Commonwealth of Massachusetts
STATE RECLAMATION AND MOSQUITO CONTROL BOARD

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2014 VECTOR MANAGEMENT PLAN

Introduction

The 1999 introduction of West Nile virus (WNV) into the United States tested the preparedness of public health agencies to identify and respond quickly to outbreaks of vector-borne disease. The U.S. Centers for Disease Control and Prevention (CDC) concluded afterwards that "the most effective and economical way to control mosquitoes is…through locally funded abatement programs" and that "mosquito control is the most effective way to prevent transmission of West Nile" (1).

Unique among state agencies are Massachusetts **Mosquito Control Projects and Districts** (MCP/D) in that they are **accountable directly to subscribing member communities**. It is the needs and concerns of member communities that drive MCP/D operational policies and strategies. This has been the charge of the Northeast Massachusetts Mosquito Control District for over forty years. Thirty-two cities and towns subscribe to the District, thirty from Essex county and two from Suffolk.

As the needs of our communities change and evolve, so have the services we provide. With the invasion and establishments of new arthropod-borne viruses ("arboviruses"), we have transformed our primary operational strategy from one of nuisance mosquito control to protecting public health. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (2). Thus, an attack by a hungry squad of mosquitoes is no longer just a nuisance on one's well-being, but is also an issue of health! Furthermore, the Federal Insecticide, Fungicide and Rodenticide Act defines a "vector" as "any organism capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including mosquitoes" (3). Therefore, by this definition, all mosquitoes are potential vectors and all mosquito control activities are conducted in the interest of public health.

West Nile virus first appeared in Essex County in 2000. Since then, there have been scores of WNV-infected bird mortalities, over 250 WNV-mosquito detections, and eight District residents hospitalized with serious virus-generated illnesses. Eastern Equine Encephalitis virus (EEEV), once a rarity north of Boston, has been detected six of the past ten years in the District; it claimed its first two District mortalities in 2012 (one each from Georgetown & Amesbury). Some may contend that number of fatalities caused by arboviruses is too small to warrant attention. However, with the knowledge, personnel, and technology readily available at a relatively small cost, **it is worth the effort** to protect the lives of our more vulnerable citizens engaged in innocent everyday summer outdoor activities. It has been documented (4) that for the protection of the public's health, the costs for mosquito control and its emphasis on prevention of disease far outweighs the costs (and suffering) of treatment of the sick and distress. In a recent publication in the **American Journal of Tropical Medicine and Hygiene**, the total cumulative costs of WNV hospitalized cases alone nationwide, from 1999 through 2012, has been estimated at almost $780 million (5)! To see reports presenting the impact of mosquitoes and the agents they transmit, the roles of mosquito control projects to protect the public, and examples/interviews with people suffering from and relatives of those that have died from mosquito-borne diseases, may we recommend that you check these video links: http://www.cbsnews.com/videos/all-the-buzz-about-mosquitoes/ and http://www.mosquito.org/mosquito-control-and-why-it-s-important-to-you. To read about a couple's battle with West Nile during the Dallas epidemic in 2012, see the article titled "Mosquito-driven death hits home: One family's loss" in **Mosquito Control** magazine pdf document (pp. 6-7) that accompanies this VMP.

The purpose of this Vector Management Plan (VMP), updated for 2014, is to first, summarize our mosquito and arbovirus surveillance/management strategies. This 2014 VMP also outlines our specific responses to arboviruses and how our limited resources will be directed toward implementing these responses effectively and efficiently.

Regional Adult Mosquito Surveillance

The District's surveillance program forms the basis for the operations engaged in the control of mosquitoes. Our surveillance of mosquito populations is based on protocols established by the CDC and Massachusetts Department of Public Health (MDPH). To monitor adult populations, the District maintains thirty-five historical trapping stations (HTS) set every year at the same locations for an entire season. There is at least one HTS in each subscribing municipality and within each HTS are two different surveillance traps (see Figure 1). The stations are generally located at secure municipal-owned facilities, with access to electrical power, in the general vicinity of major population centers. The traps operate from mid-May through the mid-October, with two collection cycles per week, each cycle lasting twenty-four hours. Trapping receptacles are retrieved by District personnel at the end of each collection cycle and **all** collected mosquitoes are identified and tallied. Fifty-one species of mosquitoes are known to live in Massachusetts.


Figure 1. Historical Trapping Station


Figure 2. "New Jersey Trap"


Figure 3. Reiter-Cummings Gravid Trap

The first of the two traps is the CO_2-baited "New Jersey trap" (Figure 2). To attract mosquitoes, carbon-dioxide (the same chemical as in our exhaled breath) is released from a pressurized cylinder into a hose located at the top of the trap. As mosquitoes approach the gas released at the hose's opening, they are drawn inside the cylinder by an internal fan, then blown into a hanging container or "basket" found below. With this trap, nearly all mosquito species in a community are collected. Because the traps are placed at the same locations every year, population trends can be studied and compared between years, as well as during the year.

The other HTS trap is the Reiter-Cummings gravid trap (Figure 3), our principal WNV detection tool. This trap is designed to attract container-breeding mosquitoes including ***Culex pipiens*** and ***Cx. restuans***, the key carriers of WNV in the District. This trap is a former tackle box whose interior is modified with a fan to draw mosquitoes through a bottom opening into a plastic "Tupperware" container. The trap is baited with rank-smelling aged organic material-filled water, held below in a pan, to attract female mosquitoes. These blood-fed females come to lay their eggs on the water's surface and when they approach the trap's underside opening, they are drawn inside. The contents are later removed. After their identification, all WNV-vector species are separated and sent to the state lab to be tested for the presence of viruses.

When necessary, additional battery-operated gravid traps are deployed in communities displaying either disturbing ***Culex*** population trends and/or with recent histories of WNV. ***Cx. pipiens*** & ***Cx. restuans*** breed proficiently in heavily urbanized areas so additional gravid traps will often be set on an "as need" basis. In the short term, these additional trappings provide us with more data on ***Culex*** population distributions and densities; over the long term, better historical information is obtained to study trends on vector populations and viral activity. See Figure 4 for a photograph of ***Cx. pipiens***, also known as the "Northern House Mosquito".

Our third surveillance trap is the Resting box. Due to the behavior and habitats preferred by yet another species of disease-carrier, resting boxes are not placed at the HTS. Instead, these are situated in the vicinity of cedar and maple swamps where ***Culiseta melanura*** (Figure 5) resides. ***Cs. melanura*** or the "Cedar Swamp Mosquito" is the principal vector of EEEV. Resting boxes are designed to simulate the tree holes and cavities where these mosquitoes normally rest during the day after they feed on blood. Resting boxes (Figure 6) are visited twice weekly from mid-June through the end of September; ***Cs. melanura***, and the closely related ***Cs. morsitans***, are gathered, identified, tallied, then separated to be later tested for the presence of viruses.

Figure 4. Adult ***Culex pipiens***
(CDC: PHIL: 4464)

Figure 5. Adult ***Culiseta melanura***

An "epicenter" of EEEV activity has developed in southeastern New Hampshire since 2005 so now, monitoring for EEEV-vectors has become another component of our surveillance program. Initially, we had resting box stations at fixed historic locations along the southeastern New Hampshire border from Methuen through Salisbury; nine stations in total (two in each town except for Salisbury) with eight boxes in each station. In addition, resting box stations have also been set gradually since 2006 in Boxford, Topsfield, Hamilton, Wenham, Newbury, Georgetown, Lynnfield, and Middleton. These additional stations were set in response to EEEV infections in mosquitoes, horses, alpacas, or humans in these communities. Additional boxes are ready for deployment and stations have been selected in more communities if resting box surveillance must be expanded. Because ***Cs. melanura*** can also transmit WNV, resting box surveillance has enhanced our WNV monitoring.

