how to implement mosquito control in federal, state, and local parks and natural areas. Establish or activate agreements to facilitate negotiations and action.
- [ ] Assign a designated mosquito control spokesperson with responsibility to interact with governmental agencies and with the public and media.

SECTION 4

Planning

INTRODUCTION

Developing an effective mosquito control program takes time, preparation, and planning. Effective planning requires strategies for addressing both routine operations and activities and emergencies caused by the risks of vector-borne disease. Planning can be viewed as a component of systems management, which is central to the three **core functions** of public health (assessment, policy development, and evaluation) and the 10 Essential Public Health Services shown in Figure 2.[31]

FIGURE 2:
The 10 essential public health services.

Mosquito control programs have opportunities to participate in larger, comprehensive planning initiatives to improve public health practice. These initiatives include:

Public health accreditation. The national Public Health Accreditation Board (PHAB) has established a voluntary program to improve and protect public health by advancing the quality and performance of tribal, state, local, and territorial public health departments. PHAB planning tools can assist mosquito control programs with their planning process or with quality improvement processes. In turn, public health agencies working towards PHAB accreditation need to document how plans are created and used in their agency. Mosquito control program staff may find that their mosquito control plans fill the need for supporting documentation for their agency's accreditation, for example, regarding standards for an all-hazards emergency operations plan (Standard 5.4) or plans and policies for communicating hazards (Standard 2.4).[32]

Environmental public health standards. Similar to public health accreditation, voluntary planning and evaluation tools are available through CDC's Environmental Public Health Performance Standards.

Emergency preparedness and response planning. FEMA and its state counterparts have developed state and local emergency operations plans as part of a nationally-standardized approach to managing emergency incidents. Planning for emergencies associated with outbreaks of vector-borne illness could be conducted as part of this more comprehensive planning effort. Plans for community preparedness and community recovery, shelter requirements for mass care, and ensuring responder safety and health should all consider the hazards posed by vectors and the need for vector control.

The state or local public health agency might also undertake planning efforts as the lead agency in a vector-borne illness outbreak response. Although training in the National Incident Management System and its Incident Command System is not required for most vector control officials, an in-depth knowledge and familiarity both systems will allow state and local programs to integrate themselves into general preparedness efforts. (This training is also an eligibility requirement to receive federal funding assistance.)[33,34]

Mosquito control programs present a unique set of challenges with respect to the planning process. Uncertainties in funding and legal authority, adverse environmental consequences of some control measures, workforce training issues, and fears of mosquito-borne disease all need to be addressed in the planning process, as described below.

ENVIRONMENTAL CONSIDERATIONS

MINIMIZING ENVIRONMENTAL IMPACT

By their very nature, mosquito control activities impact the environment. Therefore, every practical effort must be made to minimize the negative consequences of mosquito control on the environment. This is the premise behind integrated pest management or, more specifically, IMM, which employs available mosquito control methods in ways that minimize adverse ecological consequences and economic impacts. This is accomplished by using scientifically collected information to narrow the targets of mosquito control. Not all mosquitoes are harmful and targeting identifies and controls only the mosquitoes that are nuisance and disease vectors.

Even if control actions are limited to a single species in a specific location, a program cannot totally eliminate the environmental impact on other species in the system. However, mosquito control activities affect the environment in different ways. Minimizing negative environmental impacts need to be a consideration in a mosquito control program's choice of the most effective control tactic for the situation.

It is more prudent to target larval mosquitoes over adults. Environmental impacts are minimized by using adulticide spraying only when more targeted controls, such as reducing mosquito breeding habitat and larviciding, do not adequately reduce populations. Narrow spectrum larvicides (e.g., biological toxins and insect growth regulators) are preferred over broad spectrum larvicides. Insecticides that are EPA-registered as mosquito adulticides or larvicides can be legally used only according to their EPA-approved directions for use. These insecticides have undergone toxicity and environmental safety testing to ensure that their labeled directions for use are as safe as possible and cause negligible adverse effects.

A decision matrix can help policymakers and the public clarify the kinds of mosquito control programs they want in their communities (see Appendix A). State and local health agencies and universities may have entomologists and environmental specialists to help evaluate environmental impacts, and other organizations, such as the North American Pollinator Protection campaign and the Xerxes Society can also help in this process.[35,36] Some agencies also have environmental epidemiologists, toxicologists, and other professionals who evaluate health risks. Close dialogue between these agencies and mosquito control programs during the planning process can help anticipate and address public reaction and concern over mosquito control activities in their communities. Finally, local governments that hire mosquito control consultants can seek their advice for finding resources to conduct environmental reviews or assessments.

CONTROLLING MOSQUITOES IN WETLANDS AND PROTECTED AREAS

Special care must be given to controlling mosquitoes in sensitive natural areas such as wetlands, streams, and even constructed drainage systems, which can provide habitat for an array of wildlife, including amphibians, mammals, birds, and beneficial insects such as pollinators. Wetlands also help control flooding, improve water quality, and provide recreational opportunities. Draining healthy wetlands is a controversial and often inappropriate option, but controlling breeding sites like sewer catch basins, puddles, containers, and poorly designed or poorly managed stormwater management areas routine parts of IMM programs.

For some mosquito species, high levels of mosquito production frequently occur in wetlands that are used to treat domestic sewage and animal wastes (often referred to as constructed wetlands). Design features and maintenance procedures of these aquatic plant systems can either increase or decrease mosquito problems. Careful design before construction and monitoring after construction can keep mosquito breeding within acceptable levels. Early input by mosquito-control professionals can keep constructed wetlands from becoming public health problems. Similar issues may apply to retention and detention basins constructed for stormwater management.[37]

By focusing on IMM, larvicides, protecting pollinators and other non-target species, caring for sensitive environments, and employing best practices for constructed wetlands, mosquito control programs establish good relationships with community members, relationships that will be beneficial during a mosquito-borne disease public health emergency. Communities must decide how to control virus-infected mosquitoes based on science and other factors. Public support or opposition to a proposed mosquito control activity can be swayed by information, economics, legalities, technology, politics, and emotion. In addition, the concepts of environmental protection, relative risk, and protection of public health change as mosquito control programs face public health emergencies. Keeping the public and environmental interest groups informed about relative risks of mosquito control options can be crucial to gaining acceptance for implementing a sound mosquito control program.[38]

ENVIRONMENTAL CONSIDERATIONS PLANNING AND ACTION CHECKLIST

- [ ] Identify environmental groups in the community.
- [ ] Involve the appropriate professionals and environmental interest groups early in the mosquito control process.
- [ ] Determine the community's level of confidence in its local government as well as its acceptance of available scientific information regarding risks to the public and the environment.
- [ ] Create a program to collect, identify, and quantify mosquitoes by species to enable targeted control efforts.
- [ ] Identify the scientific resources available to the community's program to evaluate the risks and benefits of mosquito control actions.
- [ ] Analyze best practices for effective mosquito control that minimize adverse environmental impact.
- [ ] Perform an environmental review of potential impacts prior to program implementation, including a review of laws or regulations requiring an environmental impact assessment.
- [ ] Make the results of the environmental review available to a broad public audience.
- [ ] Anticipate objections to proposed control strategies with a plan for how to address public concerns.
- [ ] Choose a knowledgeable and articulate spokesperson to carry environmental risk information to politicians and the public.

LEGAL CONSIDERATIONS

Communities and states must have a solid legal foundation for and understanding of their mosquito control activities. Every control program should conduct an analysis of existing state and local laws, regulations, inter-jurisdictional agreements, and other legal mechanisms to identify gaps and a basis for revising and updating those authorities. Many state and local governments are already well prepared with the necessary legal infrastructure, with examples of the statutory basis for their programs provided in Appendix D.

Many states and territories have specific statutory provisions and protections outlining the legal parameters for mosquito control activities at the state and local levels. In other states, mosquito control activities are based on general health statutes and rules and general liability limitations. The vagueness or general nature of state law, combined with an existing public health threat and the prevailing public/political objections to existing mosquito control activities, can allow legislators to develop and introduce specific legislation dealing with the powers and responsibilities of mosquito control.

Government agencies need to work closely with elected officials and the public to respond to any outbreak of mosquito-borne disease. These discussions should occur well in advance of an outbreak, as relationships are best established before a crisis, and the role that each party plays should be understood by all involved. Although the hundreds of mosquito control programs throughout the country operate under different sets of enabling authorities, successful programs usually require: (1) legal authority to exist and operate as a public entity, (2) general or specific definition of function, (3) enforcement authority, and (4) funding authority (see "Funding Considerations," below). Mosquito control programs must also anticipate and define potential liabilities and learn to manage the consequences of program activities.

ESTABLISH CLEAR LEGAL AUTHORITY

The legal authority for a local mosquito control effort can be derived from state, county, and municipal laws. It can be general (such as for general health or safety powers) or specific (such as for laws creating a mosquito control district). Below are examples of legal authority options for mosquito control programs, listed in order from basic to complex.

General public welfare and safety. Counties and municipalities have a duty under their articles of incorporation to maintain public safety. These are broad powers that can be used to authorize mosquito abatement. The lack of specific authority may result in a mosquito control program having to justify its existence, procedures, and funding.

Local public health authority. This is usually characterized by a local board of health and a local health agency. Their enabling authority often includes specific language to protect the public from epidemics and nuisances. Environmental health programs historically include vector control to prevent encephalitis, even if mosquito control activities are not currently funded. During mosquito-borne disease outbreaks, local public health agencies may use this authority to build control programs.