Whereas ***Cs. melanura*** rarely bites humans, they bite and infect local birds. These infected birds become blood-meal sources for other mosquito species who themselves become infected. These other EEEV-infected species can then bite humans. These species capable of infecting humans are known as “bridge vectors”. To determine whether infected bridge vectors are present, portable CDC-CO_2 traps (Figure 7) are often placed at resting boxes locations when infected ***Cs. melanura*** mosquitoes have been collected. These traps collect other species which upon identification, are tested. Knowing the “infection status” of bridge vectors in EEEV-known habitats can result in more effective targeted adulticiding responses.

Figure 6. Recycled fiber pulp “Resting Boxes” (left back view; right front view)

Figure 7. CO_2-baited CDC trap

<u>Risk Communications and Public Relations</u>

Dissemination of mosquito and arbovirus information is paramount to the success of any mosquito control operation. With the speed which information, as well as rumors and even disinformation, can be conveyed in all public informational media, it is crucial that Boards of Health and subscribing municipality residents are kept correctly informed. To that end, the District continues to improve its communication regarding mosquito species, potential arboviral threats, and details of larviciding and adulticiding operations.

At the end of every winter, the District sends detailed “Best Management Practice Plans” (BMP’s) to each District subscribing municipality (Figure 8). Each BMP includes summaries of the previous year’s mosquito and arbovirus activities, descriptions of suggested and agreed-upon control operations, as well as their costs. When necessary, the District conducts a “Mosquito/Arbovirus Surveillance Workshop” (at Endicott Park in Danvers; Figure 9), to inform/educate health agents and Boards of Health members of District communities. Potential mosquito and arboviral threats along with response options are discussed. The District operates a website (http://www.northeastmassmosquito.com; Figure 10) with all relevant information on mosquitoes, arboviruses, and operations. Also, when requested, lectures are presented to Boards of Health, and other interested municipal organizations, which are often recorded for broadcast on public-access television as well as posted on the internet; Figure 11 is the first slide of the PowerPoint presentation (pdf version is included with this VMP packet) used in the lecture. And finally, our phone lines remains open at all times and while we are often unable to respond immediately, being that we are all in the field, **we do return all calls!**


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Joseph T. Giarrusso, Conservation Officer
Paul Sevigny, RS, CHO

Best Management Practice Plan

Haverhill

Draft: 5/22/00; Revised draft: 8/17/05; Revised: 4/06 1/07 1/08 1/09 1/10 1/11 1/12 4/13

Mosquito/Arbovirus Surveillance Summary

Introduction

Although fifty-one species of mosquitoes are found in Massachusetts, only about a dozen are of concern to public health. Their biting activity has been torturous throughout human history, often causing great misery to anyone living anywhere near a marsh or a swamp. Their biting activity has often had severe impacts on local economies by impeding outdoor work, attacking livestock, and

Figure 8. First page of Haverhill's BMP

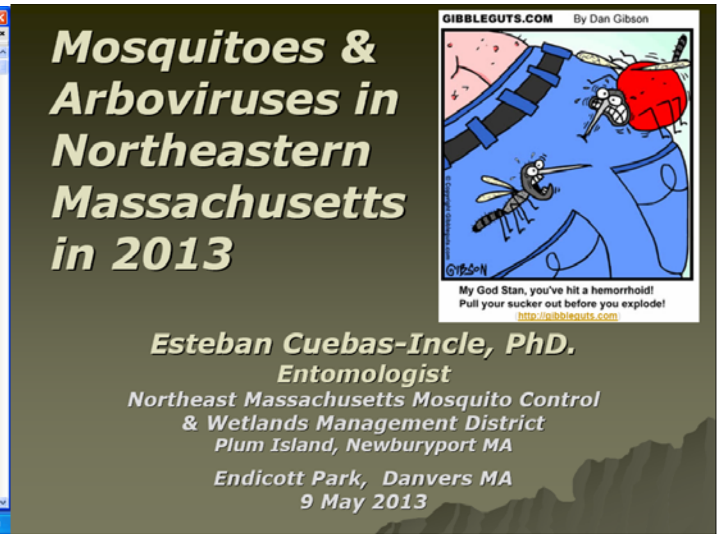


Figure 9. Arbovirus Surveillance Workshop

Figure 10. Home page of NE MA MCD website

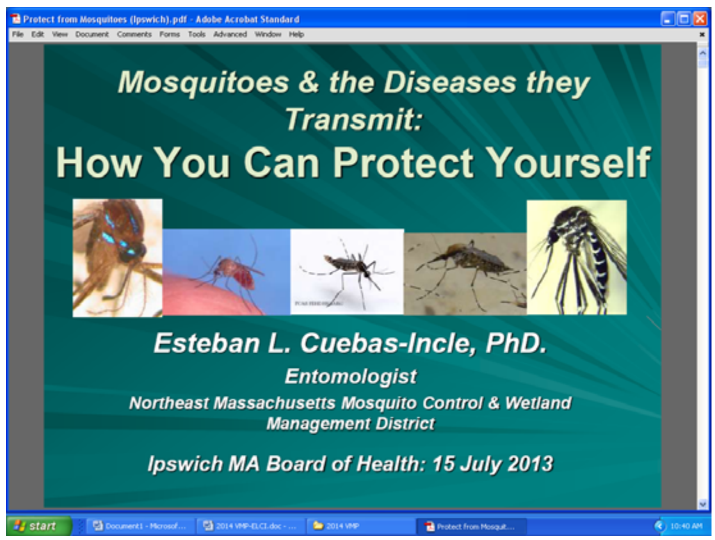


Figure 11. PowerPoint Presentation

Emergent Exotic and Recent Immigrant Mosquito Species

Newly imported (i.e., "exotic) mosquito species becoming established in our area is a growing problem. Within the past ten years, we have seen the appearance and rapid spread of ***Aëdes japonicus***, the "Japanese Rock Pool Mosquito", throughout our District (Figure 12). While this species is a competent disease vector in other areas, there is little to suggest it is currently a major disease vector in the Northeast. Therefore, as we monitor our local mosquitoes, we are also "on guard" for the appearance of new species.

Another exotic and geographically-expanding species is ***Aëdes albopictus***, the "Asian Tiger Mosquito" (Figure 13). It is a notorious daytime human-biting species and competent disease vector; it could the next exotic species to become established in northeast Massachusetts. Originally from northeast Asia, it has spread rapidly throughout the temperate regions of the world (6) assisted by the importation of used automobile tires. Water-filled discarded tires left outdoors simulate tree-holes where this species tends to lay its eggs. When tires are then imported to the U.S., they are stored outdoors, fill with rainwater, and eggs within hatch and adults eventually emerge and spread. ***Aë. albopictus*** was first found in the U.S. in Houston in 1985 and has spread nationwide as far northeast as Connecticut; it has become the dominant mosquito species in New Jersey. ***Aë. albopictus*** is a great concern in public health because of its ability to transmit many arboviruses that cause serious disease in humans, including Chikungunya and Dengue (discussed below). ***Aë. albopictus*** has been collected in Bristol County on repeated occasions the 2011 through last year (7) in used tire-collection facilities. It may soon become established there and spread throughout eastern Massachusetts.

Figure 12. Japanese Rock Pool Mosquito (***Aëdes japonicus***) Figure 13. Asian Tiger Mosquito (***Aëdes albopictus***)
Both Photographs copyright: Steve A. Marshall Published on *The Diptera Site* (http://diptera.myspecies.info)

In 2007, District personnel collected specimens believed to be ***Aë. albopictus*** and attempts were made in 2008 to collect additional specimens and locate breeding sites. Towards this endeavor, the District deployed a new type of surveillance trap, "BG Sentinel trap" to enhance collection. However, no ***Aë. albopictus*** were collected. (In fact, it was these same BGS traps that were loaned to Bristol County MCP in which they collected their ***Aë. albopictus***!)

Virus Testing

Specimens of the principal WNV- and EEEV-vectors from our trap collections are sent weekly to the Arbovirus Surveillance Laboratories of the Department of Public Health in Jamaica Plain in Boston, to be tested for the presence of encephalitis viruses (http://www.mass.gov/eohhs/docs/dph/laboratory-sciences/sli-manual-tests-services.pdf). On average, 75 samples (i.e., "pools") of mosquitoes are sent each week to the State Labs.

Emergent Virus

The threat of mosquito-borne disease is on the rise world-wide (8,9). The potential for invasion, transmission, and establishment of new arboviruses in the United States is on the increase. The invasion of exotic vector-borne disease into our District can no longer be disregarded nor deemed as heresy. After the introduction/ establishment of West Nile Virus in 2000 and emergence of EEEV in 2005, potential viral threats in the District must now be seriously considered and even anticipated.

The most recent new arboviral concern in the continental United States is Dengue virus (DENV), also known as "Break bone fever" (discussed further below). It was thought that, except for occasional imported cases, Dengue had vanished from the U.S. There were localized outbreaks near the Texas-Mexican border in the late 1990's and in Hawaii in 2000. However, the threat level was raised considerably beginning in 2009 when a

New York resident visiting Key West, Florida contracted Dengue. In December 2010, there were 55 confirmed cases of locally-acquired Dengue in Key West (10). Six cases of locally-acquired Dengue were confirmed in Florida for 2011 (11), four more in 2012 and 20 in 2013 (12). And this past November, it was announced that a Long Island (NY) man, who had not traveled in the previous months, contracted Dengue (13). The suspected vector was ***Aë. albopictus***, recently becoming established on Long Island.

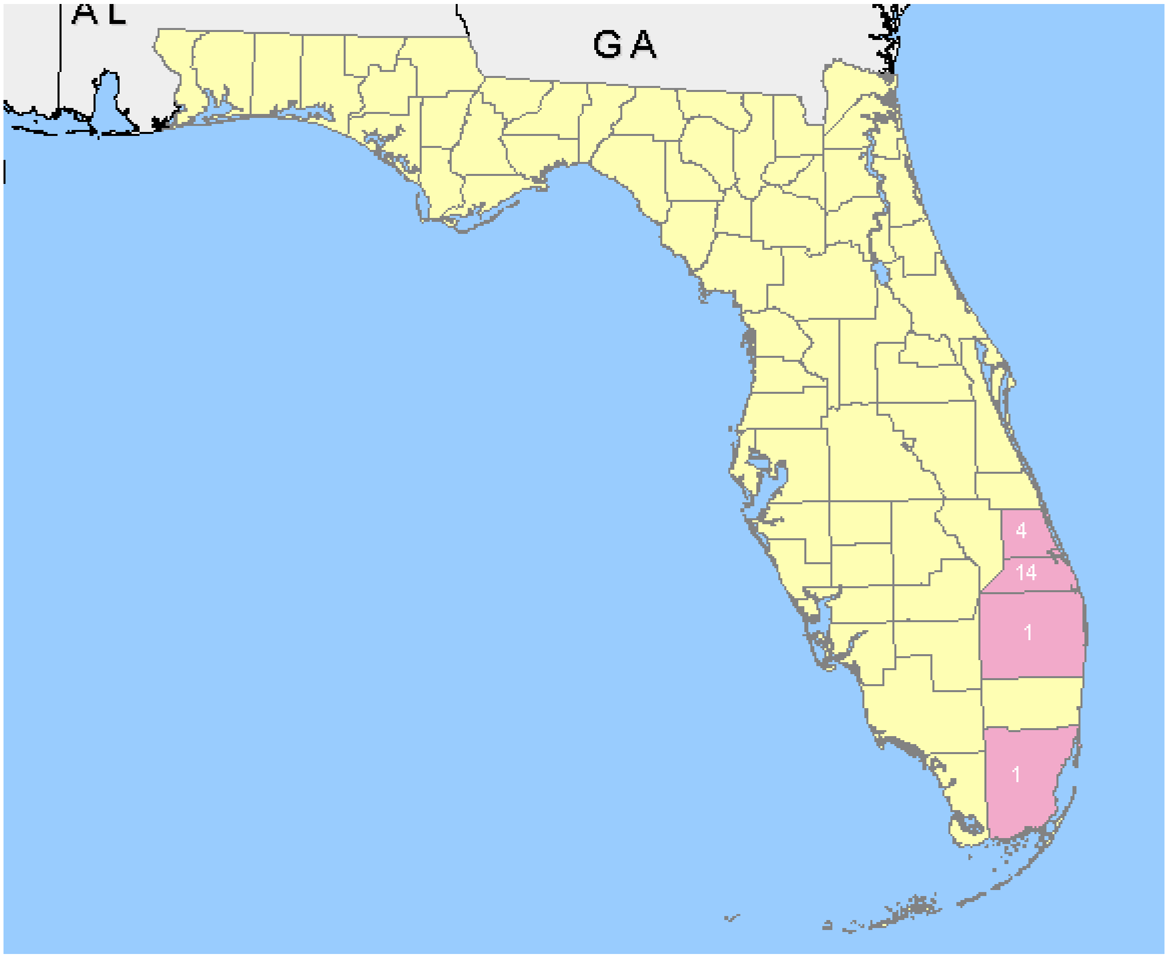


Figure 14. Cumulative 2013 Data of locally-acquired Dengue in Florida as of 3 am, 7 Jan 2014 (http://diseasemaps.usgs.gov/del_fl_human.html)

Containment of DENV transmission is not easily accomplished when at the same time there are concurrent imported cases of Dengue (infections of patients when traveling outside the US and returning ill); there were 133 imported Dengue cases in the US in 2011, 100 more in 2012, and 519 in 36 states in 2013 (12); for examples, see Figures 14 and 15. With the vectors readily present in much of the US, it will not take much for the virus to be easily transmitted from an imported case to a resident and start a panic!

DENV is the greatest mosquito-borne virus circulating in the world today, affecting anywhere from 50 to 100 million people annually in about 100 countries (15). If ***Aë. albopictus*** becomes established in Massachusetts, it can acquire DENV from an infected returning traveler, and transmit the virus locally, causing a public health havoc. Symptoms of Dengue include high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, and mild bleeding (16). A more dangerous manifestation is Dengue hemorrhagic fever which after the fever declines, there is persistent vomiting, severe abdominal pain, and difficulty in breathing. This can be followed by excessive bleeding into the body cavities leading to circulatory failure and shock, followed by death. There is no medication for the prevention or treatment of a Dengue.