- **Statutory enabling authority to establish and operate a mosquito control program.** State legislatures can provide enabling legislation to allow a county or municipality to operate a mosquito control program. The statute usually provides funding opportunities for the program.
- **Statutory enabling authority to establish mosquito control districts.** This option, which is specific, sustaining, and provides a proven funding mechanism, is a way of institutionalizing a mosquito control effort.
- **Statutory statewide mosquito control program with options for participation by county and municipal governments.** This type of program is more common in places where there is a major problem with pest mosquitoes. Under this option, a commission promulgates complex regulations and prescribes parameters for control activities for counties and municipalities. Local governments can also form districts and programs as another option.

DEFINE THE LEAD AGENCY AND ITS FUNCTIONS

Identifying and defining who is responsible for mosquito control activities is another issue related to legal authority. Usually, these activities are the job of local government, with state law authorizing or empowering local agencies to undertake control activities. If an existing agency like local public health or public works is already involved in mosquito control, it could be more economical to expand its role than to establish a new entity. State agencies may operate mosquito control services in rural or unincorporated areas where local communities lack the resources or capacity to develop a program. Establishing a mosquito control district creates a funding mechanism for abatement actions through the ability to assess a tax.

Mosquito control districts or even state mosquito control agencies may have been created in places where pest mosquitoes have been a historic community problem. In the absence of a district or a state program, local municipalities and county governments are responsible for mosquito control by default. Many cities and counties have funded and authorized local health agencies to control mosquitoes, while others have contracted the work to private mosquito control companies. Proponents of privatized mosquito control contend that such programs provide quick response in an emergency, workforce benefits, due to the seasonal nature of the work, and, importantly, the ability to shift liability to the private sector. However, if cities and counties do use contractors, it is important to maintain governmental agency oversight of their activities.

ENFORCEMENT AUTHORITY

All states and counties have provisions in law to deal with public nuisances, and most have provisions to declare a property a public health nuisance or hazard and require mitigation by the owner. In the case of significant mosquito breeding sites, such as tire piles, control authority is best when it is specific. Authority should include the ability to order mitigation, to levy fines if the owner is non-compliant, to allow access for surveillance and control activities, and to require the owner to reimburse the agency for the control activities.

LEGAL CONSIDERATIONS PLANNING AND ACTION CHECKLIST

- [ ] Review existing legal authorities and determine which entity or entities are authorized to conduct mosquito control activities. Are current emergency power authorities sufficient to use in an outbreak?
- [ ] Are general or specific authorities used to conduct mosquito control activities?
- [ ] Does state law expressly require property owners to undertake mosquito control and abatement activities?
- [ ] Do the authorities provide sufficient enforcement to perform mosquito control activities?
- [ ] In the event of non-compliance, can a governmental mosquito control entity act? If yes, can the entity receive compensation from the property owner for the control efforts?
- [ ] Does the agency regularly consult with legal counsel?

FUNDING CONSIDERATIONS

Communities and states have choices regarding how to fund mosquito control programs, from dedicated mill levies and surcharges on utility bills to general tax revenues and special property assessments. Each community must decide the level of funding that it is willing to devote to mosquito control, the best ways to raise these funds, and how it can sustain this funding over time. Identifying multiple funding streams allows mosquito control programs more flexibility, stability, and responsiveness in times of public health emergencies. Options for funding mosquito control activities include:

- **County and municipal general fund.** These funds can be one-time or sustaining. They usually go to a local office or agency (such as a local health department), but can go directly to a contractor for mosquito control services. A mosquito control program can seek support from multiple counties and municipalities.
- **Mill levy.** This is a property tax, generally collected through a special tax district (mosquito control district or another district), that usually requires voter approval. Mosquito control districts may have borders independent of existing political boundaries. Resources collected by local governments are published and can be monitored by control program support groups.
- **Benefit assessment.** Some mosquito control districts or other entities levy fees on property owners based on mosquito control's benefits to their properties.
- **Utility bill surcharge.** Added to consumer billing, a utility bill surcharge has low administrative overhead to collect and can often be added without voter approval. This mechanism is useful when a city or county has its own utility program, such as electricity or trash pickup.

- **State general fund.** Legislative funding can be one-time or sustaining. Sustaining funds are usually associated with a statutory statewide program.
- **Federal funds.** As seen during the WNV epidemic and emerging Zika virus threat, federal funding, primarily through CDC, may provide emergency funding to state governments, which in turn provides pass-through funding to local mosquito programs.
- **State and federal emergency funds.** Federal, state, territorial, county, and municipal governments have emergency accounts for disaster relief. Control efforts for epidemics may qualify for this source of support.
- **Private grants.** Private entities that maintain wetlands for parks or wildlife refuges may contribute to the cost of mosquito control efforts. Private grants may be available for other special areas that are potential mosquito harborages.
- **Reimbursement by government agencies.** Other government entities, especially federal agencies, can provide mosquito control funds. Agencies whose operations or land holdings add to the magnitude of a mosquito control program, such as the Army Corps of Engineers or the National Park Service, have contracted with local mosquito control programs for services.

THE COSTS OF CUTTING MOSQUITO CONTROL PROGRAMS

Stopping and starting mosquito control programs can significantly increase the costs of the program, with serious potential economic impacts for the community. In one eastern state, the public health division of mosquito control was eliminated as a cost saving measure in 1993. By 1996, towns had started creating their own mosquito control programs, but at a higher cost. Some communities hired private contractors to run mosquito control programs in recreational areas.

Other communities posted signs at parks warning that camping or user fees would not be refunded based on unacceptable levels of mosquitoes. Ultimately, the state mosquito control program was reinstated in 1997, after mosquitoes tested positive for EEE virus. In the interim, recreation, taxpayers, and public health protection suffered due to the lack of a comprehensive mosquito control program. In addition, CSTE documented nationwide reductions in mosquito control programs for the period 2004 to 2012, with lack of funding identified as the cause.[39]

FUNDING PLANNING AND ACTION CHECKLIST

- [ ] Identify funding sources that are currently available for a mosquito control program.
- [ ] Survey agencies that have successful programs to find an appropriate funding model. Talk to people who have experience in acquiring funding for programs.
- [ ] Identify the right program for the jurisdiction before asking for funds.
- [ ] Develop strong and diverse support from the community for the program. Is there a local elected or appointed official who is identified as a leader in fiscal matters who can champion the program?
- [ ] Leverage mosquito control funding by seeking funds from multiple sources.
- [ ] Seek sustained funding sources as the base for a program.
- [ ] Use scientifically sound data to support funding efforts.
- [ ] During emergencies, determine in advance if funds can be temporarily diverted from a lower priority program.
- [ ] Determine if there is an existing special district (e.g., park district) that might be used to carry an additional program to control mosquitoes.

WORKFORCE AND TRAINING CONSIDERATIONS

Effective response to a mosquito-borne illness or any environmental public health emergency requires a team that possesses both technical and communication skills and understands how to share scientific information in terms that the public can comprehend. Mosquito control-related workforce and training considerations include:

- **Certification for applicators and supervisory personnel.** Individuals who apply pesticides should have the appropriate certification from the responsible state agency (usually a public health certification from a state department of agriculture). Supervisory personnel benefit from being certified.[40] AMCA and many state and regional mosquito control associations produce and distribute **training manuals** for pesticide applicator certification.

- **Hiring experienced entomologists.** At least one individual must be available who has a thorough background in mosquito biology and identification and can identify all common species occurring locally.

- **General training in mosquito biology and control.** All technical staff must have sufficient understanding of the biology of mosquitoes so that they can perform the activities associated with surveillance and control. Such training is often available through government agencies, state or regional mosquito and vector control associations, university extension, or commercial sources, including online and home study courses.[41, 42, 43]

- **Specialized training.** Individuals who take blood samples from sentinel chicken flocks or wild birds must have appropriate training, and special permits or licenses are required for wild bird sampling. It is highly advisable for mosquito control programs to hire an individual who can perform insecticide resistance testing. Other useful professionals include media and public relations specialists, geographic information system technicians, and ecologists and biologists.

- **Hiring a zoonotic disease epidemiologist.** This individual will track human and animal cases through case reporting systems ad map the results of mosquito pool testing. This individual is responsible for analyzing the data and recommending necessary mosquito control actions. Such positions are usually housed in state public health agencies.

- **IMM training.** IMM uses methods to control mosquitoes based on an understanding of mosquito biology, the mosquito life cycle, and the way mosquito vectors spread viruses in order to develop plans for controlling them. IMM uses methods that are safe and have been scientifically proven to reduce mosquito populations.

WORKFORCE TRAINING PLANNING CHECKLIST

- [ ] Identify the staffing and expertise needed for a comprehensive mosquito control and surveillance program. Differentiate between full-time and temporary worker responsibilities.
- [ ] Identify skill levels for each worker and compare those to the job responsibilities being assigned to the person. What qualifications are necessary to compose a well-rounded team that will have public support? Make sure that properly credentialed persons are filling roles appropriate to their skills, knowledge, and abilities.
- [ ] Determine who will make up the primary response team and how they will be selected. Will staff be paid, voluntary, or both?
- [ ] Determine if the government agencies responsible for the program have adequate staff, equipment, and other resources. If needed, investigate the use of private contractors.
- [ ] Confirm that the personnel system is equipped to handle the staffing and expertise needed for the program and for maintenance of other programs impacted by mosquito control demands.
- [ ] Determine how to incorporate temporary personnel if they will be used to implement a mosquito control program. How will they be paid? What skills and professional disciplines will be required of temporary personnel?
- [ ] Establish an organizational chart specific to the response action.
- [ ] Determine a communications protocol for releasing technical information and educate all staff about the process.
- [ ] Consider opening training opportunities to laypersons from the community who can represent and advise on public interests.
- [ ] Investigate potential liability issues when using volunteer or contract workers.
- [ ] Implement an accounting system to keep track of all the resources used, including paid and volunteer staff.
- [ ] Create an evaluation process for private contractors and incorporate that evaluation into the contracts.