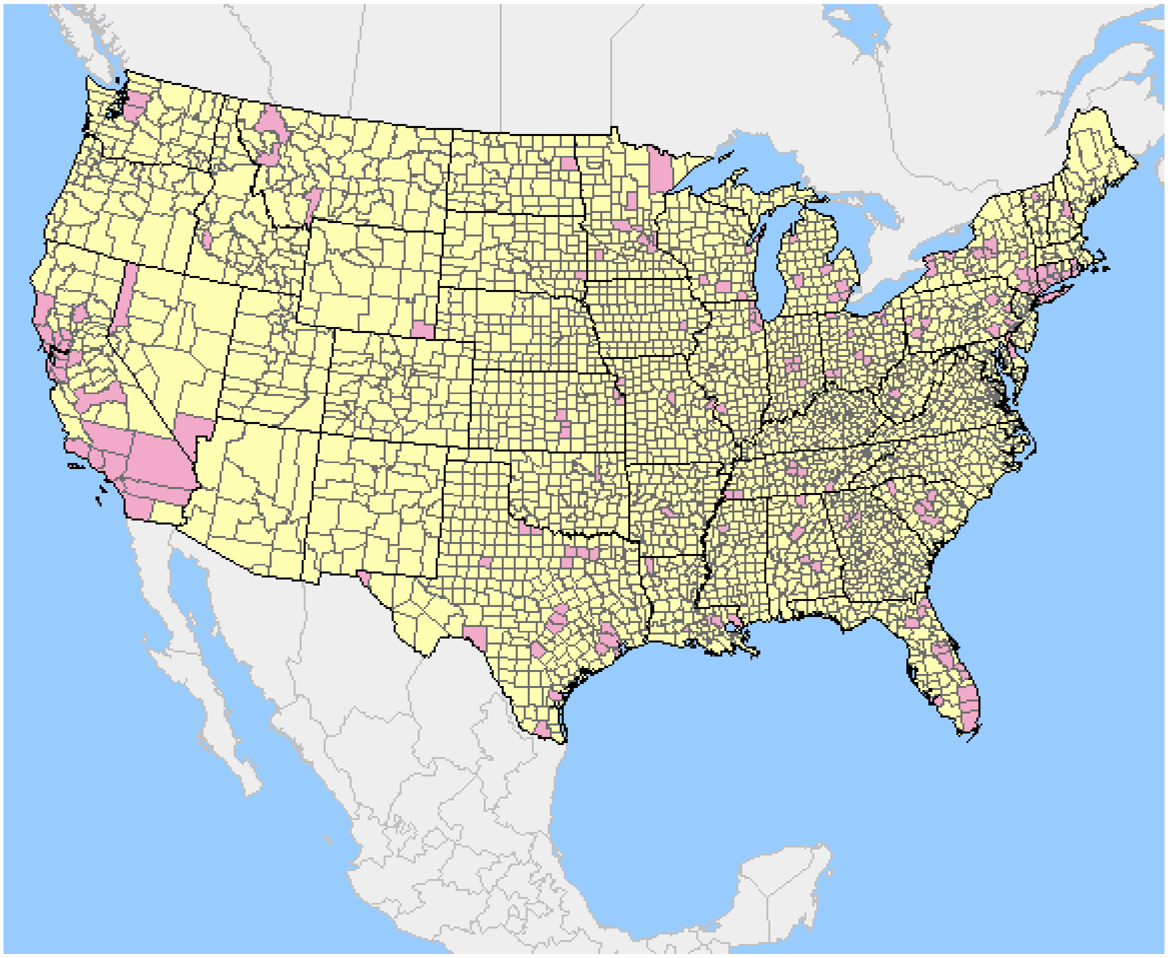


Figure 15. Cumulative 2013 Data of "imported" Dengue in the US as of 3 am, 7 Jan 2014 (http://diseasemaps.usgs.gov/dep_us_human.html)

The newest arboviral threat to the continental United States is Chikungunya virus (CHIKV). This virus, originally restricted to east Africa and southern Asia, has been causing a pandemic in South Asia and along the Indian Ocean basin. For reasons totally unknown and catching the public health authorities by surprise, locally-acquired infections by this virus have beginning this past December in several of the islands of the eastern Caribbean (17)! Chikungunya is rarely fatal, it is another debilitating illness, causing excessive and prolonged fatigue and extreme pain in joints lasting up to several weeks (18). In 2005 and 2006, Chikungunya sickened almost one third of the 800,000 inhabitants of the French island of La Reunion, off the east African coast (19).

The Caribbean outbreak was not the first recent appearance of CHIKV outside of South Asia recently. The first outbreak outside of the tropics was in northern Italy in September of 2007. The Italian CHIKV was vectored by a new strain of ***Aë. albopictus*** adapted to transmit the virus (20). Since 2006, there have been over 100 imported cases of Chikungunya in the U.S. (9) demonstrating the potential for imported cases to serve as sources of CHIKV for domestic ***Aë. albopictus*** to acquire and transmit (21). Since New Jersey is experiencing an "explosion" of ***Aë. albopictus***, with a large percentage of residents who travel to Chikungunya-endemic regions, do not be surprised if you read in the near future that a locally-acquired Chikungunya outbreak has broken out in New Jersey!

According to Dr. Jean-Paul Mutebi of the CDC, there are currently three circulating international arboviruses with the greatest potential of establishing themselves in the U.S. These are the viruses causing Chikungunya, Rift Valley Fever, and Japanese Encephalitis (8,9). Mosquito species that can easily spread these viruses are all found in abundance in the U.S.; most of these species are found in New England as well (8,9).

Rift Valley fever virus (RVFV) causes a fast-developing ("acute") fever that affects livestock animals and humans (22). Whereas RVF is devastating to livestock, the degree of virulence will vary among humans. Many infected persons will not exhibit symptoms, but others may experience fever, generalized weakness, back pain, dizziness, and extreme weight loss. Some will manifest liver abnormalities while a small percentage may suffer hemorrhagic fever (23). Approximately 1% to 10% of affected patients may have some permanent vision loss. Approximately 1% of RVF-infected humans die. There is no established treatment for infected patients and there is neither a cure nor a vaccine currently available.

RVF was first identified in 1931 and historically has been confined to eastern and southern Africa; there was a recent outbreak in South Africa with 172 human cases and 15 deaths (9). However, in 2000, there was an outbreak far north in the Arabian Peninsula and there has been concerns of RVF spreading into North America ever since. The virus is transmitted primarily by floodwater mosquitoes (***Aëdes*** species). No mosquitoes have been found infected in the U.S. with RVFV, however common species such as ***Aë. vexans*** and ***Cx. pipiens***, have demonstrated the capacity to transmit RVFV (24,25).

Infection with Japanese encephalitis virus (JEV) causes signs and symptoms similar to those caused by West Nile Virus (discussed below). The case fatality rate averages about 30%. It is the leading cause of encephalitis in Asia averaging 30,000 to 50,000 cases annually; children are most at risk to infection (26). Although its principal vectors are not found in the U.S., ***Aë. japonicus*** has been shown to transmit JEV (27) and as discussed earlier, this species has become prevalent in Massachusetts.

We will continue to monitor for these potential threats, particularly Dengue and Chikungunya. Our partnership with the state Arbovirus Surveillance Labs and our affiliations with mosquito control associations can assist us with the additional expertise to implement intervention strategies if and when necessary. In the meantime, a document recently published by the CDC and Pan American Health organization, will be sent to subscribing Boards of Health along with this VMP. It is titled **"Preparedness and Response for Chikungunya Virus Introduction in the Americas"** and it is recommended that you review chapters 1, 2, 3A, & 7.

Endemic virus: West Nile Virus

Introduction: West Nile Virus (WNV) was introduced to New York City in 1999 and within five years had spread to all 48 continental US states! It was first isolated in Essex County in 2000, and is now endemic throughout eastern MA, particularly in the Boston metropolitan area. Since its first appearance in North America, WNV has caused significant illness to over 39,000 persons in the United States (28; Table 1 shows WNV cases/fatalities in Massachusetts since 2000). While about 80% of all West Nile virus infections in humans are not symptomatic, approximately 20% of infections are manifested as some form of fever and varying degrees of serious neurological ailments are displayed by less than 1%. These neurological diseases include acute febrile paralysis, encephalitis, and meningitis resulting in death to about 10% of all neurological cases. Of the over 17,000 neuroinvasive cases since 1999, there have almost 1,600 deaths. Descriptions of all neurological manifestation of West Nile infections can be found at the Iowa State University Center of Food Security and Public Health website: http://www.cfsph.iastate.edu/Factsheets/pdfs/west_nile_fever.pdf. WNV is has also taken its toll on native bird populations with dramatic declines in seven species and many avian populations have yet to recover (29).

It was thought that WNV-associated neurological ailments were short-lived affecting only a small percentage of those infected. However, recent studies suggest that neurological disorders may be more prolonged and serious, affecting more victims than originally thought (30,31). Another recent study has shown renal disease can in patients several years after infection and whom were thought to have recovered (32).

Table 1. Total Number of Human WNV Cases/Fatalities in Massachusetts1999-2013 (as of 7 January 2014).

Year	Neuroinvasive (1)	Non-Neuroinvasive (2)	Other Clinical/Unspecified	Total	Fatalities
2001	3	0	0	3	1
2002	19	4	0	23	3
2003	12	5	0	17	1
2004	0	0	0	0	0
2005	4	2	0	6	1
2006	2	1	0	3	0
2007	3	3	0	6	0
2008	1	0	0	1	0
2009	0	0	0	0	0
2010	6	1	0	7	1
2011	4	1	0	5	1
2012	27	6	0	33	1
2013	7	1	0	8	0
Totals	88	24	0	112	9

1: CDC now classified all encephalitis, meningitis, & acute febrile paralysis cases as "Neuroinvasive Disease"
2: CDC now classified all related fevers as "Non-neuroinvasive Disease Cases"

It was also assumed that after its initial spread, WNV would decrease in prevalence in both bird and human populations, since there would be too few susceptible hosts to maintain and amplify the virus. It was theorized that the virus would "become dormant", "disappear into the landscape", and not appear again in the U.S. for several years or decades, in the manner exhibited historically by Eastern Equine and St. Louis Encephalitis viruses. However, the numbers of WNV-infected mosquito detections in Massachusetts began to increase in 2010 (Table 2) for reasons still unknown. There were human infections in the District again starting in 2010, manifested as meningoencephalitis and meningitis. All patients have "recovered", but the extent of their recovery has never been disclosed.

Mosquitoes of the species ***Culex pipiens*** are primarily responsible for the transmission of WNV to birds and humans in endemic areas in the northeast U.S. (33); ***Cx. restuans*** is also responsible for the virus's spread, but this species bites birds almost exclusively. The larvae of both these species develop in "high-organic content" water that accumulate in containers and large water-holding structures that are in greater abundance in urbanized areas. Since many water-holding structures are permanent and the water contained cannot often be drained, the water itself must then be "treated" to reduce/eliminate larvae from using the water to develop. Therefore, the principal strategy used by the District to combat WNV transmission and risk is by reducing/ eliminating larval development to ultimately reduce adult/vector presence. This is, on paper, the most cost-and environmentally-effective means for vector control. However, what is planned on paper doesn't always translate into successful control due to environmental/economic factors beyond the District's control. If efforts to reduce/eliminate larvae are not successful, then truck-based spraying operations are recommended and activated to reduce adult populations during periods of high WNV transmission. These strategies are outlined below.

Table 2. Summary of Arbovirus-infected mosquito pools in Massachusetts (as of 31 December 2013).

Year	Total number of + WNV pools			Total number of + EEEV pools	
	Statewide	NEMA District		Statewide	NEMA District
2000	4	0		16	0
2001	25	4		12	0
2002	68	14		1	0
2003	48	2		9	0
2004	15	4		39	0
2005	99	11		45	2
2006	43	5		157	11
2007	65	14(1)		31	0
2008	135	10		13	0
2009	26	2		54	13
2010	121	21		65	0
2011	275	56(2)		80	0
2012	307	48(3)		267	14(3)
2013	335	77		61	4
Totals.....	**1566**	**268**		**850**	**44**

(1) = Not including two infected pools from Manchester
(2) = Not including two infected pools from Lawrence
(3) = Includes two pools that also positive for both arboviruses

Catch Basin Treatments: As previously stated, the preferred long-term and more cost-effective vector control strategy is to eliminate larvae before they become adults. While ***Culex*** mosquitoes can develop in a variety of freshwater habitats, the greatest concentration of ***Culex*** breeding is in the estimated 80,000 catch basins found in the District (Figure 16). The two principal urban ***Culex*** mosquitoes, ***Cx. pipiens*** and ***Cx. restuans*** breed in highly organic or polluted water that collect in catch basins, storm water structures (including retention ponds; Figure 17), and discarded tires, clogged gutters, bird baths, and the like (Figures 18-20).

Figure 16. Catch Basin
(http://www.neponset.org)

Figure 17. Retention pond.
(http://dunwoodyusa.blogspot.com)

Figure 18. Discarded tire yard (Middleton)

Figure 19. Clogged rain gutter filled with water (http://www.moonworkshome.com)

Treating catch basins consist of the application of packets/"briquettes"/"ingots" of either bacteria or "growth regulators". The bacteria are effective towards killing exclusively mosquito larvae; the "growth regulator" retards or completely ceases development of larvae into adults. Short term surveillance data showed an 80% reduction in ***Culex*** species in communities where basins are treated as compared to communities with untreated basins. In a study conducted in Portsmouth NH in 2007 by Municipal Pest Management Services Inc., there was a 75% reduction in mosquitoes breeding in treated catch basins compared to untreated basin (34). It is preferred that basins be treated in the late spring or early summer to maximize the effects of the larvicidal agents. However applications of larvicides are often delayed in some communities until basins are cleaned of debris by the local DPW's. Basins filled with organic debris will reduce the effect of the larvicides to the extent they may be rendered useless.

Figure 20. Bird bath filled with debris & water (Amesbury)

Long term surveillance data has shown that the continued annual treatment of basins has gradually and significantly decreased ***Culex*** populations throughout the District in normal rainfall years. Early-season basin-treatment strategy will continue as best as possible in 2014. Droughts present special problems. How WNV-vector breeding is enhanced as well as how our operations are affected by droughts will be discussed below.

The order of catch basin larvicidal treatments for 2014 will be prioritized as follows. First to be treated will be basins in District municipalities directly north of Boston and surrounding Lawrence. These two cities are suspected of being the prime WNV foci in northeast Massachusetts. The District municipalities adjacent to these two cities had the most intense WNV activity last year and possess the most habitats that favor the breeding of the vector species; treatments of basins in these communities will begin in early April through May as conditions allow. Basins will be next treated in Ipswich and surrounding towns that had WNV detected in 2013. Ultimately, time, weather, DPW basin-cleaning schedules, and extent of other District operations will determine when all basins will be treated.

Waste Water Treatment Facilities Inspection: An additional "preemptive strategy" is to inspect and treat, where necessary, all wastewater treatment facilities, when requested. This way, actual or potential ***Culex*** breeding can be reduced or eliminated. District personnel are authorized, under the provisions of Chapter 252 Section 4 of the General Laws of the Commonwealth, to enter upon lands for the purpose of inspections for mosquito breeding.

However, we are **not** a regulatory agency. We cannot penalize any persons or agencies for providing breeding habitats. It is not our intention to cause any imposition to the management of wastewater facilities. Instead, we wish to be a resource of information and technology to assist facility managers to prevent and/or abate mosquito breeding to the mutual benefit of the facility, the community, and mosquito control.

Property Inspection: Socioeconomics often plays an important role in mosquito control and associated public health risk. In a study conducted in California in 2007, there was a 276% increase in the number of human WNV cases in association with a 300% increase in home foreclosures (33). Within most foreclosed properties in Bakersfield (Kern County, CA) were neglected swimming pools which led to increased breeding and population increases of ***Cx. pipiens/restuans***; see Figure 21.

Figure 21. Abandoned swimming pool with collapsed cover collecting water & debris (Topsfield).

Figure 22. Abandoned home property with containers of all types scattered about and collecting water (West Newbury).

In recent years we have received requests from Boards of Health to inspect abandoned properties (Figure 22) and we will continue this practice in 2014. In the course of our routine activities, we will also be "on the lookout" to inspect and report such properties to your Board. In the long term, we will offer any support that may be appropriate to resolve mosquito problems related to such properties. In the short term, with the support of the Boards of Health, we will implement the necessary control measures to mitigate any immediate mosquito problem associated with such properties.