PROGRAM EVALUATION CONSIDERATIONS

The time to develop protocols for evaluating a mosquito control program's success is during the planning process, as it's easiest to collect the data needed for evaluation before mosquito control activities begin. Program evaluation goals should focus on program improvement and enhancing the program's credibility with the public, supporters and funders, and other stakeholders. Effective evaluation initiatives document how well the program performed, providing data that can be used to support sustainable funding and counter unsubstantiated objections. There are many tools available for developing mosquito control program assessments, and they feature measures for evaluating both program performance and the ultimate outcome measures used for mosquito-borne disease surveillance.[44]

At least three components of mosquito control programs warrant inclusion in the evaluation plan: public response, technical issues, and legal issues:

Public response.
Surveys can help determine if stakeholders (residents, visitors, elected officials, interest groups, and the media) felt included in the mosquito control decision-making process. (E.g., Were they listened to? Were their ideas acted upon? If not, were they satisfied with explanations for why other measures were enacted instead? Did elected and appointed officials receive sufficient information to make good decisions?) In addition, surveys can be used to determine compliance with mosquito control recommendations. (E.g., Did residents drain standing water on their property and remove water from containers that support mosquito breeding? Did they use insect repellent? Did farmers immunize their livestock?)

Technical response.
Evaluating the technical aspects of mosquito control programs can be difficult due to the number of issues that can impact such assessments. Assessments of surveillance, epidemiology, medical interventions, and IMM may each require their own evaluation measures.

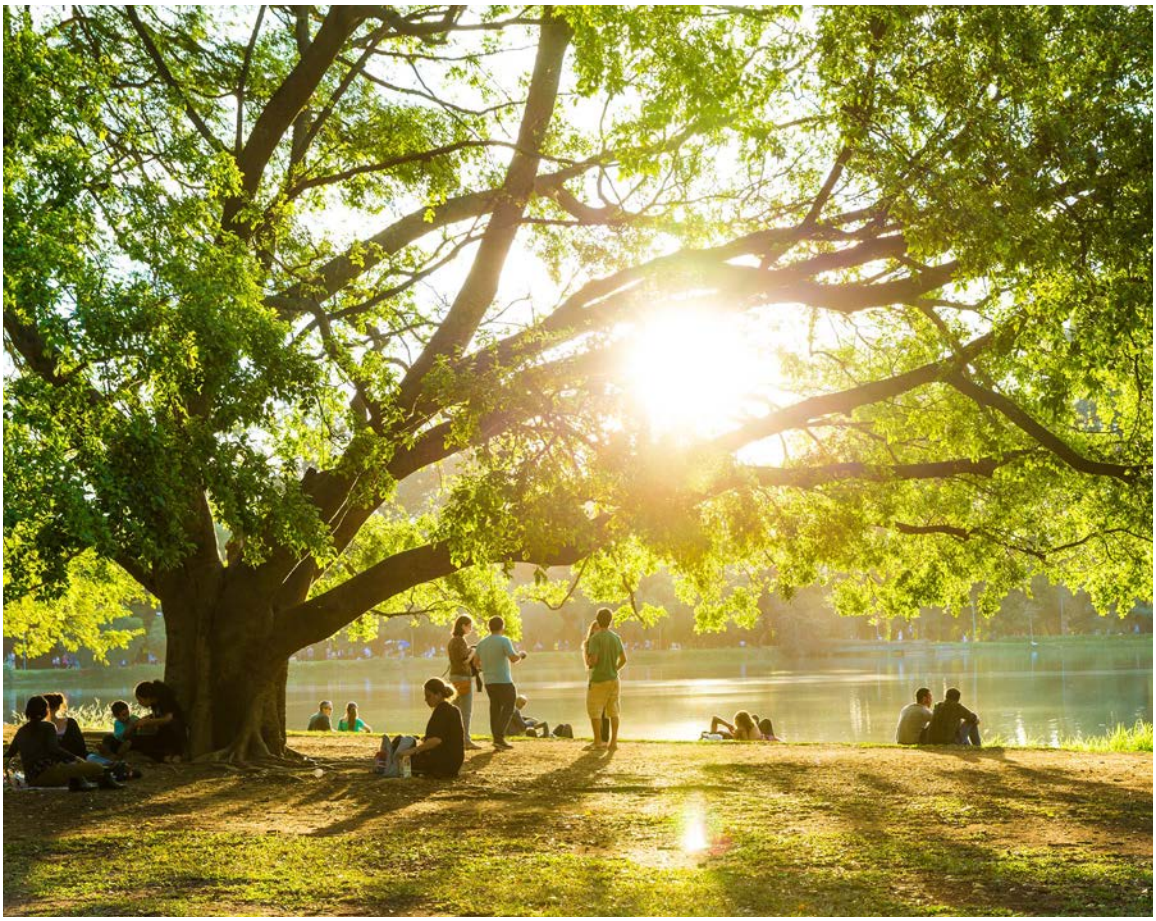
Legal issues.
Evaluating a mosquito control program's legality can confirm whether or not mosquito control activities were based on proper use of existing legal authority. For example, did those with the authority reach beyond the margins established by the law without properly following legal protocol? Were those in charge able to use their authority to its fullest extent for successful program implementation? Was the intent of the law applied, and was it adequate to meet intended consequences? Were enforcement activities supported or hindered by existing legal authority?

EVALUATING PROCESSES VS. OUTCOMES

Process evaluation measures are based on how many or how much was done and how much it cost. Schematics of inputs and outputs can be useful tools for process evaluation and to answer questions related to budgets, staffing, surveillance, areas covered by control activities, and public complaints.

Outcome evaluation measures can be used to address concerns about the risks of mosquito-borne illness. Outcomes can include data on changes in mosquito populations, complaints, and infection rates, including:

- The average percent reduction in numbers of mosquito larvae based on pre- and post-treatment assessments. (Evaluating adult mosquito control is also desirable but can be expensive and is more difficult to do because of mosquito movement from outside the control area.)
- A reduction in numbers of mosquito complaint calls compared to previous years, to the long-term average, or to neighboring areas without mosquito control.
- Changes in infection rates for humans and susceptible livestock or pets.



EVALUATION PLANNING AND ACTION CHECKLIST

General evaluation considerations:

- [ ] Determine who will perform the mosquito control program evaluation.
- [ ] Identify the criteria to be used to measure pre- and post-program activities.
- [ ] Decide how the evaluation outcomes will be used to improve program success.
- [ ] Develop evaluation outcomes that are transparent and can be openly communicated to the public.
- [ ] Create a flexible evaluation tool amenable to programs as they evolve.
- [ ] Identify measures of program performance that the public can understand.

Public response:

- [ ] Include recognized community leaders in mosquito control program evaluation activities. (Leaders may include members of the media, stakeholder groups, and citizen representatives.)
- [ ] Create a feedback mechanism to determine how the public feels about its role in the decision-making process.
- [ ] Establish a follow-up mechanism (e.g., a survey) to determine the success of volunteer efforts.
- [ ] Determine the success of mosquito control public education and outreach campaigns, especially regarding compliance with recommendations.

Legal issues:

- [ ] Inventory all applicable statutes, laws, ordinances, rules, and guidelines that give authority to perform a mosquito control program.
- [ ] Determine if the existing laws are sufficient to support program activities.
- [ ] If existing laws are not adequate, investigate the changes needed to perform the program functions.
- [ ] Evaluate any prior implementation of the laws and review any legal challenges or decisions involving mosquito control activities.

Technical issues:

- [ ] Create a peer review process of scientific data and recommendations.
- [ ] Determine compliance with communication protocols for effectively releasing technical information.
- [ ] Track resources used for the program.
- [ ] If the mosquito control program used private contractors, create an evaluation process for assessing their performance and incorporate measures into bids and contracts.

SECTION 5

Building Relationships and Public Support

INTRODUCTION

Positive relationships between key stakeholders and mosquito control programs can be the foundation for successful mosquito control activities. Identifying these key individuals, involving them early in the mosquito control planning process, and ensuring that they have the information they need to make informed decisions and contributions to the program are essential to building support for a successful program.

The public health response to the threat of Zika virus clearly demonstrated the value of such partnerships: mosquito control programs unaccustomed to dealing with sexual transmission of Zika and the potential impacts on fetal development relied on partnerships with government programs and private sector clinicians to respond to this threat. An example of this includes **Florida's Zika Incident Response Playbook**.

Mosquito control programs also need broader support from an informed public. Open communication with the public shows a respect for the community that will lead to a stronger, better supported program that is tailored to the needs and values of the community. Open communication requires both listening to public concerns about mosquito populations and control methods and informing the public about the risks of mosquito-borne disease and how to reduce these risks. The stakeholders included in mosquito control activities can be vital conduits for public communication.

FORUMS FOR INVOLVING OTHERS

Creating a task force or advisory committee is a common method of involving others in mosquito control activities. Membership can include individuals from other agencies, neighboring jurisdictions, stakeholders directly impacted by mosquito control activities, representatives from advocacy groups, and members of the public. Public health officials and county extension agencies, with their links to university researchers, can also provide credible scientific, technical, and medical information related to treating mosquito-borne diseases and supporting decisions regarding mosquito control activities. These decisions, like all potentially controversial and important public decisions, are made in a political environment. Elected officials can benefit from support from credible task force experts when under pressure as they deal with options for the communities they represent.

When there is disagreement over the proper course of action to address a public health situation, task forces or advisory committees can provide a forum where advocates and opponents can voice their concerns. Public listening sessions, information-sharing open houses, or focus group share sessions may work better than the traditional public meeting, where a lecture-and-Q&A format can set the stage for grandstanding or heated exchanges that undermine efforts to build good personal and professional relationships with key stakeholders.

Outreach that discusses prevention activities alongside a clear definition of the problems that mosquitoes present to a community can be the basis for building positive relationships with affected communities. Even when a community has diverse opinions about appropriate mosquito control methods, developing understanding about the nature of the problem promotes positive discussions about how these problems are best prevented. Agreement about low-impact prevention methods among stakeholders can be the basis for future discussions, should these prevention measures prove inadequate to control mosquito populations.

SUCCESS STORY:

Public Engagement

In Long Beach, California in 2016, enlisting the public's help to prepare for the possibility of local Zika transmission proved to be very valuable to the mosquito control program. Although *Aedes* mosquitoes had not been detected in past surveys of Long Beach, several factors made this area high risk for local transmission, including population density, a high volume of travel to and from Zika-affected areas, and an increasing presence of *Aedes* mosquitoes in neighboring towns. The Long Beach Zika preparedness plan enlisted public participation to (1) identify if *Aedes* mosquitoes were established in Long Beach and (2) educate and prepare Long Beach residents in the event of local Zika transmission.

Residents were encouraged to call the Zika Hotline to report day-biting mosquitoes. Outreach strategies to promote the hotline and educate the public included a social media campaign, billboards on main freeways, messages in the city's utility bill, distributed Zika prevention kits, and short Zika-related films aired on public television. Hotline reports directed trapping efforts, which identified *Aedes aegypti* mosquitoes in several Long Beach locations. The city conducted a Zika Community Assessment for Public Health Emergency Response (CASPER) in July 2017, which showed that 48 percent of households were aware of the Zika hotline and 82 percent of households in Long Beach had strong knowledge about how to protect themselves from mosquito-borne disease, including Zika.

COMMUNICATION CHALLENGES

There are many communication challenges related to mosquito control but developing a communication plan helps take the guesswork out of what to say and how to say it. Communications plans create a methodology for identifying, anticipating, and responding to challenges in a proactive manner that promotes and supports community involvement.

Common communication challenges include:

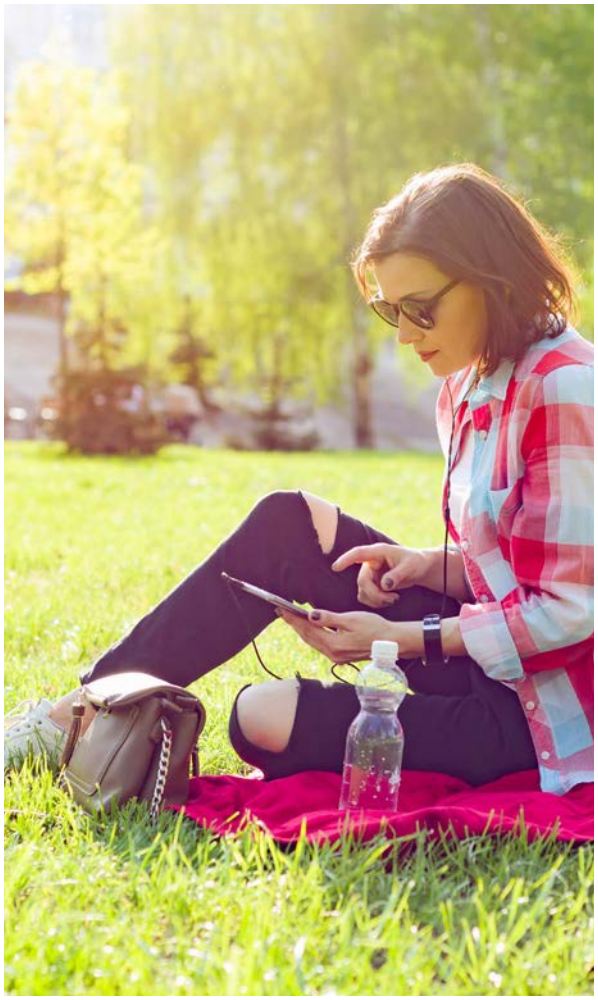
- Educating policymakers and gaining their support for policy issues.
- Informing the public about mosquito control generally.
- Instructing the public about preventing exposure and reducing risk.
- Educating the public about a permanent mosquito control strategy.
- Responding to a public health crisis related to mosquito-borne disease.
- Informing the public of pesticide risks and benefits.
- Informing the public about using and timing pesticides in their community.
- Gaining financial support for mosquito control.

For each of these challenges, mosquito control programs can benefit from knowing who in the community is likely to support or oppose the program's activities, and why. Developing a relationship with these advocates and opponents often establishes a foundation for effectively communicating and developing community-based solutions.

Mosquito control programs need to identify a credible spokesperson who is amenable to both advocates and opponents. This may be a local public health official or someone from academia, the medical community, or another individual knowledgeable about mosquito control issues. During public health emergencies (e.g., during a mosquito-borne disease outbreak), the lead agency for a local mosquito control program needs a public information officer who can work with stakeholders to develop materials, inform the media, respond to questions, and network with information officers in related organizations, such as emergency medical services, hospitals, a county or city manager's office, and state officials. Note that successful communication strategies address both how to disseminate information and how to gain public input.

CREATING EFFECTIVE MESSAGES

Effective public outreach campaigns use messages that are simple and memorable. Many states have already initiated successful public health campaigns, such as the 2003 "**Fight the Bite**" campaign. Some states such as Hawaii and Colorado have modified and relaunched their campaigns to emphasize newly emerging mosquito-borne disease, while other states established campaigns that specifically address the threats of Zika, including "**Drain and Cover**" and "**Fight Back NYC.**"



OTHER FEATURES OF SUCCESSFUL CAMPAIGNS INCLUDE:

- Websites, public service announcements, social media posts, and information hotlines that educate and involve the community in the mosquito control program.
- Establishing multiple ways of reaching people—at home, school, work, shopping areas, and places of worship.
- Succinct public messages that emphasize prevention as the best protection against illness.
- A proactive editorial calendar where messages are written, timed, and scheduled in advance for use across multiple traditional and social media platforms.
- Programs and messages that are sustained even in the absence of mosquito-borne illness in the community.

CHECKLIST FOR INVOLVING OTHERS IN MOSQUITO CONTROL ACTIVITIES

General stakeholder considerations:

- [ ] Consider how elected officials and their appointees will work collaboratively to address the problem. How will agencies work with elected and appointed officials?
- [ ] Determine how collaborating government officials and agencies will enlist citizens in the decision-making process and create a fluid mechanism that will ensure timely task completion.
- [ ] Determine how divergent views will be addressed and resolved.
- [ ] Determine how to choose leaders of advocacy groups and those opposed to mosquito control activities to sit at the negotiating table.
- [ ] Once all parties reach an agreement, decide how to communicate the message to the public to maintain support when the jurisdiction implements its control plan.

State actions:

- [ ] The lead agency for mosquito control should develop a planning process to gain input and support for the control plan. This may include stakeholder meetings, surveys, regional focus groups or town meetings.
- [ ] The lead agency should identify other stakeholders to include in statewide planning efforts, such as:
    - Elected and appointed officials, including from such boards and committees as state boards of health.
    - Representatives from other state or federal agencies (e.g., public health, environmental protection, natural resources, agriculture, emergency management, and the military).
    - Representatives from conservation groups focused on land, water, or air.
    - Individuals from statewide organizations representing local government (e.g., counties and municipalities).
    - Representatives from business and industry (e.g., agriculture, tourism, medical/hospital, veterinary, and pest control).
    - Representatives from public health (e.g., from public health associations, environmental health associations, and local health departments).
    - Individuals from recreation groups (e.g., from fishing, outdoor sports groups).
    - Statewide media.
- [ ] Consider input from members of private and quasi-governmental agencies, such as special districts, as experts in a particular function of the program.
- [ ] Develop partnerships with land grant universities and medical and veterinary schools that have mosquito expertise and research and outreach capabilities.

- [ ] Complete a plan for mosquito control and disseminate it to all state and local stakeholders.
- [ ] Develop mutual aid agreements or memoranda of understanding with all partner city and county agencies, states, and countries.
- [ ] Establish a response system that is universally accepted and can be understood by all participants in the project during an epidemic. Look to existing response systems such as the Incident Command System as an option to manage the event during an epidemic.
- [ ] Evaluate the success of mosquito control strategies and identify plans for addressing emerging issues.

Local actions:

- [ ] Identify the lead agency for mosquito control at the local level.
- [ ] Review state plans and consult with the lead state agency for mosquito control.
- [ ] Identify jurisdictional boundaries and forge mosquito control partnerships with neighboring counties and municipalities.
- [ ] Develop and implement a plan for stakeholder participation and community awareness. Key elements should include:
    - Identifying champions for mosquito control who are willing to serve as advocates and spokespeople in their legislative bodies.
    - Developing briefing materials on historical approaches to mosquito control; current surveillance data; lists of key constituency groups; best practices from similar jurisdictions; financial, legal, and regulatory options for local plans; and public awareness campaigns for local officials.
- [ ] Develop methods for stakeholder participation that may include surveys, focus groups, telephone polling, public meetings, and roundtable discussions.
- [ ] Create mailing and email lists to provide additional points of contact and discussion among community stakeholders.
- [ ] Identify a primary spokesperson to inform the community about implementation of a mosquito control plan and to address issues and concerns regarding spraying and, if necessary, the presence of mosquito-borne disease.
- [ ] Work with the local media to develop public information strategies and assist with campaigns to prevent mosquito-borne illness and promote community understanding and acceptance of the mosquito control program.