Selective Ground Adulticiding: As a final measure to reduce the risk of WNV infections, the District may recommend selective and targeted adulticiding applications when WNV-infected mosquitoes are discovered. The District uses "Ultra Low Volume" (ULV) for ground-based adulticiding operations. One advantage of ULV applications is that only very minute amounts of pesticides are dispersed over a large area (Figure 23); just 0.4 of a fluid ounce of pesticide is released per acre with each pesticide particle measuring 15 to 20 microns in diameter (there are 1,000 microns in a millimeter). Due to the pesticides employed, ground-based adulticiding is done **only at night**.

The District may recommend a "targeted" application within a municipality (several streets or a neighborhood) based on the following criteria: 1) two or more WNV-mosquito isolations in close proximity; and 2) one or more human cases of WNV. On occasions when WNV has yet been recovered but ***Culex*** populations are seen increasing at higher-than-usual rates, we will recommend that targeted adulticiding operations be commenced. These operations would only be recommended during high WNV-transmission periods (late July through September) in communities with historical WNV activity. **Only the local Board of Health can authorize ground-based adulticide operations.**

***Ground Adulticiding Exemption**:* Residents who request their property be excluded from **all pesticide applications** (including larvicide as well as adulticide) must comply with the legal process to exempt their property (333 CMR Section 13.03; see http://www.mass.gov/agr/legal/regs/333_CMR_13.00.pdf). The process consists of the property owner sending a **certified letter** with the request to the town or city clerk prior to **March 1st** of each year; the property owners **not** be allowed to make such a request by telephone**.** No exclusions will be allowed after March 1st. The deadline of Marsh 1st is to insure that residents requesting exemptions are also not subjected to springtime larviciding operations; there is no option of selecting what control operations are exempted.

Figure 23. Truck spray at night

Figure 24. Truck applying barrier treatment.

Barrier Treatment: While ULV is a cost-effective procedure on a large scale, it only affects those mosquitoes active **at the time** of the application; repeated applications are sometimes necessary to sustain population control. To reduce the need for repeated applications and provide more sustained relief from mosquitoes in high public use areas, the District may recommend a smaller scale "barrier spray treatment". This application would be made to public use areas such as schools (applications to schools must be in compliance with MGL Ch. 85), playgrounds, athletic fields, etc. (Figure 24) A barrier spray may reduce mosquito presence for up to two or more weeks. The District strongly recommends member municipalities take advantage of this service when necessary.

Special Circumstance: Droughts: During intense drought seasons, "all bets are off" regarding normal development and distributions of ***Cx. pipiens/restuans.*** Prolonged droughts together with periods of intense heat result in "explosions" of these species, as was seen in our District in 2010 and again in 2013. Patterns of heavy rainfall followed by stretches of intense heat lasting weeks will also result in greater than normal populations of these species, as exhibited in 2011.

What is going on? Whereas the availability of standing water diminishes during droughts and most mosquito species suffers significant population losses, the "breeding" habits of ***Cx. pipiens/restuans*** allow them to take advantage of conditions provided by droughts. Recall that these species breed in waters of "high organic content". One type of artificial container filled with such water is the catch basin, as discussed earlier. One would assume that that basins in urbanized areas dry during a drought. However, people continue to water their lawns and wash their cars during droughts. All the excess runoff from these activities keeps catch basins filled. If basins have been treated with most larvicides, breeding should be kept in check. If the basins are property of a municipality, and we have records of their locations, they will be treated. However, we may not know of their existence on private properties and thus, they remain untreated and become a continual source of ***Culex*** mosquitoes throughout the season.

Normally, ***Cx. pipiens/restuans*** mosquitoes do not breed in great abundance in wetlands and definitely do not breed in moving water. However during a drought, large expanses of water become smaller, shallower, and more concentrated with more organic debris, presenting ***Culex*** mosquitoes with more breeding habitats to exploit. With more development going on in more habitats, their populations surge. There are also fewer predators present (especially fish) as wetlands dry and the survivorship of the developing larvae is dramatically increased. Also during droughts, flowing waters such as rivers, streams, and brooks gradually slow and decrease in volume. Either in the very slow moving water or more likely, along the puddles and pools formed at the edges (usually filled with organic debris; see Figure 25), more breeding sites are available for ***Culex*** to utilize.

As any large body of water dries, containers and tires that were dumped into these bodies (when full of water) now become exposed (Figure 26). Being filled with polluted water, these also become ideal breeding sites for ***Culex***. Debris-filled ground holes and depressions (either naturally-occurring or artificial) can become filled with water in a sudden downpour and also become instant breeding habitats for these species. Therefore, breeding areas for "urbanized" ***Culex*** mosquitoes are **always** in abundance, even in the middle of the worst drought! All these unexpected breeding areas cannot unfortunately all be treated, even by mosquito control projects with unlimited budgets! This is why the control of ***Cx. pipiens/restuans*** populations is extremely difficult during a drought. This is also why human WNV-infections are at their highest during a drought.

Special Circumstance: Beaver Dams: In recent years, beavers have made a comeback in population and have made an environmental impact in northeastern Massachusetts. Because the impoundments beavers construct often result in large stretches of standing water, there has been great debate as to whether these impoundments create more areas to be used by mosquitoes for their reproduction. Research has been done looking at changes in local mosquito fauna (i.e., species diversity and populations) and results have been so far inconclusive. Butts (36,37,38) reported declines in populations and in some cases, reduction in species diversity in beaver ponds in central New York State; Wilson (39) concluded that there was no evidence that the presence of beavers will increase overall mosquito populations in Connecticut however, beaver activity influenced what types of mosquitoes were present.

Figure 25**.** Powow River (Amesbury) during June 2010 drought.

Figure 26. Drying pond in Newburyport in August 2010 exposing debris and containers originally found under water.

On the other hand, steady increases in permanent- and flood- water mosquito species and populations have been noted since the appearance of a beaver dam and the subsequent flooding in Warren County, New Jersey (40). Although sampling for mosquitoes in the "open water" of beaver ponds may not have demonstrated changes in mosquito populations, what has not been thoroughly explored is the role of "edge breeding". Perimeters of beaver ponds are subjected to periodic receding and re-flooding. How inundated forests could become development sites for cryptic-breeding EEEV vectors has not been investigated. Nor how the abundance of dead decaying trees in flooded forest swamp pools contribute to breeding of WNV vectors has not been studied either. We will continue to monitor beaver pond habitats with the hope to identify whether and where arbovirus vectors may be taking advantage of these habitats to enhance their populations and improve their status as public health nemeses.

Endemic virus: Eastern Equine Encephalitis Virus

Introduction: Prior to 2004 there were never serious concerns about Eastern Equine Encephalitis in Essex County. EEEV seemed to be restricted to southeast Massachusetts and its vector, ***Cs. melanura***, seemed to thrive in the expansive habitat of the great cedar swamps found there. No such huge cedar swamps are found in northeast Massachusetts nor has ***Cs. melanura*** been collected here with any abundance. Then in 2004 and 2005 came reports of EEEV-infected mosquitoes, birds, horses, and humans from just over the border from Essex County in southeast New Hampshire. And the more EEEV that was reported in New Hampshire, the more the virus began to "spill over" into our District beginning in 2005 (Table 3). Infected mosquitoes were collected from one or more of our border towns annually from 2005 through 2009 and again in 2012-2013 (Figure 27 & 28). Furthermore, most of the recent detections were in towns at a distance away from the New Hampshire border. And, these infections were in mosquitoes whose numbers were lower than usual due to the summer-long drought.

EEEV-human infections manifest symptoms similar to West Nile encephalitis and while the human infection rate is lower, the fatality rates are much higher with EEEV infections, about 33%. Also, the recovery rates from EEE disease are longer and most often are incomplete. EEEV seems to attack the young as readily as the elderly unlike WNE which the elderly are far more susceptible (41).

EEEV was first discovered in horses hence, the basis for the name "Equine Encephalitis". The name "equine" stuck even after it was later discovered that this was the same virus that caused the same encephalitis in humans.

Humans and horses are "dead-end hosts", meaning that the virus cannot be transmitted from infected horses or humans (41). Like WNV, EEEV is an avian virus, transmitted from bird-to-bird principally by ***Cs. melanura***. While ***Cs. melanura*** mosquitoes are primarily responsible the amplification of virus in bird populations, they typically do not bite humans. It is other mosquito species with wider host preferences ("bridges vectors"), when infected (after biting infected birds) can transmit EEEV to humans. Nonetheless, it is our judgment that while risks to humans directly from infected ***Cs. melanura*** are extremely low, we will continue to take preemptive protective operations directly against ***Cs. melanura*** when infected mosquitoes are detected. Lack of early intervention activity can result in accelerated EEEV amplification into other species which can increase human risk to infection later in the season.

Table 3. EEEV detections and infections in southeastern New Hampshire and northeastern Massachusetts from 2001 through 2013.

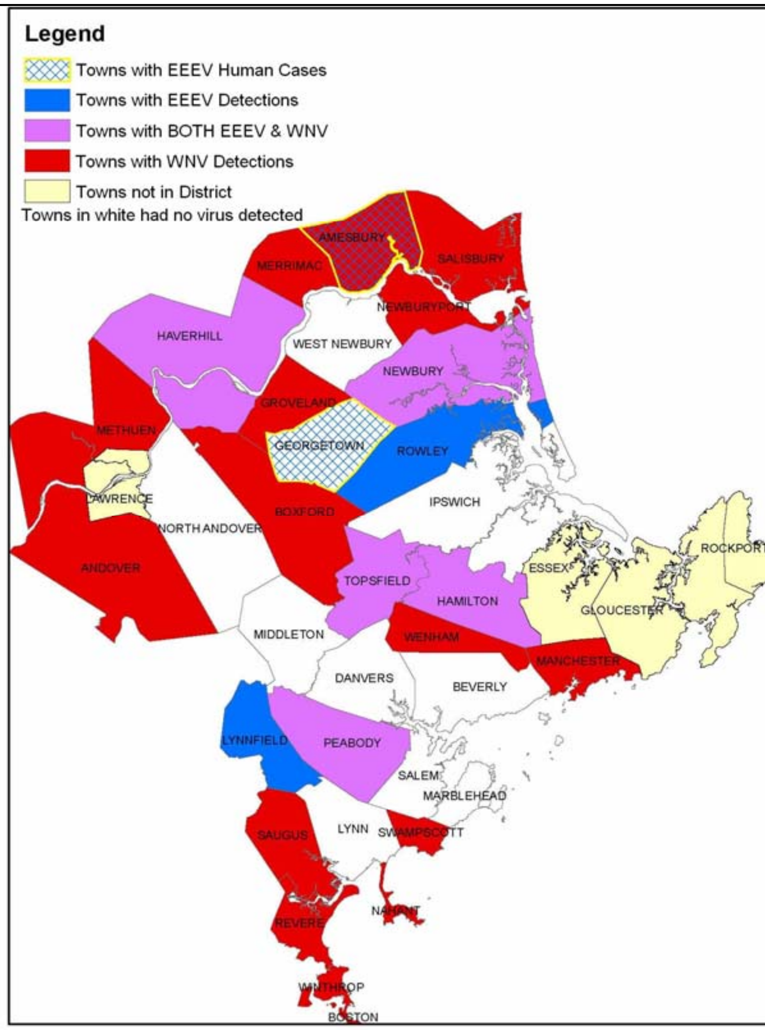
	Southeastern New Hampshire				Northeastern Massachusetts		
Year	# infected mosquito "pools"	horse infections	human infections//deaths		# infected mosquito "pools"	horse infections	human infections//deaths
2001	**0**	**0**	**0**		**0**	**0**	**0**
2002	**0**	**0**	**0**		**0**	**0**	**0**
2003	**0**	**0**	**0**		**0**	**0**	**0**
2004	**19**	**3**	**0**		**0**	**1 (3)**	**0**
2005	**14**	**14**	**7 // 2**		**2**	**2**	**0**
2006	**40**	**1**	**0**		**11**	**0**	**0**
2007	**6**	**2**	**3 // 0**		**0**	**0**	**0**
2008	**8**	**0**	**0**		**0**	**0**	**1 (4) // 1**
2009	**65**	**3**	**1 // 0**		**13**	**(alpaca)**	**0**
2010	**0**	**0**	**0**		**0**	**0**	**0**
2011	**0**	**0**	**0**		**0**	**0**	**0**
2012	**9**	**2**	**0**		**14**	**2**	**2 // 2**
2013	**24**	**2**	**0**		**4**	**0**	**0**

1: includes Merrimac, Hillsborough, Strafford, & Rockingham counties
2: Essex County only
3: also an emu was infected with EEEV
4: resident of Newburyport but acquired infection in either NH or ME

Southeast Massachusetts, the original "hotbed" for EEEV activity in New England, continues to experience serious problems with EEEV. In 2010, the much-higher-than-normal detections in both enzootic and bridge vectors culminating in an aerial adulticiding application in August. In 2011, detections of virus in mosquitoes were elevated again, but the state elected not to order an aerial operation. In 2012, MA DPH deemed the EEEV threat more dangerous to the state's residents with at least eight different species of mosquitoes infected with EEEV. The state authorized two adulticidal air sprays over much of Bristol and Plymouth counties in July and August 2012.

Whereas only WNV was encountered in the District in 2011, both WNV and EEEV were detected in abundance and distribution in 2012 and 2013 (see Figure 27 and 8). The unprecedented District-wide viral activity resulted in extensive larvicidal and adulticidal responses to a degree also unprecedented. Sadly in 2012, there were two related fatalities in the District caused by EEEV (in Georgetown and Amesbury). There were also two animal fatalities in 2012, both horses (Georgetown and Essex; Essex is not a subscribing municipality). Fortunately in 2013, there were no human or horse infections from EEEV in Northeast Massachusetts.