CHECKLIST FOR INFORMING THE PUBLIC ABOUT MOSQUITO CONTROL

- [ ] Develop an information exchange process that will keep the public in tune with decisions and anticipated actions.
- [ ] Determine who should be included in the public information network to plan for the information campaign(s). (E.g., Which sister agencies or neighboring jurisdictions need to be involved? Who are the spokespeople?)
- [ ] Decide if there will be a proactive media campaign prior to mosquito season.
- [ ] Determine who will develop and update websites and which links will be established and referenced.
- [ ] Decide what specific information can be given to the public about the use and timing of pesticide applications.
- [ ] Identify language barriers that need to be considered when developing campaigns.
- [ ] Anticipate differing opinions and develop outreach strategies to bring objections into the program, developing alternatives where you can.
- [ ] Establish a follow-up mechanism, such as a survey, to determine the success of education and outreach.
- [ ] Designate a spokesperson to handle medical questions and work with the coroner's office and hospitals if death and/or illness occur.
- [ ] Prepare factsheets for physicians and the public.
- [ ] Educate decision-makers.
- [ ] Maintain statewide data and coordinate information campaigns with a single, unified public message about preventing mosquito-borne illness.

SECTION 6

Using the Best Science

INTRODUCTION

Prevention activities provide the foundation for effective mosquito control. It is critical that science drives state and local needs assessments, strategies to prevent mosquito nuisance and mosquito-borne disease, and mosquito control program design and monitoring. Scientists and other experts learn more about mosquito control and disease transmission each year, and historical lessons and current best practices must guide mosquito control program development, implementation, and evaluation.

Many proven methodologies and practices guide the best mosquito control programs. However, all mosquito control programs need to be based on an identified need that matches state and local resources and technically sound strategies (recognizing that there may be gaps in knowledge in some areas, such as outcome evaluations).

Contrary to IMM's evidence-based practices, there is little evidence that focal or homeowner-based mosquito control strategies contribute to the public health objectives of community-wide mosquito control programs. Backyard mosquito control equipment and technologies and other focal control strategies for delivering short-term, transient declines in adult populations do not adequately address the need for surveillance, monitoring, source reduction, or larval control—all basic components of IMM. In addition to not providing area-wide protection, focal strategies are usually more expensive than the annual per person cost of organized mosquito control and may contribute to unintended consequences of mosquito control (e.g., pesticide resistance in mosquitoes and adverse impacts on pollinator populations).

SCIENTIFIC BASIS FOR MOSQUITO CONTROL

Surveillance activities provide much of the scientific basis for mosquito control. Surveillance activities include monitoring virus activity levels, vector populations, infections in vertebrate hosts, human cases, weather, and other factors to detect or predict changes in the arbovirus transmission dynamics. It's not usually possible for a single agency to collect all of this information, making it extremely important that the various data-collecting agencies actively communicate and exchange information.[45]

EPIDEMIOLOGY AND HUMAN DISEASE SURVEILLANCE

Epidemiologists at local and state health agencies and CDC work cooperatively to monitor mosquito-borne illnesses. Monitoring the timing and distribution of both human and animal cases of mosquito-borne illness provides the basis for measuring mosquito-borne disease impacts.[46] Human case surveillance for mosquito-borne disease involves receiving and recording reports of illness; confirming diagnoses; interviewing doctors and patients to determine the timing, geographic location, and conditions of infection; and scientifically analyzing the accumulated data.

Zoonoses are different from human-to-human diseases because they involve other animal hosts and, frequently, insect or tick vectors. Most zoonotic pathogen transmission takes place out of sight of, and physically removed from, humans. However, attacking the zoonotic cycle is an important way of reducing disease threat for humans and domestic animals. By the time these diseases are detected in the human population, it is often too late to have any impact on the transmission cycle; in fact, the zoonotic portion of the cycle may already be declining when human cases appear. At that point, the only effective strategies are avoidance, personal protection, and chemical control of the adult vectors (mosquitoes, in this case).

ANIMAL HOST DISEASE SURVEILLANCE

Reporting systems for tracking only human cases are inadequate for informing programs to control mosquito-borne disease.[47, 48] For example, monitoring equine EEE cases and avian WNV cases are essential to establishing early trends and allowing reasonable response times for control activities to limit the spread of disease to human populations. Reporting systems for animal cases rely on data from veterinarians, laboratories, wildlife agencies, agriculture agencies and organizations, and the public. Maintaining these reporting systems requires collaboration between the groups reporting zoonotic cases, state and territorial health agencies (S/THAs, and the medical community. S/THAs provide important services to the medical community and the public, including defining the parameters of reportable cases and keeping physicians informed of changes in case definitions, transmission routes, and treatment regimes. S/THAs also develop guidelines and factsheets on clinical features and treatment for physicians and personal protection guides.

MOSQUITO BIOLOGY AND ECOLOGY

A quality mosquito control program has at its foundation a solid understanding of the ecology of the area and the biology of the mosquito species that occur locally. This includes such information as when and where the mosquito larvae are found, where the adults rest, what time of day the adults look for a blood meal, which vertebrate species are important hosts, and what control measures are most effective against each mosquito species. In addition, an understanding of the biology of bees and other pollinators is essential to minimizing the unintended negative impacts of mosquito control activities.

MOSQUITO HABITAT AND PHYSICAL SURROUNDINGS

Much of the information needed for mosquito control activities (e.g., topography, temperature, rainfall, roads and streets, housing, population, and local mosquito species) is linked to a physical location, making it useful for the mosquito control program to have mapping capabilities. This can often be done by coordinating with another city or county department that already has a geographic information systems (GIS) section or activity.

Alternatively, mosquito control programs can use inexpensive software programs like CDC's free software package EpiInfo, which also contains a simple GIS program, EpiMap.xlvi10. EpiInfo can also be used to design data collection forms and data entry screens and provide elementary graphing capabilities. Maps provide useful information about target areas for mosquito control and also note environmentally sensitive areas that may be inappropriate for some type of control activities (e.g., applying adulticides). More recently, open-source GIS and spatial analysis freeware has become widely available. Groups such as the Free and Open Source Software for Geoinformatics consortium have concentrated on perfecting software packages such as GRASS and QGIS.[49, 50]

Habitat mapping. The off-season is a good time to map larval habitat locations within the mosquito control district. Using topography overlays is essential to any mapping program used by mosquito control, as they can characterize ecotypes consistent with oviposition (laying eggs). It may also be useful to map major sources of mosquitoes that may be located outside the boundaries of the control district, if these are known or suspected sources of problems during the mosquito season.

SURVEILLING MOSQUITO POPULATIONS

Effective mosquito surveillance and monitoring strategies are based on data about the ecology of the area, the mosquito species present, vertebrate hosts, and the disease agents likely to be found. This information will set most of the parameters for the surveillance system. In addition, data on non-target species, such as pollinators, can inform simple adjustments to mosquito control strategies and help protect these beneficial insects.

Adult mosquito population surveys. Information on adult mosquitoes, the species present, and their abundance and seasonal variation is central to a mosquito control program. Initial surveys will begin to show the pattern of dominant species and their seasonal and spatial distribution. Over time, programs will be able to compare current collections to longer-term average (i.e., 10 years) collections and begin to predict potential problem situations.

In general, adult mosquito collections (i.e., those collected from light traps, gravid traps, and BG Sentinel traps) are highest when traps are placed in an ecotone (i.e., the junction between two habitat types, such as forest and grassland or parkland and urban housing). Note that this is different from placing traps to detect the emergence of adult mosquito emergence from larval habitats.

Mosquito infection rates can be an important indicator of the magnitude of a disease threat. Surveilling mosquito pools for the presence of zoonotic viruses (e.g., Highland J virus) may provide an indication of the likelihood of the threat of other human pathogens.

Surveys of eggs, larvae, and pupae stages. Egg monitoring is confined mainly to the genus *Aedes*, whose eggs resist desiccation and can be collected and identified. Mosquito larvae population surveys indicate whether thresholds have been exceeded regarding health threats or nuisance conditions. Surveys conducted both before and after larval habitat treatment provide the data needed to determine treatment effectiveness. Controlling larvae instead of adult stages is more common because it is easier to do and less toxic to non-target species.

Seasonal characteristics. Surveillance activities vary with the seasonal fluctuations in mosquito populations, and can be characterized as early-, mid-, and late-season activities. (Note: this occurs even in territories or areas of the continental United States where adult mosquitoes are present year-round.)

After collecting surveillance data for several years, mosquito control programs can create graphs of the average weekly abundance of mosquitoes by species. When the current counts for a target species rise above the long-term average, this may indicate an emerging problem. It can be helpful to plot the relationship between mosquito species abundance and seasonal climatic factors such as temperature and rainfall.[51, 52] In some cases, it may be possible to anticipate increasing mosquito numbers or elevated disease risk based on weather patterns.

Surveilling mosquitoes for disease vectors. Placing traps for disease vector surveillance should be informed by the ecology of the target mosquito/virus. For diseases of peridomestic mosquitoes (those that live near humans), trap placement should focus on areas where people congregate. Programs can also consider WNV activity, roosting or nesting habitats of the bird hosts, and habitats of other mammalian hosts when deciding where to place traps.

METHODS FOR MOSQUITO CONTROL

The following are primary methods for monitoring and controlling mosquito populations. As Table 3 shows, mosquito control programs should use the mosquito sampling methods specific to each mosquito development stage.

METHODS FOR MONITORING AND SURVEILLING MOSQUITO POPULATIONS

STAGE	METHOD
Egg	CDC Ovitrap and similar devices. (Appropriate for aedine species with eggs resistant to desiccation.)
Larvae and pupae	Opening water sampling: "dipper" method. Peri-domestic breeders: Container sampling.
Adult	Open habitats and forest margin: • NJ light trap • CDC light trap (with additional attractant) • CDC gravid (Reiter) trap Peri-domestic species: • BG Sentinel trap • Gravid *Aedes* trap • Battery-powered aspirator

TABLE 3:
Examples of mosquito sampling methods by life stage.

Egg monitoring is confined mainly to the genus *Aedes*, likely because aedine mosquitoes have desiccation-resistant eggs that can be collected and identified. Oviposition of container-inhabiting *Aedes* mosquitoes can be monitored with a variety of devices.[53, 54] The CDC Ovitrap was developed in 1966 during the U.S. *Aedes aegypti* Eradication Program.[55, 56]

With the arrival of spring warming and rain or flooding, *Aedes* and *Ochlerotatus* eggs will hatch, and dormant *Culex* females will emerge, take a blood meal, and begin laying eggs. This is the time to begin monitoring larval populations. Monitoring methods include open-water larval surveillance, using the "dipper" method, and sampling for container-inhabiting *Aedes* and similar peri-urban species.[57] Mosquito control programs should determine triggers for control action (i.e., how many larvae per dip represent a health threat or a nuisance problem?).

Several indices can reflect the level of infestation based on the intensity of larval infestation:

Container index:
The percent of containers positive for the species of concern.

House (or premise) index:
The percent of houses in the survey area that are positive for the species of concern.

Breteau index:
The number of positive containers per 100 houses surveyed with the species of concern.

Mosquito control programs can regularly use light traps, gravid traps, or similar methods to monitor adult mosquito abundance. The control program should determine triggers for control action (i.e., how many females per trap night of a particular species pose a health threat or a nuisance problem?). No one type of trap will adequately sample all species of mosquitoes, so ideally, programs should use at least two types of adult sampling methods (e.g., CDC light trap and BG Sentinel trap or CDC light trap and gravid trap). Because there are literally hundreds of different sampling tools to collect mosquitoes, this document will only touch on a few of the most common tools, listed below.

Open habitats and forest margin species (including Culex, many Aedes, and Psorophora):

- NJ light trap[58]
- CDC light trap (with the later addition of dry ice [CO_2] to improve the catch)[59]
- CDC gravid (Reiter) trap[60]

Peri-domestic species (including *Aedes aegypti* and *Aedes albopictus*):

- BG Sentinel trap
- Gravid Aedes trap
- Battery-powered aspirator[61]

DISEASE SURVEILLANCE IN HUMAN, ANIMAL, AND MOSQUITO POPULATIONS

Mosquito pools. For some vectors, laboratory analysis of mosquito pools for viruses provides data to support mosquito control activities. Test kits are also available for performing virus testing when laboratory support is not available.[62, 63] CDC also provides funding for infectious disease threats, such as Zika, tickborne disease, and mosquito-borne disease, through the Epidemiology and Laboratory Capacity for Infectious Diseases Cooperative Agreement.[64]

Animal hosts. Animal hosts (e.g., dead birds as indicators for WNV) can be monitored for evidence of virus activity. This may include simply recording and mapping the locations of dead birds reported by the public. A state laboratory or other facility may be able to perform virus testing on dead birds or may provide test kits for jurisdictions without elaborate laboratory facilities. Please note that infection in domestic animals (e.g., EEE in horses) is an indicator of a serious risk to humans that warrants additional mosquito control actions (see Appendix A).

Human disease. Jurisdictions can measure the impacts of mosquito-borne disease by monitoring the timing and distribution of human cases.

SPECIFIC METHODS FOR CONTROLLING MOSQUITOES

Public education.
Public outreach and education are methods for raising awareness about the responsibilities of each member of the public in evaluating their own backyards for mosquito breeding sites and taking measures to prevent mosquito bites. The public can also participate in informing local health agencies of bird deaths. Public awareness and support for mosquito control programs is critical to their function. Sustained and dependable funding supports the year-round activities necessary for effective mosquito control. In addition, public outreach and education campaigns can help eliminate backyard mosquito breeding sites. Many types of outreach materials, from traditional public information brochures to electronic formats for social media campaigns, are available from CDC, AMCA, and from state and local health departments. Control programs can also raise public awareness by distributing information through mailings (e.g., monthly utility bills or other community mailings), teaching materials for K-12 grades, communications to citizen action groups and agricultural extension agents, and presentations to civic groups. Including local media in awareness campaign enhances extends their reach.

Source reduction by eliminating mosquito larval habitats.
Source reduction includes clearing stream channels, tire amnesty programs, and other community cleanup activities, which can help eliminate larval habitats from backyards, commercial sites, and abandoned premises. Communities can enlist service groups (e.g., Rotary, Lions, Kiwanis, and 4-H clubs), churches, and scouting programs to increase public awareness and support cleanup programs.

Larval control.
Most mosquito control is done once larvae appear early in the season, but some areas can be treated before they become flooded by spring rains or runoff. Efforts should concentrate increasingly on eliminating potential disease vector species' larval habitats. "Biological pesticides" such as *Bacillus thuringiensis var. israelensis* and *Lysinibacillus sphaericus* are effective mosquito control agents. Larvicidal oils and monomolecular films cover the water surface and prevent the larvae and pupae from breathing. Growth regulators, such as methoprene, affect mosquito larva development, preventing adults from emerging from the pupae. If circumstances allow, using biocontrol agents, such as mosquito eating fish (*Gambusia* spp. and others), copepods, or other agents, can help balance out a good control program. Pre- and post-treatment surveillance can assess how well your larval control program is working.

Adult control.
Mosquito control programs can use chemical pesticides (adulticides), usually applied as ultra-low volume sprays by truck- or aircraft-mounted equipment, to control threats of mosquito-transmitted illness. Because adulticiding can be a divisive issue in many communities, its use should be clearly justified through a decision matrix that specifies what data (e.g., recent temperature and rainfall, mosquito density, and levels of virus transmission in sentinels) will trigger a given level of response (see Appendix A). The decision matrix helps policymakers avoid indecision and provides justification and confidence for a specific course of action. Prior to applying any adulticides, it is necessary to perform pesticide resistance testing to determine if the treatment will be effective.[65]

Mapping the problem.
All aspects of the area should thoroughly be mapped, preferably using modern GIS technology. Much, if not all, of the background data and imagery are available at little or no cost. Once the initial effort is completed, all future information—including larval inspections, complaint calls, source reduction work, adulticiding routes—can be recorded in precise spatial locations. Simple routines are available for **cell phones** to enter data for premise inspections and source reduction projects. The different classes of information can be linked spatially to get a better understanding of the ecology of vector and pathogen, leading to better prevention and control decisions.

Use area maps to indicate treated and untreated areas and specify reasons for not treating an area (e.g., the area is environmentally sensitive, the community opted out, it's outside the district boundary, or there are no mosquitoes). Record environmental parameters, such as temperature, wind speed, and wind direction, during each application.

Closely monitor adulticiding operations and be sure to assess their efficacy via pre- and post-treatment trapping, landing counts, or other techniques. Be sure to monitor all relevant application parameters (e.g., droplet size and flow rate) in accordance with the product label and appropriate federal or state regulations.

Biologically controlling adult mosquitoes using predators (e.g., dragonflies and bats) has not proven to be effective.[66] However, novel biological control techniques, such as releasing *Wolbachia*-infected mosquitoes or sterile males, were tested in Florida Keys in April 2017. Although their effectiveness is still being evaluated, these new control techniques could become a component of an IMM control program once jurisdictions address significant developmental, logistical, and public acceptance issues.[67, 68]

BUILDING A MOSQUITO CONTROL PROGRAM

Below, we discuss ways to phase in mosquito control programs based on three tiers of available mosquito control resources: Level I (little or no resources), Level II (moderate resources) and Level III (full resources).

PLANNING A MOSQUITO CONTROL STRATEGY

Communities need to define their desire and need for mosquito control before they create mosquito control programs. A scientific response to combat a nuisance mosquito species may look very different from a program to combat mosquitoes carrying disease, although some nuisance mosquitoes, like *Aedes vexans*, are occasionally involved in disease transmission.

As too many agencies across the United States have learned in the wake of WNV, mosquito control programs can't be created at a moment's notice. As detailed in the Planning section of this document, effective, efficient, and publicly-embraced programs need to be developed and initiated well in advance of a disease outbreak or post-disaster mosquito control emergency.

Communities need help assessing their existing and necessary scientific and technical infrastructure for a program. They should be educated about available proactive and reactive mosquito control options and models of successful programs that they can weigh against their resources. They also need information about minimum criteria and standards for programs with limited resources, along with timely and site-specific threat assessment models.

MANAGING AND STAFFING A MOSQUITO CONTROL PROGRAM

Communities with limited to moderate resources will have some capacity to conduct mosquito control activities but cannot mount a comprehensive program. In this situation, jurisdictions often wonder, "Should we use a contractor, or should we develop an in-house program?" The answer depends on the knowledge and training of individuals in the local health or public works department (or mosquito control program, if one is being developed) the size of the community and proximity to other communities (with or without existing mosquito control programs), regional ecology, and level of public support.