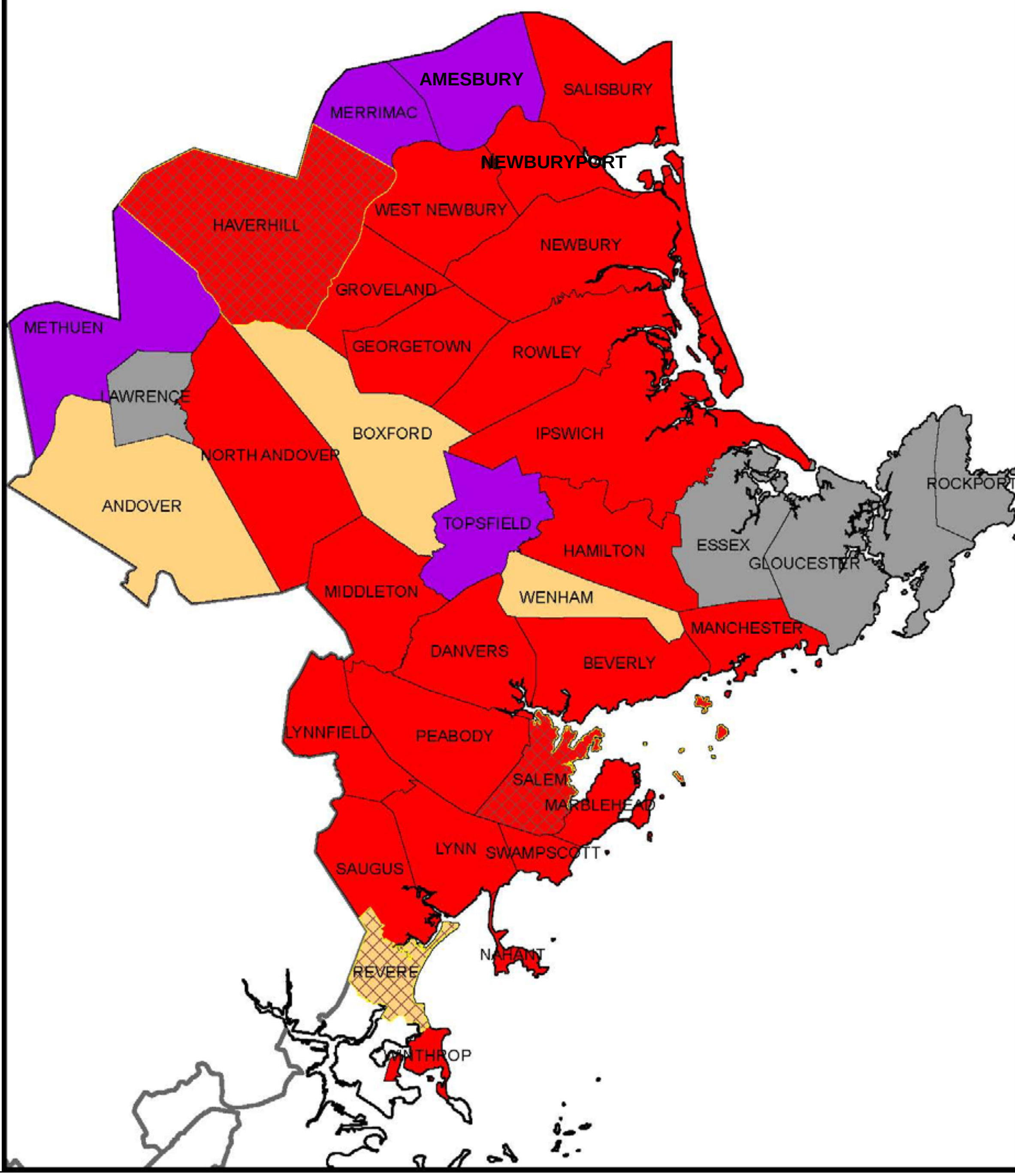
Figure 27. NE MA Mosquito Control District Municipalities reporting WNV and EEEV infections in 2012



The extremely low presence of floodwater mosquitoes in late summer 2012 and 2013 may have been the principal reason why EEEV was not as prevalent in Essex County as compared to Plymouth and Bristol counties. These mosquitoes, principally ***Aëdes vexans*** and ***Aë. canadensis***, are also notorious human-biting mosquitoes and can effectively transmit EEEV.

Habitat Surveillance: Predictive models of EEEV cycles and distributions are apparently no longer reliable as is EEEV activity can no longer be estimated by high populations of ***Cs. melanura***. It was seen in several resting box sites in 2012 that even with lower than usual populations of ***Cs. melanura*** EEEV was still being transmited. Monitoring their populations to help in predicting EEEV activity has been troublesome due to the locations where this species breeds and develops. ***Cs. melanura*** is one of only a few mosquitoes that survive the winter in the larval stage. Instead of open water, they develop inside flooded root meshes, holes and tunnels ("crypts") under trunks of trees and in tree hummocks in Atlantic white cedar and red maple swamps (Figure 29 & 30).

Figure 28. NE MA Mosquito Control District Municipalities reporting WNV and EEEV infections in 2013



Legend:
Municipalities in **RED**..................... WNV detected in mosquitoes
Municipalities in **PURPLE**.............. **BOTH** EEEV and WNV detected in mosquitoes
Cross-hatching................................. Municipalities with one WNV-infected human
Municipalities in **TAN**...................... NO virus detected in mosquitoes
Municipalities in **GREY**................... Non-subscribing municipalities

Figure 29. "Inside the Atlantic White Cedar Swamp Trail"

http://www.paulscharffphotography.com/occ-insidetheatlanticwhiteceda.htm

Figure 30. "Breeding" habitat of ***Cs. melanura***.
(http://www.co.oswego.ny.us/info/news/2012/061112-1.html)

These habitats are in relative abundance in northeast MA, although they exist more as isolated pockets and are difficult to access. Since 2004, we have been searching for ***Cs. melanura*** habitat to monitor in winters. Trying to find ***Cs. melanura*** larvae breeding in crypts is very much like trying to find a needle in a hay stack; to date we have been unsuccessful in locating such sites with consistency. During the winters, we continue to narrow our search for ***Cs. melanura*** breeding to areas within a one mile radius of our surveillance stations in communities bordering NH and in the Hamilton/Topsfield area. The objective is to find these breeding locations from which we can monitor larval populations through the winter; the expectation is to make better projections of what may happen in the following seasons and prepare better for intervention.

Selective Ground Adulticiding: Because of the elusive nature of ***Cs. melanura*** larval development, larviciding is not a viable option as a manageable preemptive strategy. Therefore, the District may recommend selective and targeted adulticiding applications to reduce ***Cs. melanura*** populations in an effort to break the mosquito-to-bird transmission phase of the virus cycle. Historically, when horse and human infections are reported, truck-spray operations are initiated. But by this time, these interventions are late and their effectiveness in reducing risk are limited at best. Therefore to reduce risk, adulticiding operations will be recommended to a municipality when the any one of following criteria are met: 1) above average ***Cs. melanura*** populations; 2) one EEEV detection in ***Cs. melanura*** mosquitoes; 3) one EEEV isolation in horses; 4) one human EEE cases. As with WNV intervention, the District uses Ultra Low Volume (ULV) for ground adulticiding applications.

Barrier Treatment: The discussion of barrier application in the attempt to reduce exposure to WNV-infected mosquitoes also applies to reduce exposure to EEEV-infected mosquitoes.

Emergency Response Aerial Adulticiding Plan: In the event that the risk of EEEV infection escalates to a point that ground adulticiding is insufficient to reduce that risk, an emergency aerial adulticiding application may be warranted. The effectiveness of aerial adulticiding operations have been documented (42). Fixed-winged aircraft would be employed to release adulticides over targeted areas. For this aerial application to proceed, a consensus must be reached by the District, the State Reclamation and Mosquito Control Board, the Massachusetts Department of Health, an independent advisory board, and lastly a declaration of a Public Health Emergency from the Governor is required.

Typically, once the decision is made, the need for action is immediate and the window of opportunity is short. It is imperative that the complex logistics of executing the aerial application are already in place even before a consensus is achieved. The Emergency Response Aerial Adulticiding Plan is outlined as follows:

1. The District has already in place, and continually revises, a Global Positioning Satellite (GPS) mapping program that designates areas to be excluded from an aerial adulticide operation. These include reservoirs, endangered species areas, etc. The areas to be sprayed would be determined by the current mosquito and risk data and environmental circumstances. These data can be quickly downloaded into an aircraft’s navigation system which would then direct the aircraft to areas to be sprayed as well as areas to be avoided.

2. The District has (and annually revises) Memorandums of Understanding (MOU) with the Lawrence and Beverly airports. In the event that an aerial adulticiding operation is essential, Lawrence airport would be closest to the likely target area to be the staging area for the operations. In the event Lawrence airport is unavailable or the target area has broadened, then the Beverly airport would be used.

3. Through the state’s procurement program, contracts are already in place for the acquisition of aircraft and pesticides. If events warrant, it is the District that will communicate directly with aircraft and pesticide contractors, airport staff, and other relevant personnel to secure the necessary equipment and materials for our use.

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