In the absence of existing local expertise, it may be advisable to use a reliable contractor or, if feasible, form a collaborative with an adjoining county, parish, or municipality with a successful existing mosquito control program. However, regardless of whether contractors or agency staff will conduct mosquito control activities, effective programs need a clearly-defined statement of services or deliverables and a clear performance evaluation document that discussed the activities that will be performed, the needed resources (e.g., equipment, staff, and insecticides), how often inspections will be conducted, how the program will be evaluated, and what happens in the event of non-performance. The end objective is to have an IMM program that relies on a thorough understanding of the ecology of the area mosquitoes, the extent of the disease threat or nuisance problem, and the community's history.

A PHASED APPROACH TO BUILDING A MOSQUITO CONTROL PROGRAM

Once the community has decided to develop an organized response to a mosquito or mosquito-borne disease problem, it is necessary to decide the type of response and the magnitude of the effort. These decisions will be impacted by a variety of considerations, such as the severity of the problem, the community's financial resources, public perceptions and attitudes, and available technical expertise.

A primary focus of an IMM effort is to define the range of options for local mosquito programs from the simplest (but still effective) program, to the ideal program where resources are not the primary limiting factor. The options discussed below can be used by both state and local governments, depending on jurisdictional funding and support mechanisms. This document assumes that the programs described focus on both disease vector control and nuisance control. It also assumes that the area needing protection has already been defined through some process (e.g., buffers around the community or a city/county boundary).

The following options describe three mosquito control program levels. Level I and Level II describe programs that require additional program development before being considered competent or fully capable. Most U.S. mosquito control programs (84%) fit into these categories.[69]

LEVEL 1:

Elements of a minimal program (minimal or no available resources to support mosquito control activities).

Communities with no dedicated mosquito control staff or budget can take the following actions to reduce the threat of mosquito-transmitted disease and, to some extent, the irritation of pest mosquitoes:

- Public outreach: Raise awareness about preventing mosquito bites using existing communication channels to the public, community partners, and the media.
- Surveillance: enlist the public in reporting dead birds related to WNV.
- Source reduction: Raise awareness about reducing habitats for mosquito larvae by eliminating standing water, tires, and containers.

LEVEL 2:

Elements of an intermediate program (little to moderate resources available to support a mosquito control program).

Communities in this category will have some capacity to conduct mosquito control activities but cannot mount a comprehensive program. They can implement the following activities:

- *Program management:* Communities can determine whether to use staff or contract support for program activities.
- *Larval control:* Based on knowledge of local mosquito habitats, communities can perform early season larval control.
- *Surveillance:* Communities can use one or two mosquito traps to assess its program's effectiveness. The CDC portable light trap or any of several similar traps have been shown to be useful. These traps can be placed at crucial sites within the community, perhaps where experience has indicated particularly severe pest problems or increased disease activity. As more resources become available, communities can adjust the number of traps according to the size of the district and the variety of mosquito habitats within the district.
- *Perform adulticide:* If additional funds are available, it may be worthwhile to contract for or purchase equipment (e.g., ultra-low volume sprayers) for adult mosquito control. Since mosquitoes can fly substantial distances (from less than one mile to more than 15 miles, depending on the species and conditions), it may be difficult to protect communities with large outlying areas that can generate millions of mosquitoes. However, these methods can increase community protection if the program can cover an adequate area and the insecticides are applied appropriately (usually at dusk or after sunset, depending on the species being controlled).

LEVEL 3:

Elements of a comprehensive program (moderate to full resources available to support a mosquito control program).

Communities with moderate to full resources will be able to develop and implement more comprehensive mosquito control programs. The recommendations in this section are drawn largely from AMCA's Bulletin #4 and from AMCA's **Best Practices for Integrated Mosquito Management: A Focused Update.**[70] Please refer to those documents or to the many excellent training manuals developed by state mosquito control associations for additional guidance in organizing a full-scale program.

A general principle of IMM programs is that a specific control measure is only instituted when an action threshold, or "trigger," is met. An example of thresholds and suggested responses for WNV and Zika activity are shown in Appendix A. These are broadly defined thresholds, and individual states or communities may wish to institute more precise thresholds that reflect local experience and concerns.

One of the first things a mosquito control program should recognize, once funding becomes available, is that mosquito control is a year-round activity. The information in this section gives a general picture of the activities that a program will need to perform for basic year-round comprehensive mosquito control.

PRE- OR OFF-SEASON ACTIVITIES

Often, communities have to decide where to allocate scarce mosquito control resources. Many mosquito activities are appropriate for times when mosquitoes are not a problem (usually during the winter).

General Activities:

- Staff training and certification.
- Equipment purchase, repair, and calibration.
- Budgeting and other financial and administrative activities.

Surveillance Activities

- Data analysis and review, including information on cases of mosquito-borne disease, location of high-risk populations, and analysis of the previous year's data. In some areas, source reduction activities (see above) can also be done now.
- Review all published data, past health department records, and other data to determine the types of mosquito-borne diseases, numbers of cases by year and date of onset (or diagnosis), and economic and other costs, if known. Review complaints of calls for nuisance mosquitoes, meteorological data, locations of larval habitats by year and date, and determine the peak periods of nuisance problems.
- Collect and review historical meteorological data for the area: temperature, rainfall, humidity, and wind direction. Plot this information against mosquito abundance (or nuisance calls) to see if there are any predictors of high mosquito abundance, disease transmission, etc.
- Map the locations of high-risk populations (e.g., elderly citizens), using local census or other community data. This will allow the program to prioritize resources if an epidemic should occur.

- Collect and review topographic maps, aerial photography, and other similar resources to help in locating probable larval habitats, concentrations of bird or other hosts of mosquito-transmitted viruses, and the location of breeding sites for peri-domestic mosquitoes.
- Map concentrations of scrap tires, commercial nurseries, and other known sources of peri domestic *Aedes* mosquitoes.
- Use the data collected above to decided where to place light traps or other sampling stations, and where to concentrate effort.

Based on the results from these activities, communities can select the areas at greatest risk within the service area and concentrate their available resources accordingly.

Control Activities

- *Source reduction:* Communities can employ several types of source reduction during the off-season, including clearing stream channels and community cleanup (e.g., door-to-door inspections and tire amnesty programs).
- *Larval control:* Most control is done later in the season, but communities can treat some areas before they become flooded by spring rains or runoff.
- *Adult control:* Communities should not do adult control at this time.
- *Public education:* Communities can carry out public education, especially activities focused on K-12 school programs, any time of the year. Arrange for presentations at meetings of civic groups, nature groups, service clubs, and other groups that have an impact on the local community. To reach the agricultural community, coordinate activities with local county extension agents where those services are available.
- *Pesticide resistance testing:* Pesticide resistance testing is an important component of IMM and is an important tool for insuring that applications of pesticides will be effective. CDC has established guidelines for how and when pesticide resistance testing is performed.[71]

EARLY-SEASON ACTIVITIES

Surveillance Activities

During early-season activities, as above, surveillance activities gather the intelligence data needed to combat mosquitoes and prevent disease transmission. Activities focus on species delimitation (i.e., identifying the boundaries of where mosquitoes occur) and include habitat mapping, characterizing the abundance of each species and comparing it to previous years, sending exotic species for confirmation to CDC, and reporting surveillance data to CDC's **MosquitoNet**.

Control Activities

- *Source reduction:* Activities can continue during this period. Efforts should concentrate increasingly on eliminating potential disease vector species' larval habitats.
- *Larval control:* Communities should focus on reducing or eliminating larval populations early in the season.
- *Adult control:* Depending on the species of concern, there may be little adulticiding to do during the early part of the season.
- *Public education:* Communities can prepare newspaper, social media, radio, and television announcements to increase public awareness of the threat of mosquito-transmitted disease. Mosquito control programs can coordinate with the local media to increase community awareness of the mosquito control program work. (This is most important for peri-urban *Aedes* control programs.)

MID- AND LATE-SEASON ACTIVITIES

Activities for the remainder of the mosquito control season will be much the same as those for the early part of the season, except that communities should dedicate increasing resources to larviciding and, when needed, adulticiding. Disease surveillance data will guide the level of mosquito control, especially for adult mosquitoes. Mosquito control programs should continue to educate the public and remain in close contact with media resources.

As mosquito populations decline with the onset of cold weather, the program should return to the pre-season/off-season routine, in preparation for the next year.

ADDITIONAL CASE STUDIES

CASE STUDY:

Past Mosquito Control Practice Impacts Public Expectations

Communities in neighboring New England states differ significantly in their expectations for adult mosquito control. One state's mosquito control program rarely receives public complaints regarding nuisance adult mosquito populations. This state's mosquito control program focuses almost exclusively on prevention, either through habitat modification to re-establish fish populations in salt marshes or by distributing larvicide briquettes to limit mosquito production in storm water catchment basins and other breeding areas. In contrast, just across the state border, soon after mosquitoes become apparent, this state's mosquito control programs expect to receive public complaints and pressure to continue a longstanding tradition of spraying pesticides to address nuisance mosquitoes. This pressure occurs despite the program's preventive larviciding, source reduction, and education activities.

Similar differences in public expectation frequently exist between rural communities (whose populations are too sparse to support local mosquito control programs) and neighboring urban or suburban communities with long histories of supporting local mosquito control activities.

CASE STUDY:

Good Science Does Not Always Calm Public Concerns

People don't like being bitten by mosquitoes. Add the risk of disease, no matter how remote, and this annoyance can build to outrage, fueling public demand for the control of nuisance mosquito populations. The National Park Service (NPS), which has a policy to protect wildlife and abstain from spraying for nuisance mosquitoes, successfully addressed nuisance mosquito concerns in 1998 in communities adjacent to its Otis Peak High Dune Wilderness area within New Jersey's Fire Island National Seashore while maintaining its wildlife protection policy. To start, NPS conducted a three-year, comprehensive study to gather data demonstrating that mosquitoes from the wilderness area, primarily *Aedes solicitans*, did not contribute to neighboring communities' mosquito problems. When these data did not silence residents' complaints, NPS succeeded with a three-pronged **strategy** to address the community's need for public safety, public education, and resource protection. NPS addressed public safety through a mosquito-borne disease surveillance and response plan, and its public education work included open meetings and distributing educational materials. NPS enhanced its resource protection through salt-march restoration. These attempts to address community concerns were the foundation for building credibility and trust necessary to help the public accept and act on good scientific data.

CASE STUDY:

Using Citizen Science to Promote Informed Community Engagement

Citizen science projects, which recruit members of the public to collect data for scientific research, can be a helpful way to inform and engage the community in mosquito control.[72] Citizen science projects can raise awareness of Zika and other mosquito-borne disease as well as promote community engagement and acceptance of mosquito control program activities. Relevant projects include surveilling mosquito populations via simple egg traps (e.g., North American Mosquito Project, **Mosquitoes of Hawaii Project**) and monitoring non-target species, such as pollinators, that are unintentionally impacted by spraying pesticides to control adult mosquitoes (e.g., **Bee Spotter**, **Bumblebee Watch**).[73, 74, 75, 76]

APPENDIX A:

Suggested Guidelines for Phased Response to West Nile Virus and Zika Virus Surveillance Data

RISK CATEGORY	WEST NILE	ZIKA
0 **NO RISK**	No risk of human disease. Off season, adult vectors inactive, climate unsuitable.	No risk of mosquito Zika transmission. Outside *Aedes aegypti* and *Aedes albopictus* range.
	Response: Develop West Nile virus response plan. Secure surveillance and control resources necessary to enable emergency response. Initiate community outreach and public education programs. Conduct audience research to develop and target education and community involvement. Contact community partners.	No response necessary.
1 **REMOTE RISK**	No current surveillance findings of epizootic activity in the area.	No current *Aedes aegypti* and *Aedes albopictus* activity.
	Response as in category 0, plus: conduct entomologic survey (inventory and map mosquito populations, monitor larval and adult mosquito density); initiate source reduction; use larvicides at specific sources identified by entomologic survey and targeted at likely amplifying and bridge vector species; maintain avian mortality, vector, and virus surveillance; expand community outreach and public education programs focused on risk potential and personal protection and emphasizing residential source reduction; maintain surveillance (avian mortality, mosquito density/infection rate, human encephalitis/meningitis and equine illness).	Develop mosquito control plan that includes integrated mosquito management (IMM) strategies. Develop a communications network within the state's incident management structure to ensure timely exchange of information to guide optimum vector control efforts. Review and assess ranges of *Aedes aegypti* and *Aedes albopictus*; update range maps with survey if warranted, resources permitting. Review local staffing, resources, expertise, vendor contracts, inter-governmental agreements and capacity for local vector control. Link vector control activities to public education on personnel protection and mosquito habitat prevention activities.
2 **LOW RISK**	Areas with limited or sporadic West Nile virus (WNV) epizootic activity in birds and/or mosquitoes. No positives prior to August.	Current *Aedes aegypti* and *Aedes albopictus* activity, but no human cases of disease.
	Response as in category 1, plus: increase larval control, source reduction, and public education, emphasizing personal protection measures, particularly among the elderly. Enhance human surveillance and activities (e.g., mosquito trapping and testing) to further quantify epizootic activity. Implement adulticide applications if vector populations exceed locally established threshold levels, emphasizing areas where surveillance indicates potential for human risk to increase.	Using the plan previously developed, survey and map presence of *Aedes aegypti* and *Aedes albopictus* within the state. Actively engage the community in removal of larval habitat and Aedes breeding sites, including community cleanup campaigns (tire removal, trash pickup, removal and cleaning of small and large containers). Leverage partnerships with local governments and nonprofits for support. If possible, conduct rapid insecticide resistance testing for local mosquito populations in advance of the need for pesticide application to prevent Zika transmission. Use larvicides in containers and bodies of water that cannot be removed or dumped.

RISK CATEGORY	WEST NILE	ZIKA
3 **MODERATE RISK**	Areas with confirmed epizootic WNV in birds prior to August; a horse/human case; sustained WNV activity in birds/mosquitoes.	
	Response as in category 2, plus: intensify adult mosquito control in areas where surveillance indicates human risk; initiate adult mosquito control if not already in progress; initiate visible activities in community to increase attention to WNV transmission risk (speaker, social marketing efforts, community mobilization for source reduction, etc.); work with collaborators to reduce risks to elderly (e.g., screen repair).	
4 **HIGH RISK**	High dead bird densities or other quantitative measures of high risk of human infection. In early summer, sustained high mosquito infection rates, multiple positive mosquito species, horse/mammal cases indicating escalating epizootic transmission, a human case and high levels of epizootic activity or positive surveillance measures consistent with past WNV epidemics.	First identification of a confirmed case(s) in a single building.
	Response as in category 3, plus: expand public information program to include TV, radio, and newspapers (use of repellents, personal protection, continued source reduction, risk communication about adult mosquito control); increase visibility of public messages, engage key local partners (e.g., government officials, religious leaders) to speak about WNV; intensify and expand active surveillance in areas of high risk of human cases. Reschedule public outdoor public events (e.g., sporting events, block dances, and concerts).	Implement targeted control efforts around the case-patient's home or building. Conduct intensified larval and adult mosquito control in a 150-yard radius (or other boundary as deemed appropriate) around the case patient home. Targeted control activities involving home visits should be closely coordinated with concurrent educational efforts and messaging. Consider adding community-based adult mosquito control consisting of outdoor residual spraying and space spraying, if necessary. Intensify larviciding and source reduction efforts. Consider targeted indoor residual spraying in areas where air conditioning and screens aren't widely available.
5	**OUTBREAK IN PROGRESS.** Multiple confirmed cases in humans; conditions favoring continued transmission to humans (e.g., persistent high infection rate in mosquitoes and continued avian mortality due to WNV).	**WIDESPREAD TRANSMISSION.** Multiple confirmed cases in a single jurisdiction.
	Response as in category 4, plus: intensify emergency adult mosquito control program, repeating applications as necessary to achieve adequate control. Enhance risk communication about adult mosquito control. Monitor efficacy of spraying on target mosquito populations. If outbreak is widespread and covers multiple jurisdictions, consider a coordinated widespread aerial adulticide application. Emphasize urgency of personal protection through community leaders and media and emphasize use of repellent at visible public events.	Vector control efforts should align with state, tribal, and local government decisions regarding boundaries for declaring an area as a site of "active Zika transmission." This may model county lines or be a ZIP code designation. At this phase, officials should plan to intensify and expand vector control efforts within the areas of active transmission. In addition to continuing to target case-patient homes and the surrounding vicinity, area-wide treatments with larvicides and adulticides using application methods appropriate for the scale of the treatment area should be considered. Control plans should be tailored to the local needs and might require truck or aerial spraying (aerial for areas > 2,000 acres) or a combination of both. Monitor for effectiveness of treatments through trapping and retreat if mosquito numbers begin to increase again. For areas where air conditioning and screens aren't widely available, consider adding targeted indoor residual spraying to vulnerable homes.

APPENDIX B:

Suggested Components for Bids or Contracts for a Mosquito Control Program

Government agencies may need to purchase mosquito control services from private vendors. The list below reflects components that may be included in bid and/or contract specifications for a quality program and effective results. (Please note that any agency contracting for services should contact its agency attorney for guidance.)

DESCRIPTION OF SERVICES

- Surveillance, mapping, and monitoring of potential mosquito sites.
- Monitoring and suppression of larval and adult populations.
- A requirement to use integrated pest/mosquito control methods and materials sanctioned for use by the U. S. Environmental Protection Agency, the Centers for Disease Control and Prevention, the U.S. Department of Agriculture, and the American Mosquito Control Association.
- A public outreach program, including:
    - A 24-hour phone line.
    - A 24-hour response-to-resolution timeline.
    - Printed materials and advertisements.
    - Informational presentations,
    - Advance public notices of scheduled sprayings, whenever feasible.
    - Provisions to exclude properties from being sprayed at the owner's request, whenever feasible.
- Reports detailing all larviciding, trapping, and adulticiding activities.
- Reports of public outreach and citizen interaction activities.
- Year-end reports summarizing the season's results and activities, with recommendations for the following year's program.
- Copies of all maps, records, logs, complaints, and correspondence available upon request.
- A description of proposed staffing levels.
- A description and number of major equipment items.
- A description of the anticipated activities, methods, and materials to be used, including:
    - Pesticides with EPA establishment number and registration numbers.
    - A requirement to use pesticides consistent with the Federal Insecticide, Fungicide and
    - Rodenticide Act.
    - The application rate.
    - The acreage to be covered.
    - The times of coverage.
    - The details of reporting.
    - The need for neighborhood notification.
    - A hotline, if necessary, or a 24-hour local customer access telephone number for complaints and
    - Information.
    - Monitoring data.
    - Timelines—including whether the contract is multi-year—and due dates.
    - The methods to be used for surveillance.
    - Control methods.
    - The evaluation plan.
    - Access to real-time surveillance, mapping, and control data, including maps.
- Access to contractor personnel during regular hours and after-hours emergency access.
- Standards for complaint resolution (e.g., 24-hour resolution).

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